Chapter 32

Diabetes in Hispanic Americans

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SUMMARY

Most of the information on diabetes in Hispanic Americans comes from four large studies: the San Antonio Heart Study, the San Luis Valley Diabetes Study, the Starr County Study, and the Hispanic Health and Nutrition Examination Survey (HHANES). These studies have clearly established that the prevalence of non-insulin-dependent diabetes mellitus (NIDDM) is two to three times higher in Mexican Americans than in non-Hispanic whites. HHANES is the only one of the four studies that included information on Cuban Americans in the Miami area and Puerto Ricans in the New York City area. Diabetes prevalence in Puerto Ricans was as high as in Mexican Americans. Cuban Americans had a lower prevalence, although it was still 30%-50% higher than in non-Hispanic whites. Risk factors for NIDDM in Hispanic Americans are similar to those in non-Hispanics and include obesity, unfavorable distribution of body fat, hyperinsulinemia, and dyslipidemia (high triglyceride and low high-density lipoprotein, HDL). These abnormalities are also more common in nondiabetic Mexican Americans. NIDDM prevalence in Mexican Americans in Texas tends to be inversely related to socioeconomic status and degree of acculturation to mainstream U.S. society. Little is known about behavioral factors that may mediate these sociocultural effects, although newly diagnosed diabetic Hispanics in Colorado reported consuming greater amounts of dietary fat than nondiabetic Hispanics. There is a strong ecological association between the percentage of Native American genetic admixture and the prevalence of diabetes in various Hispanic and Native American populations. Since admixture and sociocultural factors co-vary, it is difficult to disentangle their joint effects on diabetes risk.

In contrast to NIDDM, registry data indicate that the incidence of insulin-dependent diabetes mellitus (IDDM) is lower in Hispanics than non-Hispanics. Diabetic Mexican Americans experience higher mortality than nondiabetic Mexican Americans although, surprisingly, all-cause mortality in the general population of adult Mexican Americans is quite similar to that of non-Hispanic whites. The prevalence of myocardial infarction is lower in Mexican-American men, with or without diabetes, than in the corresponding category of non-Hispanic white men, but there is no similar ethnic difference in women. This pattern of a sex-ethnic interaction for myocardial infarction is similar to the pattern that has been reported previously for coronary heart disease mortality. There is also evidence that diabetic Mexican Americans have a higher prevalence of peripheral vascular disease as assessed by ankle-arm blood pressure ratios than non-Hispanic whites with diabetes.

With respect to microvascular complications of diabetes, there is a discrepancy among studies: The San Antonio Heart Study and the Third National Health and Nutrition Examination Survey (NHANES III) show an excess of microvascular complications in diabetic Mexican Americans compared with non-Hispanic white diabetic people, although the San Luis Valley Diabetes Study shows no such ethnic difference. The explanation for this discrepancy is not clear but is probably related to the fact that Mexican Americans with diabetes in San Antonio, TX were more hyperglycemic than non-Hispanic whites with diabetes, whereas in the San Luis Valley, CO there were no differences in the level of hyperglycemia between the two ethnic groups. Although findings differ between the San Antonio and San Luis Valley studies, statewide surveillance results indicate that the rates of renal replacement therapy for diabetes-related end-stage renal disease (ESRD, kidney dialysis and transplant) are markedly higher in Hispanics than in non-Hispanics in both Texas and Colorado. Moreover, this excess is greater than can be explained on the basis of the higher diabetes prevalence in Hispanics. Interestingly, in

Texas the survival of Mexican Americans with diabetes on dialysis is longer than for non-Hispanic whites with diabetes on dialysis. Finally, there is evidence that the rate of microvascular complications is increased in San Antonio Mexican Americans with diabetes who have less effective health insurance coverage.

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INTRODUCTION

Hispanics are the second-largest minority population in the United States. In 1991, the estimated size of the Hispanic population was 21.4 million, representing ~8.6% of the total U.S. population[1]. Hispanics are also one of the most rapidly growing minority groups in the United States, and it is projected that by the year 2050 they will comprise 21% of the U.S. population[2]. The three major subgroups that make up the Hispanic population are Mexican Americans, Puerto Ricans, and Cubans. By far the largest of these is the Mexican-American population, the majority of whom live in the southwestern United States.

In the past 10 years, a great deal has been learned about the epidemiology of diabetes in Mexican Americans. Most of this information has come from four studies: the San Antonio Heart Study, the San Luis Valley Diabetes Study, the Starr County Study, and the HHANES. These studies have established that the prevalence of NIDDM is two to three times higher in Mexican Americans than in non-Hispanic whites. HHANES has also provided information about the occurrence of diabetes in Puerto Ricans and Cuban Americans.

PREVALENCE OF NIDDM IN HISPANICS

TEXAS

One of the first studies of glucose intolerance in Mexican Americans was carried out in 1979 in Laredo, TX[3]. A population-based random sample of 389 Mexican Americans age 40-74 years was identified and a fasting blood specimen was obtained from all study participants. Approximately 16% of men and women reported either a history of diabetes with current use of antidiabetic medications or had fasting plasma glucose ≥140 mg/dl (Table 32.1). In a sense, these rates represent the frequency of "severe" diabetes since additional individuals could have been diagnosed as having diabetes on the basis of their 2-hour glucose values if oral glucose tolerance tests (OGTTs) had been administered.

The prevalence of "severe" hyperglycemia was assessed in Mexican Americans residing in Starr County, TX, in 1981[4]. This study included 2,498 persons age ≥15 years who resided in sampled households. Subjects were considered to have "severe" hyperglycemia if they were currently taking antidiabetic medications or if they fulfilled all of the following three criteria: 1) their blood glucose value from a nonfasting finger stick was ≥130 mg/dl; 2) their glucose value following a 4-hour fast was ≥130 mg/dl; and 3) their glucose values following a 12-hour fast met the National Diabetes Data Group (NDDG) criteria on a full 2-hour

Table 32.1
Prevalence of Previously Diagnosed Diabetes and Fasting Hyperglycemia in Mexican Americans, Laredo, TX, 1979

	Men				Women			
Age (years	No.	Previously diagnosed %	Fasting hyperglycemia %	Total %	No.	Previously diagnosed %	Fasting hyperglycemia %	Total %
40-44	18	5.6	5.6	11.1	34	8.8	0	8.8
45-54	37	8.1	2.7	10.8	93	7.5	0	7.5
55-64	42	16.7	0	16.7	70	12.8	4.3	17.1
65-74	30	16.7	6.7	23.3	65	27.7	3.1	30.8
Total	127	12.6	3.1	15.7	262	14.1	1.9	16.0

Previously diagnosed diabetes defined as a history of diabetes and either fasting plasma glucose ≥140 mg/dl or currently taking antidiabetic medications. Fasting hyperglycemia defined as fasting plasma glucose ≥140 mg/dl with no medical history of diabetes.

Source: Reference 3

OGTT. A total of 5.2% of males and 5.3% of females age ≥15 years had a history of previously diagnosed diabetes and were either taking antidiabetic medications or fulfilled the NDDG criteria for diabetes. Severe hyperglycemia was present in an additional 1.6% of males and 1.4% of females who had no prior history of diabetes (Table 32.2). As in the Laredo study, the true prevalence of NIDDM in Starr County could not be estimated from these data because glucose tolerance tests were administered only to individuals with fasting hyperglycemia.

The first population-based study of Hispanics in which a full glucose tolerance test was administered to all participants was the San Antonio Heart Study. The baseline component of this study was carried out in two phases, the first during 1979-82 and the second during 1984-88. Diabetes was diagnosed by a 2-hour OGTT. In both baseline phases combined, a total of 3,302 Mexican Americans and 1,877 non-Hispanic whites age 25-64 years were examined. Subjects were sampled from three types of neighborhoods: low-income barrios, middle-income transitional neighborhoods, and high-income suburbs. In Mexican Americans, NIDDM prevalence was two to four times higher in the barrio than in the suburban neighborhoods (Table 32.3). Age-adjusted prevalence for men was 14.0% in the barrio versus 6.5% in the suburbs and for women was 18.0% in the barrio versus 4.3% in the suburbs. NIDDM prevalence was similar between Mexican Americans and non-Hispanic whites in the suburban neighborhoods, but in the transitional neighborhoods there was a fourfold excess of NIDDM among Mexican Americans (Figure 32.1). Overall in San Antonio, NIDDM prevalence was two to three times higher in Mexican Americans than in non-Hispanic whites[5].

COLORADO

Diabetes prevalence was also estimated for Hispanics and non-Hispanic whites residing in two counties in southern Colorado in the San Luis Valley Diabetes Study[6]. In this study, all persons with previously diagnosed diabetes residing in the two counties, as well as a random sample of individuals with no prior history of diabetes, were invited to receive a medical examination. Individuals with previously diagnosed diabetes were identified through a review of medical records from all health care facilities in the study area, and additional cases were ascertained through a public media campaign. A sample of 607 persons age 20-74 years without a prior history of diabetes was also identified, and these individuals, as well as all previously diagnosed diabetic persons (n=343), attended a medical clinic where they received a 2-hour OGTT. Diabetes was diagnosed (or verified) using World Health Organization (WHO) plasma glucose criteria or by current use of antidiabetic medications. The prevalence of confirmed, previously diagnosed NIDDM was estimated for southern Colorado using county census estimates as the denominator. The prevalence of previously diagnosed NIDDM in San Luis Valley was 2.9% in Hispanic men and 4.7% in Hispanic women age ≥20 years (Table 32.4). These rates were ~1.8-fold and ~4.1-fold higher than the rates of previously diagnosed NIDDM in non-Hispanic white males and females of the same age. Diabetes was newly diagnosed in an additional 4.5% of Hispanic men and 8.4% of Hispanic women, rates that were also in excess of those for non-Hispanic whites (Table 32.4).

Table 32.2
Prevalence of "Severe" Hyperglycemia in Mexican Americans, Starr County, TX, 1981

	Males				Females			
Age (years)	No.	Previously diagnosed %	Newly diagnosed %	Total %	No.	Previously diagnosed %	Newly diagnosed %	Total %
15-24	211	0	0	0	285	0.4	0	0.4
25-34	115	2.6	0	2.6	254	0.4	0	0.4
35-44	92	3.3	0	3.3	210	3.8	1.9	5.7
45-54	95	7.4	5.3	12.6	204	8.3	2.5	10.8
55-64	85	12.9	3.5	16.5	142	18.3	0.7	19.0
65-74	60	13.3	3.3	16.7	94	10.6	6.4	17.0
≥75	35	11.8	5.8	17.6	50	6.0	2.0	8.0
Total	692	5.2	1.6	6.9	1,239	5.3	1.4	6.7

Previously diagnosed hyperglycemia defined as a history of diabetes and either meeting National Diabetes Data Group (NDDG) blood glucose criteria for diabetes or currently taking antidiabetic medications. Newly diagnosed hyperglycemia defined as casual blood glucose ≥130 mg/dl and 4-hour fasting blood glucose ≥130 mg/dl and meeting NDDG criteria for diabetes, with no medical history of diabetes.

Source: Reference 4

Table 32.3

Prevalence of NIDDM in Mexican Americans and Non-Hispanic Whites According to Neighborhood, San Antonio, TX, 1979-88

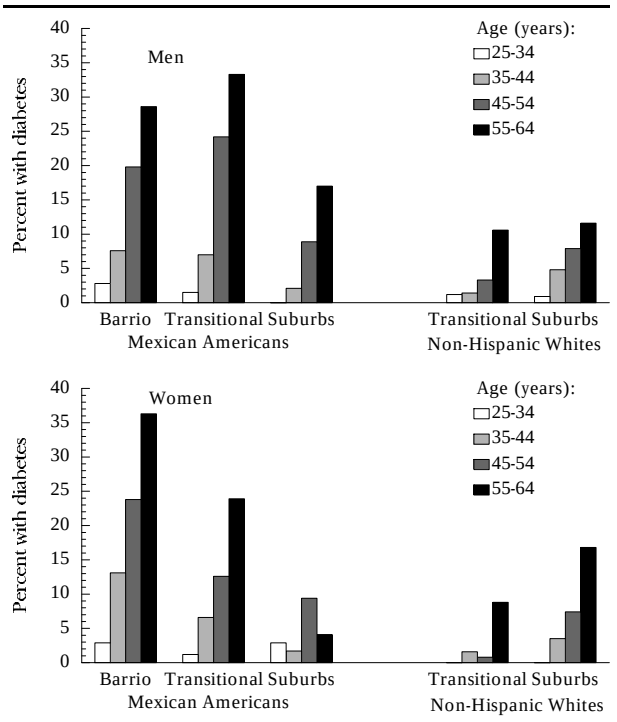
Age (years)	Mexican Americans: Barrio %	Barrio No.	Transitional %	Transitional No.	Suburbs %	Suburbs No.	Non-Hispanic whites: Transitional %	Transitional No.	Suburbs %	Suburbs No.
Men										
25-34	2.8	180	1.5	131	0	73	1.2	87	0.9	111
35-44	7.6	119	7.0	100	2.1	143	1.4	142	4.8	63
45-54	19.8	121	24.2	66	8.9	135	3.3	122	7.9	76
55-64	28.6	154	33.3	60	17.0	59	10.6	94	11.6	121
Total	14.3	574	12.6	357	6.1	410	3.8	445	6.5	371
Age-adjusted	14.0		15.6		6.5		3.9		6.0	
Women										
25-34	2.9	239	1.2	171	2.9	103	0.0	119	0.0	116
35-44	13.1	222	6.6	136	1.7	173	1.6	193	3.5	8
45-54	23.8	235	12.6	95	9.4	117	0.8	126	7.4	95
55-64	36.3	240	23.9	67	4.1	49	8.8	102	16.8	167
Total	19.1	936	8.3	469	4.3	442	2.4	540	8.2	463
Age-adjusted	18.0		10.4		4.3		2.6		6.4	

No non-Hispanic white subjects in the barrio neighborhoods were studied; age-adjusted rates were computed by the direct method using the pooled population as the standard. NIDDM was diagnosed by World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour glucose ≥200 mg/dl) or by current use of antidiabetic medications.

Source: San Antonio Heart Study

Figure 32.1

Prevalence of NIDDM in Mexican Americans and Non-Hispanic Whites by Neighborhood, San Antonio, TX, 1979-88



Diabetes diagnosed by World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour plasma glucose ≥200 mg/dl) or by current use of antidiabetic medications.

Source: San Antonio Heart Study

Table 32.4

Prevalence of NIDDM in Mexican Americans and Anglos, San Luis Valley, CO, 1984

Age (years)	Previously diagnosed: Hispanics %	Hispanics No.	Anglos %	Anglos No.	Newly diagnosed: Hispanics %	Hispanics No.	Anglos %	Anglos No.
Men								
20-29	0	802	0.1	1,137	0	5	0	4
30-39	0.8	533	0.1	754	0	7	0	8
40-49	3.6	388	0.9	531	0	21	0	29
50-59	7.4	312	4.6	460	8.3	36	1.9	52
60-69	8.2	255	5.3	375	6.5	31	6.5	46
70-74	6.7	104	2.9	138	0	11	0	10
Total	2.9	2,394	1.5	3,395	4.5	111	2.7	149
Age-adjusted	3.3		1.8		2.2		1.2	
Women								
20-29	0.1	839	0.1	1,065	0	12	0	9
30-39	0.6	505	0.5	762	0	15	0	20
40-49	2.6	391	0.6	533	4.0	25	0	31
50-59	11.0	344	2.0	545	5.3	38	5.6	72
60-69	12.4	314	2.5	435	11.1	36	5.7	53
70-74	19.0	142	6.2	161	29.4	17	10.5	19
Total	4.7	2,535	1.1	3,501	8.4	143	4.4	204
Age-adjusted	4.9		1.2		4.3		2.1	

Previously diagnosed NIDDM defined as a history of previously diagnosed diabetes with confirmation at clinic examination using World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour glucose ≥200 mg/dl). Newly diagnosed NIDDM defined as subjects with no prior history of diabetes who met WHO criteria.

Source: Reference 6

Table 32.5
Prevalence of Self-Reported Diabetes in Hispanics, Albuquerque, NM, 1984-85

Age (years)	Men		Women	
	%	No.	%	No.
18-24	0	70	0	127
25-34	1.9	105	0.6	174
35-44	2.2	90	5.9	101
45-54	7.9	76	8.7	92
55-64	9.8	61	10.8	93
65-74	11.5	52	12.2	74
≥75	13.8	29	16.1	31

Reported diabetes defined as previously been told by a physician or nurse that the subject had diabetes or sugar diabetes.

Source: Reference 7

NEW MEXICO

The prevalence of diagnosed diabetes was ascertained in 1984-85 through a population-based health survey conducted among 1,175 Hispanic residents of Albuquerque, NM[7]. Diabetes was considered present if the participant reported ever having been told by a physician or nurse that he or she had diabetes or sugar diabetes. The prevalence of reported diabetes increased monotonically with increasing age, with 13.8% of men and 16.1% of women age ≥75 years reporting a history of diabetes (Table 32.5). These rates were similar to the rates of previously diagnosed diabetes among Mexican Americans in Starr County, TX, and the San Luis Valley, CO.

HHANES

The HHANES, conducted in 1982-84, is the only survey that has provided data on the prevalence of diabetes in different Hispanic subgroups[8]. The three populations in HHANES were Mexican Americans in the southwestern United States, Cubans in Dade County (Miami), FL, and Puerto Ricans in the New York City area. The diabetes component of the survey consisted of a diabetes history interview, which was administered to all 6,588 participants, and an OGTT, which was administered to a subsample of 1,326 participants. Cubans were considerably less likely than either Mexican Americans or Puerto Ricans to have ever been told that they had diabetes (Table 32.6). The prevalence of previously and newly diagnosed diabetes combined was also lower in Cubans, whereas there was little difference in prevalence rates between Mexican Americans and Puerto Ricans (Figure 32.2). Among those age 20-44 years, 2.4% of Cubans were estimated to have diabetes, compared with 3.8% and 4.1% of Mexican Americans and Puerto Ricans, respectively. Among individuals age 45-74 years, 15.8% of Cubans had diabetes, compared with 23.9% and 26.1% of Mexican Americans and Puerto Ricans, respectively.

The lower prevalence of NIDDM in Cubans relative to Puerto Ricans and Mexican Americans in HHANES[8] is interesting in light of the fact that the latter two populations are considered to have significantly higher degrees of native Amerindian genetic admixture than the Cuban population[9]. As discussed later in this chapter, it has been hypothesized that genes originating from Amerindian ancestry influence susceptibility to NIDDM. On the other hand, Cubans participating in the HHANES survey had a higher socioeconomic status than the Puerto Rican and Mexican American participants[8,10], and it is possible that the lower prevalence of NIDDM among Cubans is associated with their higher socioeconomic status.

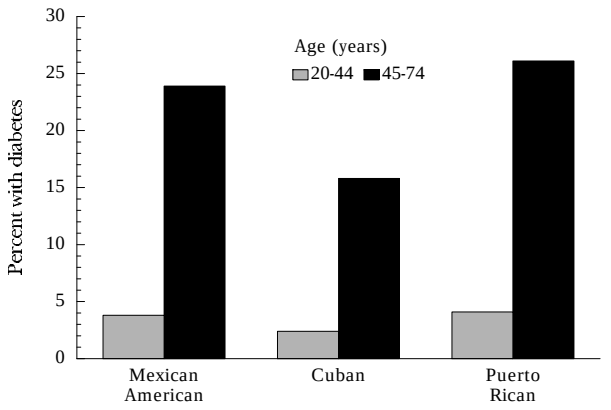
Table 32.6
Prevalence of NIDDM in U.S. Hispanic Groups, HHANES, 1982-84

	Previously diagnosed						Newly diagnosed		Total
	Men		Women		Both sexes		Both sexes		Both sexes
	%	No.	%	No.	%	No.	%	No.	%
Age 20-44 years									
Mexican American	1.6	1,138	2.3	1,297	1.9	2,435	1.8	566	3.8
Cuban	1.0	202	1.8	267	1.5	469	1.0	77	2.4
Puerto Rican	1.2	311	2.5	521	2.0	832	2.1	122	4.1
Age 45-74 years									
Mexican American	13.4	657	15.2	836	14.3	1,493	9.6	337	23.9
Cuban	5.2	302	6.6	363	5.9	665	9.9	114	15.8
Puerto Rican	11.3	269	16.2	418	14.3	687	11.8	110	26.1

HHANES, 1982-84 Hispanic Health and Nutrition Examination Survey. Previously diagnosed NIDDM defined as previously been told by a doctor that the subject had diabetes. Newly diagnosed NIDDM defined according to World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour glucose ≥200 mg/dl).

Source: Reference 8

Figure 32.2
Prevalence of NIDDM in U.S. Hispanic Groups, HHANES, 1982-84



HHANES, 1982-84 Hispanic Health and Nutrition Examination Survey. Rates of NIDDM are the sum of previously diagnosed NIDDM (previously told by a doctor that the subject had diabetes) and newly diagnosed NIDDM (World Health Organization criteria of fasting plasma glucose ≥140 mg/dl or 2-hour plasma glucose ≥200 mg/dl).

Source: Reference 8

PUERTO RICO

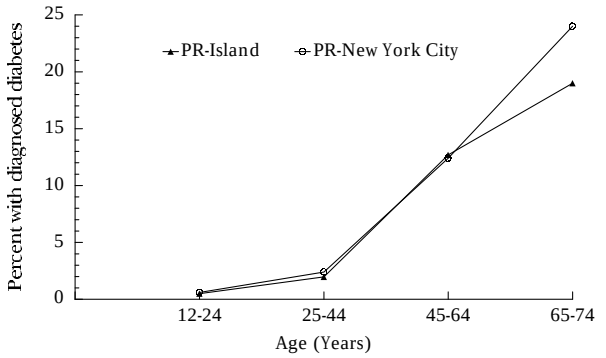
The prevalence of previously diagnosed diabetes in Puerto Rico was estimated through the Puerto Rico Household Health Interview Survey. This survey was administered by the Puerto Rico Department of Health to a multistage probability sample of the Puerto Rican population. Study participants were asked if anyone in the family had diabetes, and prevalence rates were obtained by dividing the estimated number of cases by the population census. Household interviews were conducted annually, and total prevalence increased nearly monotonically every year from 3.1% in 1975 to 5.1% in 1986[11]. A total of 4.5% of males and 5.8% of females reported a history of diabetes (Table 32.7). These rates are comparable to the prevalence of previously diagnosed diabetes among Puerto Ricans in the HHANES survey (Figure 32.3).

Table 32.7
Prevalence of Self-Reported Diabetes, Puerto Rico, 1985

Age	Male		Female		Total	
(years)	%	Cases	%	Cases	%	Cases
<6		0		0		0
6-16	0.6	5	0.5	4	0.5	9
17-24	0.4	2	0.9	6	0.7	8
25-44	2.5	22	2.2	23	2.3	45
45-64	11.9	81	14.8	119	13.5	200
≥65	16.4	60	21.6	92	19.2	152
Mean	4.5	170	5.8	244	5.2	414

Source: Reference 11

Figure 32.3
Prevalence of Diagnosed Diabetes in Puerto Rican Populations, 1982-84



Source: Reference 11; 1982-84 Hispanic Health and Nutrition Examination Survey

In 1969, the Puerto Rico Heart Health Program estimated the prevalence of diabetes to be 3.6% in rural men and 9.0% in urban men age 45-64 years[12]. Since that time, diabetes prevalence has increased at a faster rate in rural men than in urban men so that, by 1985, the prevalence of diagnosed diabetes was approximately similar for urban and rural residents. One hypothesis to explain the disappearance of the urban-rural difference is that the modernization of Puerto Rico has been accompanied by lifestyle changes that are associated with an increase in diabetes prevalence, and that these changes have affected the rural as well as the urban population.

MEXICO

One of the most recent studies to have examined diabetes prevalence in Hispanics is the Mexico City Diabetes Study, in which 2,282 Mexicans age 35-65 years were examined during 1989-92[13]. Participants were sampled from low-income *colonias* in Mexico City, and the examination procedures were identical to those used in the San Antonio Heart Study. Diabetes was diagnosed according to WHO criteria and by current use of antidiabetic medications. Diabetes was present in 12.8% of men and 13.3% of women. These rates were somewhat lower than the corresponding prevalence rates for Mexican Americans residing in the San Antonio barrios (Table 32.8). Some, but not all, of the excess NIDDM in San Antonio could be accounted for by the higher body mass index of the Mexican Americans in San Antonio[13].

Table 32.8
Prevalence of NIDDM in Mexican Americans in the San Antonio Barrio, 1979-85, and Mexicans in Mexico City, 1989-92

	Men				Women			
Age	SA		MC		SA		MC	
(years)	%	No.	%	No.	%	No.	%	No.
35-44	7.6	119	5.9	389	13.1	222	4.8	563
45-54	19.8	121	12.7	322	23.8	235	15.3	477
55-64	29.1	151	25.0	220	36.0	239	26.9	286
Total	19.7	391	12.8	931	24.6	696	13.3	1,326
Age-adjusted	17.7		13.6		22.8		14.2	
Odds ratio adjusted for age	1.38 (p=0.049)				1.81 (p<0.001)			
Odds ratio adjusted for age and sex	1.65 (p<0.004)							

SA, San Antonio barrio; MC, Mexico City, Mexico; diabetes diagnosed by World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour glucose ≥200 mg/dl) or by current use of antidiabetic medications.

Source: San Antonio Heart Study and Mexico City Diabetes Study

COMPARISON OF NIDDM PREVALENCE BETWEEN HISPANICS AND NON-HISPANIC WHITES

In the San Antonio Heart Study, the San Luis Valley Diabetes Study, and the HHANES survey, diabetes prevalence was assessed in a comparison non-Hispanic white population, thus allowing direct comparison of diabetes prevalence between Hispanics and non-Hispanic whites. In addition, a non-Hispanic white group from the 1971-75 NHANES I survey was also included as a reference population in the Laredo Diabetes Study. Comparisons of the ethnic differences in diabetes prevalence are provided in Table 32.9. In general, the prevalence of diabetes is two to four times higher in Hispanics than in non-Hispanic whites. The only exception is the Cuban population, for which the prevalence of diabetes is only 1.3-1.5 times higher.

INCIDENCE OF NIDDM IN HISPANICS

Only two studies have provided data on the incidence of NIDDM in Hispanics. In the San Antonio Heart Study, the incidence of NIDDM in Mexican Americans varied by neighborhood (Figure 32.4). The 8-year incidence of NIDDM was 8.7% among Mexican Americans in the low-income barrio neighborhoods, 8.4% among Mexican Americans in the transitional neighborhoods, and 3.4% in the suburban neighborhoods (Table 32.10). When compared with NIDDM incidence among non-Hispanic whites, this represents a 1.66 times higher odds of NIDDM among Mexican Americans in the transitional neighborhoods and a 2.27 times higher odds of NIDDM among Mexican Americans in the suburban neighborhoods.

The 6-year incidence of previously diagnosed NIDDM was estimated for Hispanics and non-Hispanic whites in San Luis Valley, CO[14]. During 1983-88, medical record reviews and public media campaigns were used to ascertain all cases of NIDDM that were medically diagnosed during this period in two counties in the San Luis Valley. The diagnosis of NIDDM was confirmed by inviting all known cases to receive a 2-hour OGTT and applying WHO plasma glucose diagnostic criteria. County census figures were used as estimates for the population at risk. The age-specific annual incidence rates for diagnosed diabetes are shown in Table 32.11. When adjusted for age, the incidence of

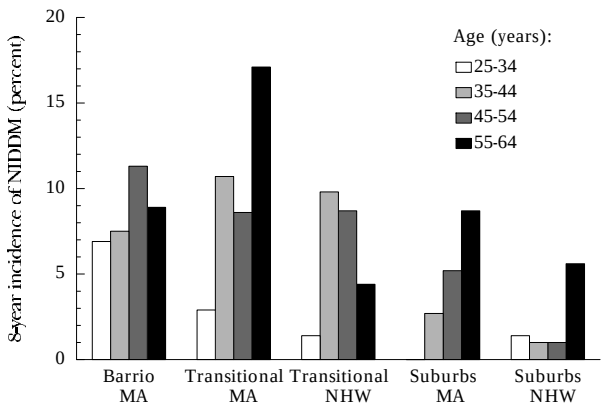
Table 32.9
NIDDM Prevalence Rate Ratios for Hispanics and Non-Hispanic Whites

Study	Age (years)	Age-adjusted ratio, Hispanic/non-Hispanic white			Source of Anglo comparison group
		Men	Women	Both	
Laredo, TX	45-75	2.6	2.7		NHANES I
San Luis Valley, CO	30-69	2.1	4.8		internal
San Antonio, TX	25-64	2.3	3.1		internal
HHANES					
Mexican American	20-44			2.4	NHANES II
	45-74			2.0	NHANES II
Cuban	20-44			1.5	NHANES II
	45-74			1.3	NHANES II
Puerto Rican	20-44			2.6	NHANES II
	45-74			2.2	NHANES II

NHANES, National Health and Nutrition Examination Survey; HHANES, Hispanic Health and Nutrition Examination Survey.

Sources: Laredo, Reference 3; San Luis Valley, Reference 6; San Antonio Heart Study; HHANES, Reference 8

Figure 32.4
Incidence of NIDDM in Mexican Americans and Non-Hispanic Whites by Neighborhood, San Antonio, TX, 1979-92



Diabetes diagnosed by World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour plasma glucose ≥200 mg/dl) or by current use of antidiabetic medications. MA, Mexican American; NHW, Non-Hispanic white.

Source: San Antonio Heart Study

reported NIDDM was 2.4 times higher in Hispanic men than in non-Hispanic white men (95% confidence interval (CI) 1.6-3.6), and the incidence in Hispanic women was 3.6 times higher (95% CI 2.4-5.4).

RISK FACTORS FOR NIDDM IN HISPANICS

Many variables associated with NIDDM in Caucasian populations are also associated with NIDDM in Hispanic populations. The results from some studies are summarized in the following sections.

Table 32.11
Incidence of Medically Diagnosed NIDDM, San Luis Valley, CO, 1983-88

	Hispanic		Non-Hispanic white	
Age (years)	Cases	Average annual rate (per 1,000)	Cases	Average annual rate (per 1,000)
Men				
20-29	1	0.2	0	
30-39	12	3.2	1	0.2
40-49	11	4.6	5	1.5
50-59	19	10.2	12	4.3
60-69	16	10.4	15	6.6
70-74	4	6.3	5	5.8
Total	63	4.3	38	1.8
Women				
20-29	3	0.6	3	0.5
30-39	10	2.8	3	0.5
40-49	14	5.8	3	0.9
50-59	31	15.2	9	2.8
60-69	19	10.0	14	5.3
70-74	4	4.6	1	1.0
Total	81	5.3	33	1.5

Source: Reference 14

OBESITY

Overall obesity, as reflected by body mass index, is one of the strongest known risk factors for NIDDM. Among participants of the San Antonio Heart Study who were nondiabetic at baseline, the 8-year risk of developing NIDDM was strongly associated with level of body mass index[15]. The age-, sex-, and ethnicity-adjusted odds ratio associated with a 5.0 kg/m^2 increase in body mass index was 2.01 (Table 32.12).

The prevalence of overall obesity is higher in Mexican Americans than in non-Hispanic whites[5,7]. However,

Table 32.10
Eight-Year Incidence of NIDDM in Mexican Americans and Non-Hispanic Whites, San Antonio, TX, 1979-92

	Barrio		Transitional				Suburbs			
Age	MA		MA		NHW		MA		NHW	
(years)	%	No.	%	No.	%	No.	%	No.	%	No.
25-34	6.9	72	2.9	102	1.4	72	0	62	1.4	70
35-44	7.5	67	10.7	84	9.8	51	2.7	111	1.0	96
45-54	11.3	71	8.6	58	8.7	69	5.2	96	1.0	101
55-64	8.9	56	17.1	41	4.4	92	8.7	23	5.6	90
Total	8.7	266	8.4	285	5.6	284	3.4	292	2.2	357
Age-adjusted odds ratio (MA/NHW)				1.66 (0.85-3.22)				2.27 (0.81-6.41)		

No non-Hispanic white subjects in the barrio neighborhoods were studied; MA, Mexican American; NHW, Non-Hispanic white; diabetes diagnosed by World Health Organization criteria (fasting plasma glucose ≥140 mg/dl or 2-hour glucose ≥200 mg/dl) or by current use of antidiabetic medications.

Source: San Antonio Heart Study

Table 32.12
Risk Factors for the Incidence of NIDDM, San Antonio, TX, 1979-92

Risk factor	Odds ratio	95% CI	p-value
Anthropometric variables			
Body mass index (kg/m^2) (5 kg/m^2 difference)	2.01	1.69-2.49	<0.001*
Subscapular/triceps ratio (1.0 unit difference)	1.89	1.22-2.93	0.004
Metabolic variables			
Fasting plasma glucose (10 mg/dl difference)	3.25	2.54-4.17	<0.001*
Two-hour plasma glucose (10 mg/dl difference)	1.43	1.32-1.54	<0.001*
Fasting serum insulin (5 µU/ml difference)	1.60	1.49-1.71	<0.001
Impaired glucose tolerance (present/absent)	8.88	5.39-14.6	<0.001
Triglycerides (50 mg/dl difference)	1.44	1.28-1.63	<0.001
HDL cholesterol (5 mg/dl difference)	0.72	0.65-0.80	<0.001*
Hemodynamic variables			
Systolic blood pressure (10 mmHg difference)	1.49	1.25-1.77	<0.001
Diastolic blood pressure (10 mmHg difference)	1.61	1.25-2.07	<0.001
Pulse pressure (10 mmHg difference)	1.35	1.08-1.69	0.008*
Heart rate (10 beats/min difference)	1.23	0.98-1.59	0.076
Hypertension (present/absent)	1.86	1.02-3.39	0.043
Hyperdynamic circulation (present/absent)	2.24	1.00-5.01	0.051

*Variable was statistically significant in multiple regression model that included all variables in the table. CI, confidence interval. Data are from an age-, gender-, and ethnicity-adjusted logistic regression analysis of the 8-year incidence of NIDDM. Pulse pressure is defined as difference between systolic and diastolic blood pressure. Hyperdynamic circulation is defined as all of the following criteria: heart rate ≥80 beats/min, pulse pressure >50 mmHg, and diastolic blood pressure <90 mmHg.

Source: Reference 15

the excess obesity in Mexican Americans only partially accounts for their higher prevalence of NIDDM compared with non-Hispanic whites. This is demonstrated by analyses of the San Antonio Heart Study which show that for each level of obesity the prevalence of NIDDM remains two to four times higher in Mexican Americans than in non-Hispanic whites[16] (Table 32.13, Figure 32.5). In the San Luis Valley Diabetes Study, the odds ratio between Mexican American ethnicity and prevalence of NIDDM decreased only slightly, from 3.5 to 3.0, in multivariate analyses that adjusted for two measures of obesity: the subscapular skinfold thickness and the waist-to-hip ratio[17].

Not only overall obesity, but also the distribution of obesity, is associated with NIDDM. Both upper body obesity, as measured by the ratio of waist-to-hip circumference, and central adiposity, as measured by the ratio of subscapular to triceps skinfolds, are positively associated with the prevalence of NIDDM in both the San Antonio Heart Study[18] and the San Luis Valley Diabetes Study[17]. In the latter study, both the waist-to-hip ratio and subscapular skinfold thickness were more strongly associated with NIDDM prevalence than were either body mass index or the subscapular-to-triceps skinfold ratio. In an analysis of prospective data from the San Antonio Heart Study, central adiposity was significantly associated with the incidence of NIDDM (Table 32.12), although in a multivariate analysis that included body mass index, fasting and 2-hour plasma glucose, HDL cholesterol level, and pulse pressure as additional independent variables, central adiposity was no longer statistically significant[15].

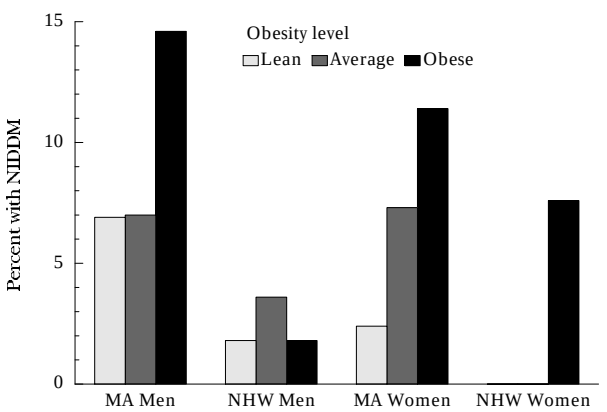
Table 32.13
Prevalence of NIDDM in Mexican Americans and Non-Hispanic Whites According to Obesity Level, San Antonio, TX, 1979-82

Obesity level	Men				Women			
	MA		NHW		MA		NHW	
	%	No.	%	No.	%	No.	%	No.
Lean	6.9	87	1.8	55	2.4	83	0	76
Average	7.0	128	3.6	55	7.3	124	0	77
Obese	14.5	166	1.8	56	11.4	334	7.6	79
All levels	10.2	381	2.4	166	9.1	541	2.6	232
Ratio, MA/NHW	4.02 (p=0.003)				2.41 (p=0.020)			

MA, Mexican American; NHW, non-Hispanic white.

Source: Reference 16

Figure 32.5
Prevalence of NIDDM in Mexican Americans and Non-Hispanic Whites by Level of Obesity, San Antonio, TX, 1979-82



MA, Mexican American; NHW, Non-Hispanic white.

Source: Reference 16

METABOLIC VARIABLES

There is considerable evidence that Mexican Americans, like other populations at high risk for diabetes (e.g., Pima Indians), show signs of peripheral resistance to the action of insulin. In population studies, insulin levels have often been used as a proxy for insulin resistance. In both San Antonio and San Luis Valley, mean serum insulin levels are higher in Mexican Americans than in non-Hispanic whites[19,20]. The San Luis Valley Study has also reported that Hispanics have higher levels of C-peptide than non-Hispanic whites[20] (Table 32.14).

In addition to obesity and hyperinsulinemia, a number of other metabolic variables have been associated with the incidence of NIDDM. For example, an analysis of risk factors for development of NIDDM in the San Antonio Heart Study was based on 844 Mexican Americans and 641 non-Hispanic whites who were nondiabetic at baseline[15]. In analyses adjusted for age, gender, and ethnicity, the following variables were associated with 8-year incidence of NIDDM: body mass index, subscapular-to-triceps ratio, fasting and 2-hour plasma glucose, fasting serum insulin, triglycerides, systolic and diastolic blood pressure, pulse pressure (defined as the difference between systolic and diastolic blood pressure), hypertension, and low levels of HDL cholesterol (Table 32.12). When these variables were entered in a single stepwise multiple logistic regression model, only fasting and 2-hour plasma glucose, body mass index, HDL cholesterol, and pulse pressure remained significantly associated with the incidence of NIDDM[15] (Table 32.12). The fact that fasting serum insulin level was not statistically significant when the other factors were included in the model implies that hyperinsulinemia and the other variables may be in the same causal pathway in the development of NIDDM.

Table 32.14
Mean Insulin and C-Peptide in Mexican Americans and Non-Hispanic Whites with Normal Glucose Tolerance, San Luis Valley, CO, 1984-88

	Serum insulin (nM)			Plasma C-peptide (nM)		
	NHW	MA	p	NHW	MA	p
Fasting	0.07	0.08	0.003	0.54	0.58	0.012
1-hour	0.47	0.52	0.013	2.46	2.72	<0.001
2-hour	0.27	0.36	<0.001	1.97	2.25	<0.001

1-hour and 2-hour values are after a 75-g glucose challenge; NHW, non-Hispanic white; MA, Mexican American.

Source: Reference 20

SOCIOCULTURAL AND BEHAVIORAL RISK FACTORS

A number of sociocultural factors have been associated with both the prevalence and incidence of NIDDM in Mexican Americans. A major challenge of ongoing research programs is to identify the mediating factors that account for these relationships.

In Mexican Americans in the San Antonio Heart Study, the incidence of NIDDM is significantly higher in subjects with a high school education or less than in subjects with greater than a high school education[21]. When age, sex, and body mass index are also included in a multiple logistic regression model, however, the relationship between educational status and NIDDM incidence becomes less clear. As shown in Table 32.15, the incidence of NIDDM is lower (but not significantly) in Mexican Americans with more than a high school education than in Mexican Americans with less than a high school education, but Mexican Americans with a high school education have a significantly higher incidence of NIDDM than Mexican Americans with less than a high school education (odds ratio = 1.82, p=0.05). Among Mexican Americans in the San Luis Valley Diabetes Study, higher prevalence of diagnosed NIDDM was associated with fewer years of education and smaller annual income[17]. In contrast to San Antonio and San Luis Valley, neither education level nor income was associated with the prevalence of NIDDM determined by medical history and OGTT among Mexican Americans examined in the HHANES survey[10].

The hypothesis that increasing levels of acculturation to mainstream U.S. society correlate with reduced prevalence of diabetes was examined in Mexican Americans in the San Antonio Heart Study. Three dimensions of adult acculturation were measured: functional integration with mainstream society, value

Table 32.15
Risk Factors for the Incidence of NIDDM in Mexican Americans, San Antonio, TX, 1979-92

Variable	Odds ratio	95% CI
Age (10-year difference)	1.47	1.16-1.86
Sex (male/female)	0.91	0.56-1.48
Body mass index	1.16	1.12-1.21
Education level		
Less than high school	1.00	reference
High school	1.82	1.00-3.30
More than high school	0.76	0.39-1.49

CI, confidence interval. Data are from a multiple logistic regression analysis of 8-year incidence of NIDDM.

Source: San Antonio Heart Study

placed on preserving Mexican cultural origin, and attitude towards traditional family structure and sex-role organization. In both men and women, higher levels of acculturation were significantly associated with a lower prevalence of diabetes[22]. This association was independent of the effects of socioeconomic status in women (Table 32.16). In men, however, the association between acculturation and prevalence of NIDDM became weaker and no longer achieved statistical significance when socioeconomic status was included in the model. In the HHANES Mexican American population, there was no significant association between diabetes prevalence and acculturation as measured either by three measures of language preference or by an eight-factor acculturation scale that incorporated language preference, birthplace, and ethnic identification of the subject and his/her parents[10].

The relation between physical activity and diabetes has been examined in several Hispanic populations. In the HHANES survey, the prevalence of diabetes in Mexican Americans declined with increasing occupational physical activity after controlling for age and obesity[10]. However, no significant association was apparent in either the Cuban or Puerto Rican groups.

The relation between diet and NIDDM in Mexican Americans has been examined in the San Luis Valley Diabetes Study. The amount of dietary fat and carbohydrate intake, as determined by 24-hour recall, was compared among 70 subjects with newly diagnosed NIDDM, 171 subjects with impaired glucose tolerance, and 1,076 subjects with normal glucose tolerance[23]. Subjects with newly diagnosed NIDDM and impaired glucose tolerance had higher fat consumption and lower carbohydrate consumption than subjects with normal glucose tolerance, with the differences between impaired and normal glucose tolerance groups achieving statistical significance at the .05 level (Table 32.17). After taking physical activity levels into account, subjects with newly diagnosed NIDDM were 2.66 times more likely to report a 40 g per day or higher fat intake than subjects with normal glucose tolerance, and subjects with impaired glucose tolerance were 2.17 times more likely to report a 40 g per day or higher fat intake[23]. The association of dietary fiber intake with NIDDM was also investigated among Hispanic and Anglo participants of the San Luis Valley Diabetes Study[24]. Dietary fiber intake was higher among persons with known NIDDM than among nondiabetic subjects. This result may have been due to changes in the diet that occurred after onset of NIDDM, however, since there was little difference in fiber intake between subjects with newly diagnosed NIDDM and normal controls.

Table 32.16
Relation of Acculturation and Socioeconomic Status to Prevalence of NIDDM, San Antonio, TX, 1979-82

	Odds ratio	95% CI	Estimated prevalence (%) of NIDDM according to sociocultural stratum	
			Lowest stratum	Highest stratum
Men				
Univariate analyses				
Socioeconomic status adjusted for age	0.94	0.73-1.21	16.5	14.1
Functional integration adjusted for age	0.75	0.59-0.96	22.7	11.1*
Multivariate analyses				
Socioeconomic status adjusted for functional integration	not significant			
Functional integration adjusted for socioeconomic status	not significant			
Women				
Univariate analyses				
Socioeconomic status adjusted for age	0.64	0.48-0.85	13.2	3.8*
Functional integration adjusted for age	0.63	0.48-0.82	15.2	4.4**
Multivariate analyses				
Socioeconomic status adjusted for functional integration	0.76	0.55-1.02	10.5	4.8
Functional integration adjusted for socioeconomic status	0.73	0.54-0.99	11.9	5.0*

*p<0.05; **p<0.001. Functional integration defined as functional integration with mainstream society; prevalences are age-adjusted. CI, confidence interval.

Source: Reference 22

Table 32.17
Dietary Intake According to Glucose Tolerance Status, San Luis Valley, CO, 1984-88

	Newly diagnosed NIDDM (n=70)	Impaired glucose tolerance (n=171)	Normal glucose tolerance (n=1,076)
No. kilocalories/day	1,943.3±100.7	1,798.4±64.3	1,877.9±25.9
Fat			
g/day	83.7±2.3	84.2±1.5*	80.9±0.6
% of calories	39.2±1.1	39.8±0.7*	38.1±0.3
Carbohydrate			
g/day	189.5±6.1	187.3±3.9*	197.3±1.6
% of calories	45.1±1.3	44.3±0.9*	46.6±0.3
Protein			
g/day	73.8±2.5	73.2±1.6	70.5±0.7
% of calories	15.7±0.6	16.1±0.4	15.5±0.2

*p<0.05 compared with normal glucose tolerance. Mean dietary intake is adjusted for age, sex, ethnicity, and kilocalories.

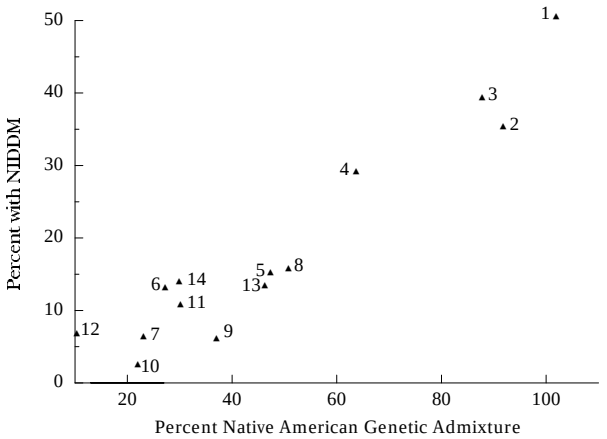
Source: Reference 23

GENETIC FACTORS

In Mexican Americans as in other populations, there is a strong degree of familial aggregation of diabetes. In San Antonio, the prevalence of NIDDM was determined in 375 relatives of NIDDM probands[25]. Among first-, second-, and third-degree relatives of the diabetic probands, the prevalence of NIDDM diagnosed by WHO criteria was 28.2%, 13.3%, and 11.1%, respectively. These rates were 2.0-fold, 1.3-fold, and 1.1-fold higher than the corresponding rates for Mexican Americans reporting no parental history of diabetes. Interestingly, diabetes prevalence was twice as high in the first-degree relatives of early onset probands (age at onset <40 years) compared with first-degree relatives of late onset probands (age at onset ≥40 years) (47% versus 24%, p<0.001).

It has been hypothesized that Amerindian populations are enriched with diabetogenic genes and that the high prevalence of NIDDM observed in Mexican Americans may be related to their Amerindian ancestry. There is a reasonably strong ecologic correlation between the degree of Amerindian admixture in a population and the prevalence of NIDDM for that population[26] (Figure 32.6). Among Mexican Americans in San Antonio, the degree of Amerindian admixture as estimated from skin reflectance was 46%, 27%, and 18% for Mexican Americans residing in the barrio, transitional, and suburban neighborhoods, respectively[27]. The decline in admixture across these neighborhoods corresponds closely with the decline in NIDDM prevalence.

Figure 32.6
Relationship of Native American Genetic Admixture to NIDDM Prevalence



The populations are 1) Pima Indians in Arizona; 2) Seminole Indians in Florida; 3) Seminole Indians in Oklahoma; 4) Cherokee Indians in North Carolina; 5) barrio Mexican-American men; 6) transitional Mexican-American men; 7) suburban Mexican-American men; 8) barrio Mexican-American women; 9) transitional Mexican-American women; 10) suburban Mexican-American women (groups 5-10 are from the San Antonio Heart Study); 11) Mexican Americans in Starr County, TX; 12) non-Hispanic whites from the San Antonio Heart Study; 13) Hispanics in Colorado; 14) Puerto Ricans in Puerto Rico.

Source: Reference 26

Amerindian admixture was estimated from a panel of 17 polymorphic red blood cell and serum protein markers in subjects with normal glucose tolerance, in subjects with impaired glucose tolerance, and in subjects with NIDDM in San Antonio[28]. Consistent with the skin reflectance analyses[27], Amerindian admixture was highest in the barrio, intermediate in the transitional neighborhoods, and lowest in the suburbs (Table 32.18). In all neighborhoods combined, mean

Table 32.18
Proportion of Amerindian Genes in Mexican Americans, San Antonio, TX, 1979-85

Diabetes status	Barrio	Transitional	Suburb	Total
Males				
NIDDM	43.5±4.5	28.5±4.8	17.8±6.6	31.5±2.6
IGT	41.9±2.4	32.1±2.1	20.1±1.5	30.2±1.4
Normal GT	40.9±2.0	20.7±1.3	22.3±1.6	28.7±1.3
Total	41.7±1.5	25.2±1.4	20.3±1.3	29.3±1.0
Females				
NIDDM	44.5±3.4	28.4±5.8	36.6±6.9	41.1±4.6
IGT	39.8±2.0	32.0±1.2	16.2±1.7	31.1±1.2
Normal GT	48.2±2.0	35.8±1.3	17.3±1.6	35.0±1.3
Total	45.1±1.4	33.0±1.2	17.2±1.3	34.0±1.0

IGT, impaired glucose tolerance; Amerindian proportion was detected by 17 polymorphic blood group and protein enzyme loci.

Source: Reference 28

Amerindian admixture was higher in diabetic persons than in nondiabetic persons, although the results were not consistent across all neighborhoods. Overall, men with impaired glucose tolerance had a mean Amerindian admixture that was intermediate between that of men with NIDDM and men with normal glucose tolerance, but this was not true for women.

While admixture analyses provide support for the hypothesis that Amerindian genes influence susceptibility to NIDDM, this analytic approach suffers from the limitation that the observed associations are ecological in nature. In San Antonio, for example, the most admixed neighborhoods (the barrio) differ substantially from the least admixed neighborhoods (the suburbs) in a variety of socioeconomic and sociocultural variables. It is thus difficult to determine whether the observed differences in NIDDM are attributable to admixture or to other confounding variables.

In the San Antonio Heart Study, an association has been reported between NIDDM and the distribution of phenotypes for both the Rhesus blood group and haptoglobin[29]. The former association is interesting in view of the fact that sib-pair analyses from the San Antonio Family Diabetes Study have revealed evidence for possible linkage between 2-hour insulin levels and the Rh blood group locus[30]. In the San Luis Valley Diabetes Study, however, there was no evidence for a population level association between Rh blood group and NIDDM[31].

Associations have also been reported between NIDDM and polymorphisms at loci which are of special interest because of their involvement in glucose and carbohydrate metabolism. One such association was observed among Mexican Americans from the San Antonio Heart Study, where the frequency of a 3.4 kb DNA restriction fragment length polymorphism (RFLP) of the insulin receptor gene was present in 42.8% of diabetic persons, but in only 17.7% of nondiabetic subjects[32]. Population level associations such as this should be interpreted cautiously, however. The frequency of this 3.4 kb allele is reported to be 34% in Pima Indians[33] and the allele is totally absent in non-Hispanic whites[32,33]. These population differences raise the possibility that the association between this allele and NIDDM in the San Antonio Study may simply reflect a greater degree of Amerindian admixture among diabetic Mexican Americans relative to nondiabetic Mexican Americans.

In the Starr County population, polymorphic length variation in the signal peptide of the apolipoprotein B (apoB) gene was described, and individuals who were homozygous for one of the alleles had elevated plasma glucose levels relative to other individuals[34]. However, there was no association between this allele and plasma glucose levels in a sample of French whites. In the San Luis Valley Diabetes Study, an association was reported between the mean level of fasting glucose and polymorphisms of GC, the vitamin D binding protein of human plasma[35].

It seems reasonable to expect that genes associated with diabetes susceptibility will influence traits that precede the onset of clinical NIDDM. Among nondiabetic participants in the San Antonio Heart Study, fasting serum insulin concentration was significantly higher in nondiabetic subjects reporting that both parents had diabetes (87.6 pmol/L) than in subjects reporting that neither parent had diabetes (71.7 pmol/L)[36]. In the San Antonio Family Diabetes Study, nondiabetic first-degree relatives of diabetic probands had significantly higher body mass indexes than nondiabetic second-degree family members (29.7 versus 27.5 kg/m^2), implying that the diabetes genes also influence the accumulation of body fat long before the development of diabetes[37].

Evidence that a major gene influences 2-hour postchallenge insulin levels has been observed among 641 pedigreed members of 45 randomly ascertained Mexican-American families in San Antonio[38]. Using complex segregation analysis, an autosomal dominant major gene best described the inheritance of 2-hour insulin levels in these families. Eighty-four percent of the population was heterozygous or homozygous for the high insulin allele, and the major gene accounted for ~30% of the variation in 2-hour insulin levels.

IDDM IN HISPANICS

There are considerably fewer data concerning the epidemiology of IDDM in Hispanic Americans than there are for NIDDM. One of the first incidence studies of IDDM that included Hispanics was conducted in San Diego, CA in 1978-81[39]. Although the number of cases in the non-Anglo ethnic groups was small, this study suggested that Mexican-American children had a lower incidence of IDDM than non-Hispanic white children.

A major source of data on IDDM in Hispanics is the Colorado IDDM Registry, which was developed to identify all newly diagnosed cases of IDDM in Colorado. During 1978-83, the incidence of IDDM statewide among children age 0-17 years was estimated to be 15.2 per 100,000 per year, a rate similar to other populations in the United States[40]. Ethnic compari-

sons of these data revealed a 50%-70% lower incidence in Hispanics compared with non-Hispanic whites[41,42]. During 1978-88, IDDM incidence in each age group in Hispanics was lower than in the non-Spanish origin population, although for the age group 10-17 years, the 95% confidence intervals overlapped particularly for females (Table 32.19). While Hispanics of both sexes had a lower incidence of IDDM than non-Hispanic whites, the differential was larger for males than for females (Figure 32.7). After adjusting for age, non-Hispanic males had a 2.3-fold greater incidence of IDDM, while non-Hispanic females had a 1.4-fold excess of IDDM. Among non-Hispanics, IDDM incidence was slightly higher in males than in females, whereas Hispanic females had a higher incidence than Hispanic males (10.5 per 100,000 per year in Hispanic females versus 7.1 per 100,000 per year in Hispanic males)[42].

Comparisons made from the Colorado IDDM registry do not provide any evidence that the clinical characteristics of IDDM cases differ between Hispanic and non-Hispanic white children. For example, in neither boys nor girls were there marked differences in insulin dose, level of HbA_1, distribution of HLA-DR antigens, or level of islet cell antibodies. Compared with non-Hispanic white girls with IDDM, however, Hispanic girls with IDDM had higher body mass index, subscapular skinfold thickness, waist-to-hip ratio, and C-peptide level. Hispanic ethnicity, however, accounted for just 3% of the overall variability in C-peptide levels after controlling for diabetes duration, age, sex, and fatness[43]. In several other populations, differences in HLA-DR antigens and haplotype frequencies have been reported between Hispanics and non-Hispanic whites, with the IDDM-associated HLA antigens observed more frequently among non-Hispanic whites[44-46].

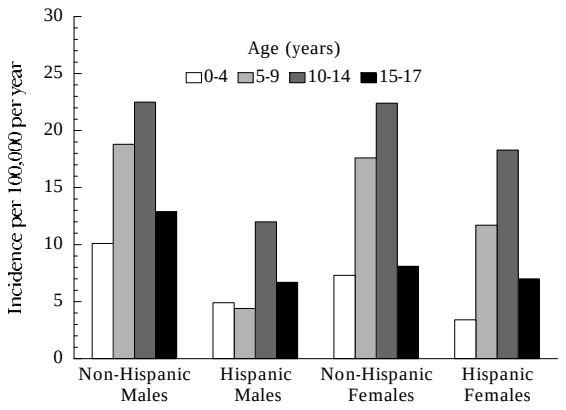
Table 32.19
IDDM Incidence in Colorado According to Ethnic Group, 1978-88

	Non-Hispanics			Hispanics		
Age (years)	No. of cases	Rate	95% CI	No. of cases	Rate	95% CI
Males						
0-4	120	10.1	8.4-12.1	12	4.9	2.5-8.6
5-9	199	18.8	6.3-21.6	10	4.4	2.1-8.1
10-14	241	22.5	19.8-25.5	25	12.0	7.8-17.8
15-17	94	12.9	10.4-16.0	9	6.7	3.1-12.7
Total	654	16.2	14.9-17.5	56	6.9	5.2-9.0
Age-adjusted		16.4	15.1-17.7		7.1	5.4-9.3
Females						
0-4	82	7.3	5.8-9.1	8	3.4	1.5-6.7
5-9	178	17.6	15.2-20.4	25	11.7	7.6-17.3
10-14	228	22.4	19.8-25.4	37	18.3	12.8-25.4
15-17	56	8.1	6.2-10.5	9	7.0	3.2-13.3
Total	544	14.1	13.0-15.4	79	10.1	8.0-12.6
Age-adjusted		14.5	13.0-15.7		10.5	8.4-13.1

Rate is per 100,000 population in the age group per year; CI, confidence interval.

Source: Reference 42

Figure 32.7
Incidence of IDDM in Colorado by Ethnic Group, 1978-88



Source: Reference 42

MORTALITY

Most mortality data on Hispanic Americans pertains specifically to Mexican Americans and, to a lesser extent, Puerto Ricans. Moreover, since these data are derived principally from vital statistics, they relate to mortality in the overall population rather than to mortality in diabetic subjects, per se. To obtain the latter, cohort data, which are much more limited, are necessary.

ALL-CAUSE MORTALITY IN THE TOTAL POPULATION

Despite their high rate of NIDDM, all-cause mortality in Mexican-American adults is not excessive relative to non-Hispanic whites. Table 32.20 compares age-specific and age-adjusted mortality derived from 1979-81 vital statistics for Texas for Mexican Americans and non-Hispanic whites age ≥35 years[47]. It is apparent that there is little if any excess mortality in Mexican Americans. (At age <45 years, all-cause mortality is higher in Mexican American men, but this excess is principally due to trauma, homicides, etc.) It has also been reported that life expectancy at attained ages of 0, 15, 40, and 65 years among Spanish-sur-

Table 32.20
All-Cause Mortality Rate for Mexican Americans and Non-Hispanic Whites, Texas, 1979-81

Age (years)	Mexican Americans	Non-Hispanic whites	Ratio, MA/NHW
Men			
35-44	340	269	1.26
45-54	720	712	1.01
55-64	1,545	1,733	0.89
65-74	3,717	3,969	0.94
≥75	9,397	10,514	0.89
Age-adjusted	2,013	2,170	0.93
Women			
35-44	134	145	0.92
45-54	340	374	0.91
55-64	885	833	1.06
65-74	2,145	1,880	1.14
≥75	7,335	7,386	0.99
Age-adjusted	1,294	1,260	1.03

Mortality is expressed as the average annual number of deaths per 100,000 persons in the age group per year. MA, Mexican American; NHW, Non-Hispanic white.

Source: Reference 47

named individuals in California is virtually identical to life expectancy among non-Hispanic whites[48]. These results are in marked contrast to African Americans, whose life expectancies at these same ages are substantially less than among non-Hispanic whites. All-cause mortality has also been examined for the "Spanish-origin" population of Suffolk County, NY, which is predominantly Puerto Rican[49]. Compared with the "all whites" population of the county, the standardized mortality ratio for all-cause mortality in Puerto Ricans is significantly less than 1.0 (Table 32.21). Finally, based on the U.S. National Death Index, standardized mortality ratios are consistently below 1.0 for the three major Hispanic subgroups, Mexican American, Cuban American, and Puerto Rican[50].

MORTALITY IN DIABETIC SUBJECTS

Table 32.22 presents age-adjusted mortality with diabetes listed as the underlying cause of death derived from vital statistics data from New Mexico for the years 1958-87[51]. There are rising trends in diabetes mortality in both sexes and in all three ethnic groups, especially in Hispanics and Native Americans, whose rates, at least after 1967, far exceed those observed in non-Hispanic whites. Limitations of these data include the fact that only 55% of the death certificates that mention diabetes listed it as the underlying cause of death. Also, growing physician awareness of diabetes as an important public health problem in Hispanics and Native Americans could have contributed to

Table 32.21
Standardized Mortality Ratios for Deaths in Hispanics, Suffolk County, NY, 1979-83

Underlying cause of death (ICD codes)	Sex	Observed no.	Expected no.	SMR
All causes	Male	513	642.2	0.80
	Female	392	523.9	0.75
Infectious diseases	Male	13	5.3	2.43
(001-139)	Female	5	4.5	1.12
All neoplasms (140-239)	Male	105	152.5	0.69
	Female	91	145.8	0.62
Diabetes mellitus (250)	Male	8	10.2	0.79
	Female	19	11.0	1.73
Ischemic heart disease	Male	130	197.2	0.66
(410-414)	Female	196	150.6	0.70
Pulmonary circulation	Male	26	28.7	0.90
(415-429)	Female	25	25.9	0.97
Cerebrovascular diseases	Male	27	31.3	0.86
(430-438)	Female	31	43.5	0.71
Respiratory system	Male	26	31.3	0.83
(460-519)	Female	15	22.1	0.68
Chronic liver disease (571)	Male	12	14.1	0.85
	Female	7	9.8	0.71
Accidents (E800-929)	Male	54	61.7	0.88
	Female	27	23.2	1.16
Suicide (E950-959)	Male	11	15.6	0.71
	Female	3	6.0	0.50
Homicide (E960-969)	Male	15	6.0	2.48
	Female	3	2.8	1.08

Expected number of deaths is computed on the basis of age- and sex-specific death rates for "all whites" in Suffolk County; SMR, standardized mortality ratio, is the ratio of observed to expected number of deaths.

Source: Reference 49

increasing mentions of diabetes as a cause of death on death certificates.

Cohort data are presented in Table 32.23, which shows 8-year crude and age-adjusted all-cause mortality rates from the San Antonio Heart Study. Mortality among diabetic persons was increased in both ethnic groups. The relative risks associated with diabetes were nearly identical in non-Hispanics whites and Mexican Americans (2.64 and 2.67, respectively). The age-adjusted all-cause mortality rates for diabetic and nondiabetic persons combined was slightly, but not significantly, higher in Mexican Americans than in non-Hispanic whites (1.8% versus 1.4%).

Additional cohort data have been reported from Starr County, TX[52]. A population-based cohort consisting of 353 Mexican Americans with NIDDM was followed for a mean duration of 8 years, during which 67 deaths were recorded. Table 32.24 shows the distribution of causes of death in 55 of the individuals for whom death certificates were obtained. Of note is the fact that, among these known diabetic persons, diabetes was mentioned on the death certificate in only

Table 32.22
Mortality from Diabetes Listed as the Underlying Cause, U.S. and New Mexico, 1958-87

	1958-62	1963-67	1968-72	1973-77	1978-82	1983-87
Men						
U.S. whites	15.3	15.8	17.1	14.6	13.0	12.5
New Mexico						
Non-Hispanic whites	12.0	13.3	13.4	12.2	18.0	16.2
	(118)	(157)	(156)	(166)	(293)	(295)
Hispanic whites	10.5	16.0	23.0	21.8	27.9	25.3*
	(55)	(92)	(136)	(143)	(203)	(205)
American Indians	11.6	10.5	26.2	24.9	22.4	40.5*
	(10)	(10)	(28)	(30)	(29)	(57)
Women						
U.S. whites	18.5	17.6	17.8	14.4	12.3	11.6*
New Mexico						
Non-Hispanic whites	13.5	9.6	12.0	12.3	15.0	15.7
	(154)	(145)	(184)	(216)	(329)	(388)
Hispanic whites	15.7	19.8	27.3	24.5	28.6	33.3*
	(84)	(120)	(167)	(170)	(234)	(305)
American Indians	6.6	7.7	26.0	18.0	32.2	42.9*
	(5)	(7)	(26)	(20)	(46)	(65)

*p<0.05 using linear regression to assess temporal trends. Values are age-adjusted rates per 100,000 with number of deaths in parentheses.

Source: Reference 51

25.5% of cases, and in no case was it listed as the underlying cause of death. Heart disease was overwhelmingly the most common cause of death, accounting for 60.0%-72.7% of all deaths, and cerebrovascular disease accounted for another 12.7%-23.6% of deaths. This is in marked contrast to San Antonio, where heart disease and cerebrovascular disease combined accounted for only 37.1% (13/35) of deaths among diabetic persons. One probable factor contributing to this discrepancy is that the mean age at baseline of diabetic decedents in Starr County was 64 years, whereas in San Antonio it was only 54 years. It is also noteworthy that baseline glucose and glycated hemoglobin levels were virtually identical in the Starr County diabetic persons who died and those who survived (10.6 mM versus 10.6 mM for glucose and 10.7% versus 10.8% for glycated hemoglobin). Disease duration was longer in those who died (9.6 versus 5.9 years), but this difference disappeared after adjusting for the presence of diabetic retinopathy.

Table 32.23
Eight-Year Mortality in Mexican Americans and Non-Hispanic Whites, San Antonio, TX, 1979-90

	Mexican Americans		Non-Hispanic whites	
	Diabetic	Nondiabetic	Diabetic	Nondiabetic
Number of subjects	249	1,713	75	1,054
Mean age (years)	52.3	41.3	55.2	44.9
Crude mortality (%)	12.9	1.8	8.0	3.1
Age-adjusted mortality (%)	4.0	1.5	3.7	1.4
Mortality ratio, DM/nonDM	2.67		2.64	

Mortality rates are adjusted to the mean age of the overall population (43.8 years) by multiple logistic regression analysis.

Source: San Antonio Heart Study

MACROVASCULAR COMPLICATIONS

MYOCARDIAL INFARCTION

The prevalence of myocardial infarction (MI) has been reported for Mexican Americans and non-Hispanic whites who participated in the San Antonio Heart Study[53]. In both sexes and both ethnic groups, diabetes was associated with an increased prevalence of MI ascertained either by Minnesota-coded EKGs or by self-report of a physician-diagnosed MI (Table 32.25). Mexican-American men, whether diabetic or not, had a lower prevalence of MI, although this ethnic difference was not statistically significant. A similar ethnic difference was not seen in women. Thus, the sex-ethnic pattern of MI prevalence parallels the pattern for cardiovascular mortality[53]. Similar results were reported from the San Luis Valley Diabetes Study in southern Colorado in that Hispanics tended to have a lower prevalence of MI than non-Hispanic whites[54] (Table 32.26). A difference between these results and the San Antonio results was that the deficit in Hispanics was present in both men and women with diabetes and in men with impaired glucose tolerance.

Table 32.24
Percent Distribution of Deaths Based on Death Certificates, U.S. (1988) and Starr County, TX (1981-92)

Cause of death (ICD 9-CM codes)	U.S. population	Deaths in Starr County individuals with NIDDM*			
	Underlying cause, percent of total deaths	Underlying cause of death		Underlying or contributing cause	
		No.	% of total	No.	% of total
Heart disease (390-398, 402, 404-429)	35.3	33 (36)	60.0 (53.7)	40	72.7
Malignant neoplasms (140-208)	22.4	3 (4)	5.5 (6.0)	4	7.3
Cerebrovascular disease (430-438)	6.9	7 (7)	12.7 (10.4)	13	23.6
Accidents (E800-E949)	4.5	0 (4)	0 (6.0)	0	0
COPD (490-496)	3.8	0 (0)	0 (0)	1	1.8
Pneumonia and influenza (480-487)	3.6	0 (0)	0 (0)	0	0
Diabetes mellitus (250)	1.9	0 (2)	0 (3.0)	14	25.5
Suicide (E950-E959)	1.4	1 (1)	1.8 (1.5)	1	1.8
Liver disease (571)	1.2	0 (0)	0 (0)	2	3.6
Nephritis (580-589)	1.0	1 (2)	1.8 (3.0)	6	10.9
All other	18.0	10 (15)	18.2 (22.4)	30	54.5

COPD, chronic obstructive pulmonary disease; numbers in parentheses include both death certificates results and interview results.

Source: Reference 52

PERIPHERAL VASCULAR DISEASE

Mexican Americans with NIDDM appear to have an increased prevalence of peripheral vascular disease, although this condition represents both a micro- and a macrovascular complication. In the San Antonio study, ankle-arm blood pressure ratios were measured by Doppler ultrasound using the brachial artery and either the posterior tibial or dorsalis pedis artery on each leg[55]. Peripheral vascular disease was considered to be present if any of the four ratios was <0.95. For subjects with NIDDM, the odds of peripheral vascular disease for Mexican Americans compared with non-Hispanic whites was 1.84, although this excess was not statistically significant (Table 32.27).

MICROVASCULAR COMPLICATIONS

HYPERGLYCEMIA

In the San Antonio Heart Study, diabetic Mexican Americans had higher levels of glycemia, a major risk factor for microvascular complications, than diabetic non-Hispanic whites[56]. This led to the hypothesis that the former group would also have higher rates of microvascular complications, since these complications are generally considered to be glycemia dependent. It is not known whether the ethnic difference in glycemia observed in San Antonio has a genetic or an environmental or lifestyle basis. The latter could include access to and quality of health care. A point against the health care explanation is the fact that in San Antonio, among diabetic persons newly discovered at the time of their survey visit, Mexican Ameri-

Table 32.25
Age-Adjusted Percent with Myocardial Infarction, San Antonio, TX, 1979-88

	Diabetic		Nondiabetic		Diabetes adjusted ethnic odds ratio		
	MA	NHW	MA	NHW	MA/HNW	95% CI	p
Men							
ECG	13.5	19.8	3.2	4.6	0.65	0.37-1.15	0.14
Self-reported	12.6	13.3	3.1	4.0	0.79	0.51-1.22	0.29
Either	21.6	29.9	5.6	8.2	0.65	0.41-1.03	0.06
Both	4.8	2.6	0.5	1.8	0.58	0.21-1.59	0.29
Women							
ECG	6.3	4.5	1.8	1.1	1.49	0.65-3.33	0.34
Self-reported	4.2	7.2	1.1	1.2	0.99	0.52-1.89	0.96
Either	10.7	11.7	3.1	2.5	1.24	0.68-2.26	0.49
Both	0.0	0.0	0.2	0.1		Too few events	

MA, Mexican American; NHW, non-Hispanic white; CI, confidence interval; ECG, electrocardiogram.

Source: Reference 53

Table 32.26
Prevalence of Coronary Heart Disease Endpoints, Age 25-74 Years, San Luis Valley, CO, 1984-88

CHD endpoint	Men						Women					
	Normal		IGT		NIDDM		Normal		IGT		NIDDM	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Heart attack												
Hispanic	16	6.7	5	8.8	8	5.6†	1	0.4	2	2.5	8	2.8*
NHW	17	4.8	6	11.6*	14	12.3**	8	2.0	1	1.4	5	4.4
Angina												
Hispanic	17	8.0	1	2.6	7	6.1	16	7.3†	4	6.8	25	13.0
NHW	17	5.4	3	7.7	5	5.7	14	4.0	3	5.8	6	8.2
Ischemic ECG												
Hispanic	27	12.5	6	13.3	17	14.2	32	14.9	13	20.9	40	18.5
NHW	31	9.7	8	19.0*	16	16.7*	53	15.5	10	18.3	21	25.5**
Asymptomatic ischemic ECG												
Hispanic	11	5.2	1	2.4	14	12.2**	22	10.3	10	16.7	28	13.6
NHW	14	4.5	3	7.4	7	7.7	40	11.8	8	15.3	14	17.8
Probable MI												
Hispanic	6	2.6	2	4.5	2	1.7	2	0.8	0	0.0	5	1.8
NHW	9	2.7	2	4.9	6	5.5	7	1.9	0	0.0	4	3.7
Possible MI												
Hispanic	34	16.3	7	18.0	13	11.3††	19	8.7	7	11.6	25	12.4
NHW	40	12.8	7	18.1	23	26.5**	24	7.0	5	9.5	11	14.2
Overall CHD												
Hispanic	61	29.7	11	29.1	33	29.7	70	32.6	21	36.4	84	44.5**
NHW	70	23.1	14	37.7*	31	36.9**	83	24.6	20	40.1**	36	50.6**

*p<0.1, **p<0.05 for comparison with the normal glucose tolerance group. †p<0.1, ††p<0.05 for the comparison with non-Hispanic whites. Data are age-adjusted prevalences. IGT, impaired glucose tolerance; NHW, non-Hispanic white; CHD, coronary heart disease; ECG, electrocardiogram; MI, myocardial infarction. Heart attack, subject has been told by a physician that he/she had had a heart attack; angina pectoris, Rose questionnaire; ischemic ECG, Whitehall criteria, Minnesota codes 1.1-1.3 or 7.1 or 4.1-4.3 or 5.1-5.3; asymptomatic ischemic ECG, ischemic ECG without history of heart attack, angina, MI pain, or exertional chest pain; probable MI, Minnesota codes 1.1-1.2 or 7.1; possible MI, history of heart attack or pain of MI or Minnesota codes 1.1-1.2; overall CHD, any of the above or nitrate use or exertional chest pain.

Source: Reference 54

cans were still more hyperglycemic than non-Hispanic whites, i.e., even before differential health care could have had an impact. Plasma glucose values for HHANES, the San Luis Valley Study, and the San Antonio Study are shown in Appendix 32.1.

Table 32.27
Ethnic Differences in Peripheral Vascular Disease in NIDDM, San Antonio, TX, 1984-88

	Mexican Americans		Non-Hispanic whites		Odds ratio	95% CI
	No.	%	No.	%		
Male	140	16.9	38	10.0	1.83	0.51-6.61
Female	225	14.7	42	8.6	1.84	0.53-6.41
Ethnic odds ratio					1.84	0.75-4.49
Sex effect		NS		NS		

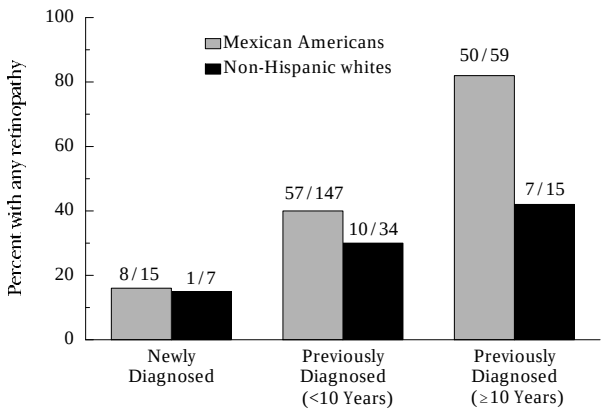
CI, confidence interval; odds ratio is the Mexican American/non-Hispanic white Mantel-Haenszel odds ratio.

Source: Reference 55

RETINOPATHY

In the San Antonio Heart Study, seven-field stereoscopic fundus photographs were taken of each eye by certified photographers, and these were graded by the University of Wisconsin Fundus Photographic Reading Center. As predicted by their greater degree of hyperglycemia, diabetic Mexican Americans had a higher prevalence of retinopathy than diabetic non-Hispanic whites[57]. Figure 32.8 shows the prevalence of any grade of retinopathy (background, preproliferative, and proliferative) and Figure 32.9 shows the prevalence of severe retinopathy (preproliferative and proliferative) according to ethnic group and diabetes duration. The prevalence of retinopathy increases with increasing duration in both ethnic groups, but for any given duration Mexican Americans with diabetes have a higher prevalence than non-Hispanic whites with diabetes. Mexican Americans with diabetes diagnosed prior to the survey (previously diagnosed) also had a two- to threefold higher prevalence of diabetic retinopathy than previously diagnosed non-Hispanic whites with diabetes in the Wisconsin

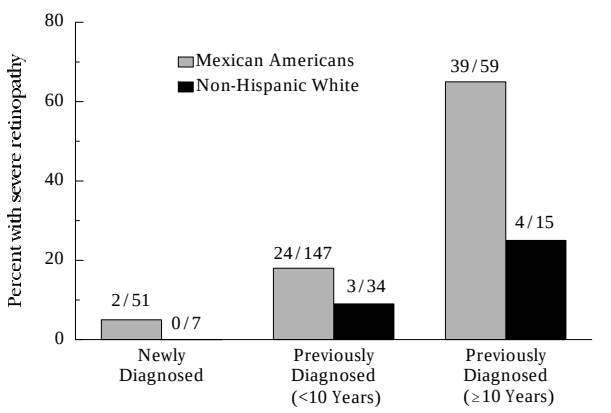
Figure 32.8
Prevalence of Any Retinopathy by Duration of NIDDM and Ethnic Group, San Antonio, TX



Source: Reference 57

Epidemiologic Study of Diabetic Retinopathy (WESDR)[57]. Multivariate analysis showed that, in addition to duration of diabetes, level of glycemia was a risk factor for diabetic retinopathy, although age and systolic blood pressure were not (Table 32.28). Even after controlling for these risk factors, however, retinopathy was significantly more common in diabetic Mexican Americans than in diabetic non-Hispanics by a factor of two to three. Among previously diagnosed diabetic persons who were on hypoglycemic treatment, insulin use was also a risk factor for retinopathy, probably because its use implied greater disease severity. Contrary to expectation, lower socioeconomic status was not a risk factor for retinopathy among Mexican Americans with diabetes[58]. The impact on

Figure 32.9
Prevalence of Severe Retinopathy by Duration of NIDDM and Ethnic Group, San Antonio, TX



Source: Reference 57

Table 32.28
Risk Factors for Retinopathy in Previously Diagnosed NIDDM, San Antonio, TX, 1984-88

	Any retinopathy		Severe retinopathy	
Risk factor	OR	95% CI	OR	95% CI
Ethnic group				
(MA vs. NHW)	1.65	0.91-2.99	2.91*	1.30-6.51
Duration of diabetes				
<10 years	1.00		1.00	
>10 years	3.31†	1.71-6.44	5.51†	1.36-11.4
Glucose sum				
Low	1.00		1.00	
Medium	2.08	0.95-4.59	1.50	0.53-2.16
High	5.01†	3.29-10.9	3.01*	1.12-8.08
Age (10-years intervals)	1.12	0.75-1.68	0.99	0.59-1.42
Systolic blood pressure				
Low	1.00		1.00	
Medium	0.75	0.34-1.66	0.89	0.35-2.24
High	1.36	0.50-3.71	1.87	0.77-4.56
Therapy				
None	1.00		1.00	
Oral agents	1.76	0.92-3.39	1.92	0.85-4.42
Insulin	3.00‡	1.27-7.12	3.20‡	1.31-10.0

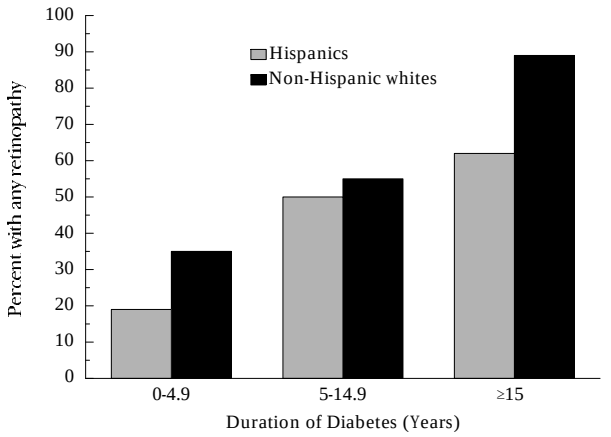
*p<0.01, †p<0.001, ‡p<.05. Data were calculated by multiple logistic regression analysis; OR, odds ratio; CI, confidence interval; MA, Mexican American; NHW, non-Hispanic whites from the Wisconsin Epidemiology Study of Diabetic Retinopathy (WESDR).

Source: Reference 57

diabetic retinopathy of risk factors such as age, gender, diabetes duration, level of glycemia, type of therapy, and blood pressure was similar in Mexican Americans with diabetes in San Antonio and non-Hispanic whites with diabetes in the WESDR, with the possible exception of systolic blood pressure, which was statistically significant in the WESDR population but not in Mexican Americans[59]. Thus, the excess of retinopathy in diabetic Mexican Americans in San Antonio does not appear to be due to a greater susceptibility to the standard risk factors.

In the San Luis Valley Study in southern Colorado, fundus photographs were obtained and graded using the same protocol as the San Antonio Heart Study. The results, however, were very different from those in San Antonio. In Colorado, the prevalence of diabetic retinopathy was lower in Hispanics than in non-Hispanic whites[60] (Figure 32.10). After adjustment for various retinopathy risk factors, the odds of retinopathy in diabetic Mexican Americans compared with diabetic non-Hispanic whites fell to 0.40, which was highly statistically significant (Table 32.29). As in San Antonio, insulin use and glycemia (assessed as glycated hemoglobin in the Colorado study) were significantly associated with retinopathy. However, the Colorado study differed from the San Antonio study in that diabetes duration was not significantly associated with retinopathy, but systolic blood pressure was. The

Figure 32.10
Prevalence of Retinopathy by NIDDM Duration and Ethnic Group, San Luis Valley, CO



Source: Reference 60

Colorado investigators carried out detailed analyses and concluded that the discrepancy between their results and the San Antonio results was genuine and not an artifact caused by different definitions or differences in disease duration. The ethnic differences are highly dependent on the rates of retinopathy in non-Hispanic whites, which constitute the denominator for the rate comparisons. Because of its much larger number of diabetic persons, the WESDR population provides the most definitive retinopathy rates for non-Hispanic whites, although this study did not include newly diagnosed diabetics. The discrepancy between the Colorado and San Antonio retinopathy results appears to be due more to a low rate of retinopathy in San Antonio non-Hispanic whites than to a high rate in Colorado non-Hispanic whites[61](Table 32.30). However, even when compared with WESDR non-Hispanic whites, San Antonio Mexican Americans have more retinopathy[57]. A possible clue to resolving this dilemma is that in Colorado the average glycated hemoglobin levels were similar in Hispanic and non-Hispanic whites with diabetes (10.6% and 10.3%), whereas in San Antonio, diabetic Mexican Americans were clearly more hyperglycemic than diabetic non-Hispanic whites[56].

Table 32.29
Risk Factors for Diabetic Retinopathy in NIDDM, San Luis Valley, CO, 1984-86

	Model 1		Model 2	
Risk factor	Odds ratio	95% CI	Odds ratio	95% CI
Ethnicity, Hispanic vs. non-Hispanic white	0.40	0.21-0.76	0.40	0.21-0.78
Duration of NIDDM (5-year increase)	1.23	0.98-1.54	1.20	0.95-1.51
Age at diagnosis (5-year increase)	0.85	0.72-0.99	0.86	0.73-1.01
Glycosylated hemoglobin (% increase)	1.12	1.00-1.27	1.14	1.01-1.30
Systolic blood pressure (10-mmHg increase)	1.27	1.11-1.46	1.29	1.12-1.49
Insulin use (yes vs. no)	3.06	1.61-5.82		
Current smoking (yes vs. no)				
Taking insulin			0.37	0.14-0.94
Not taking insulin			2.62	0.93-7.34

CI, confidence interval; an interaction term between current smoking and insulin therapy was significant ($p<0.01$) in model 2.

Source: Reference 60

Results from the 1988-91 phase of NHANES III are similar to those from San Antonio in that blacks and Mexican Americans with previously diagnosed NIDDM had a higher prevalence of retinopathy than non-Hispanic whites with NIDDM[62]. These results are presented in Figure 32.11 according to diabetes duration and in Figure 32.12 according to severity of retinopathy.

In Starr County, TX, diabetic retinopathy was highly predictive of subsequent mortality over 8 years in Mexican Americans of both sexes (Figure 32.13), an effect that was independent of both age and diabetes duration[52]. When cholesterol was added to the multivariate model, however, the effect of retinopathy on subsequent mortality was statistically significant only in men.

NEPHROPATHY AND END-STAGE RENAL DISEASE

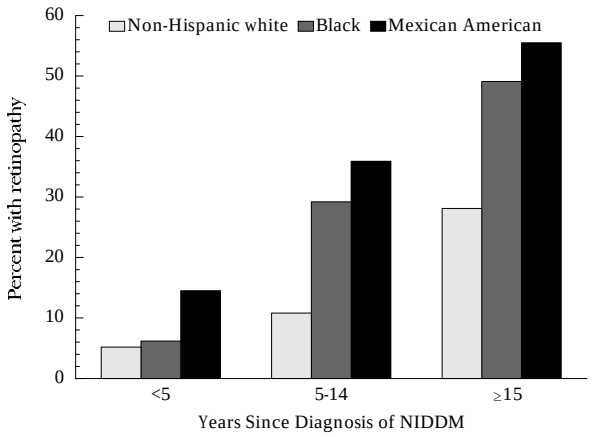
In the San Antonio Heart Study, the prevalence of clinical proteinuria (≥1 on Ames Albustix) was 1.87 times as common in diabetic Mexican Americans as in

Table 32.30
Percent with Retinopathy in Previously Diagnosed NIDDM in Three Studies

		Retinopathy level			
Population	No.	None	Background	Preproliferative	Proliferative
Non-Hispanic white					
Wisconsin	1,370	45.6	28.7	16.9	8.5
San Antonio, TX	49	65.3	20.4	8.2	6.1
Colorado	85	48.2	32.9	14.1	4.7
Mexican American					
San Antonio, TX	206	48.1	21.3	23.3	7.3
Colorado	166	57.2	23.5	12.7	6.6

Source: Reference 61

Figure 32.11
Prevalence of Retinopathy by NIDDM Duration and Ethnic Group, NHANES III, 1988-91

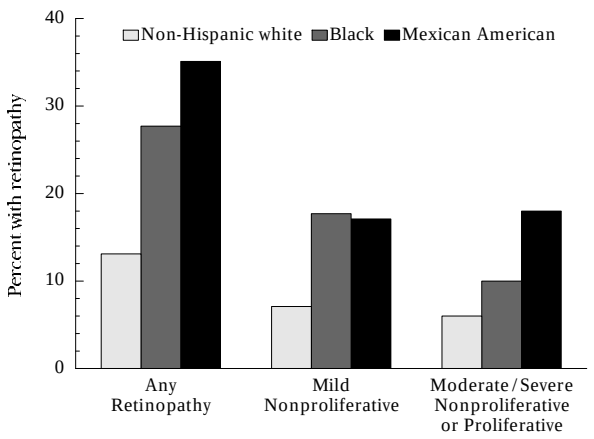


NHANES III: Third National Health and Nutrition Examination Survey.

Source: Reference 62

diabetic non-Hispanics[63] (Table 32.31). After adjustment for age and duration of diabetes, the odds ratio for clinical proteinuria in Mexican American versus non-Hispanic white persons with diabetes increased to 2.82 (p=0.039). Among previously diagnosed persons with diabetes, the frequency of clinical proteinuria was 43% higher in Mexican Americans in San Antonio than in non-Hispanic whites in the WESDR (Table 32.31). Among diabetic subjects without clinical proteinuria, the odds ratio for microalbuminuria (≥30 mg/L) also indicated a higher prevalence in Mexican Americans than in non-Hispanic whites

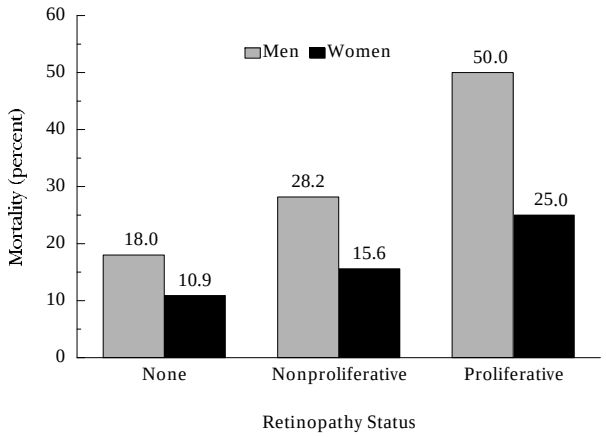
Figure 32.12
Prevalence of Retinopathy in NIDDM by Severity and Ethnic Group, NHANES III, 1988-91



NHANES III: Third National Health and Nutrition Examination Survey.

Source: Reference 62

Figure 32.13
Effects of Retinopathy and Sex on 8-Year Mortality in Mexican Americans with NIDDM, Starr County, TX



Source: Reference 52

(OR=3.62, p=0.063)[63]. Adjustment for covariates including age, diabetes duration, systolic blood pressure, fasting glucose, and cigarette smoking increased this odds ratio rather dramatically to 6.95 (p=0.004).

As in the case of retinopathy, results from San Luis Valley differed from those of the San Antonio Heart Study. Duration-adjusted indicators of diabetic nephropathy indicated either no difference or an excess in non-Hispanic whites relative to Hispanics[61] (Table 32.32). Again, the discrepancy between the San Antonio and the San Luis Valley results may be due to the fact that, in San Antonio, Mexican Americans with diabetes had significantly higher levels of fasting glucose than non-Hispanic whites with diabetes[56], whereas no ethnic differences in the level of glycemia were observed in the San Luis Valley study. Thus, ethnic differences in microvascular complications would not have been expected in the latter.

Among subjects with NIDDM in San Antonio, those with microalbuminuria had higher systolic and diastolic blood pressures and fasting plasma glucose concentrations than those without microalbuminuria[64]. They did not, however, have higher lipids or lipoproteins, including Lp(a). Obesity and body fat distribution were also similar in NIDDM subjects with and without microalbuminuria. A somewhat different pattern has been reported for nondiabetic persons among whom those with microalbuminuria had higher systolic and diastolic blood pressures, serum triglyceride concentrations, and insulinemia, and lower levels of HDL cholesterol but no differences in plasma glucose levels[65].

Table 32.33 shows the incidence of renal replacement

Table 32.31

Clinical Proteinuria According to Ethnicity in NIDDM, San Antonio, TX, and Wisconsin

	Mexican Americans		Non-Hispanic whites		
	Newly diagnosed (SAHS)	Previously diagnosed (SAHS)	Newly diagnosed (SAHS)	Previously diagnosed (SAHS)	Previously diagnosed (WESDR)
No. of subjects	74	243	9	58	476
Negative/trace (%)	90.5	81.1	100	89.7	86.8
1-4+ (%)	9.5	18.9	0	10.3	13.2

SAHS, San Antonio Heart Study; WESDR, Wisconsin Epidemiology Study of Diabetic Retinopathy.

Source: Reference 63

Table 32.32

Prevalence of Markers of Nephropathy in People with NIDDM, San Luis Valley, CO, 1984-86

	Hispanic			Non-Hispanic white		
Nephropathy marker	No.	Adjusted prevalence %	95% confidence interval	No.	Adjusted prevalence %	95% confidence interval
Serum creatinine >132.6 uM	10/184	5.2	2.1-8.3	7/92	8.9	3.2-14.7
Urine protein-creatinine ratio >1	18/187	9.2	5.4-13.1	9/91	11.4	4.8-18.0
Urinary albumin >25.5 ug/ml*	53/145	34.5	27.1-41.9	21/62	34.3	24.3-44.3

*Roughly equal to 30 ug/min excretion rate. Prevalence is adjusted for NIDDM duration by the direct method with use of duration distribution of all subjects as standard.

Source: Reference 61

Table 32.33

Diabetes-Related End-Stage Renal Disease in the Texas Population, 1978-84

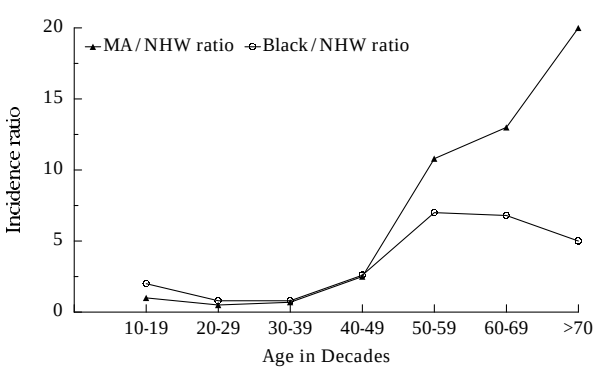
	Incidence per 100,000 per year			Incidence ratios	
Years	Mexican American	Non-Hispanic white	Black	Mexican American/ Non-Hispanic white	Black/Non-Hispanic white
1978-80	6.68 (6.29-7.07)	1.02 (0.95-1.08)	4.42 (4.06-4.78)	6.55	4.33
1979-81	8.43 (7.98-8.87)	1.27 (1.20-1.34)	5.00 (4.75-5.52)	6.64	3.94
1980-82	9.62 (9.15-10.09)	1.46 (1.38-1.54)	5.14 (4.72-5.55)	6.59	3.52
1981-83	6.77 (6.30-7.24)	1.51 (1.43-1.59)	5.84 (5.42-6.26)	4.48	3.87
1982-84	10.11 (9.63-10.60)	1.57 (1.49-1.66)	7.14 (6.69-7.60)	6.44	4.55

Age-adjusted 3-year moving average annual incidence per 100,000 population; data in parentheses are 95% confidence intervals; statistical significance for incidence ratios, $z \geq 3.29$, $p=0.001$.

Source: Reference 66

therapy (dialysis or transplant) for diabetes-related ESRD in 1978-84 for Mexican Americans, non-Hispanic whites, and blacks in Texas[66]. The age-adjusted incidence ratios comparing Mexican Americans to non-Hispanic whites exceed six in four of the five 3-year time periods. These incidences represent the rate of occurrence of diabetes-related ESRD in the general population and not among diabetic persons per se. The excess ESRD in the Mexican-American population is greater than would be expected based on their excess prevalence of diabetes alone, which is only about two- to threefold (Table 32.9). These results imply that diabetic Mexican Americans in Texas have an excess risk of ESRD compared with diabetic non-Hispanic whites; the results are thus compatible with the proteinuria data from the San Antonio Heart Study (Table 32.31). Blacks in Texas have an approximate fourfold excess of diabetes-related ESRD (Table 32.33), which is probably also greater than would be predicted based on their excess prevalence of diabetes. The age-specific incidence ratios presented in Figure 32.14 indicate that for both Mexican Americans and blacks, the excess of diabetes-related ESRD occurs after age 50 years, suggesting that it is principally due to NIDDM. Indeed, at age <40 years, the ratios are very close to 1.0, suggesting that the occurrence of ESRD due to IDDM is quite similar in the three major race/ethnic groups in Texas. The excess at age ≥50 years is clearly much greater in Mexican Americans than in blacks. These inferences are reinforced by data from a surveillance study in two Texas counties (which include Dallas and San Antonio) involving medical record review and algorithms for IDDM and NIDDM. The results indicate that among diabetic

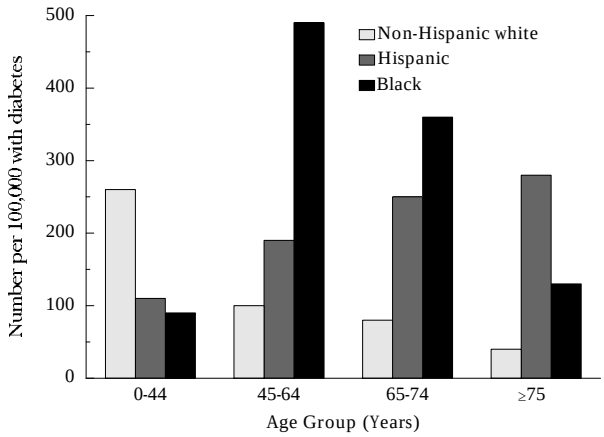
Figure 32.14
Incidence of Diabetic ESRD in Mexican Americans and Blacks Relative to Non-Hispanic Whites, Texas, 1980-82



ESRD, end-stage renal disease; MA, Mexican American; NHW, Non-Hispanic white.

Source: Reference 66

Figure 32.15
Average Annual Incidence of ESRD Treatment in Diabetic Patients, Colorado, 1982-89



ESRD, end-stage renal disease.

Source: Reference 68

Mexican Americans developing ESRD, 99% met criteria for NIDDM, whereas the corresponding figure for diabetic non-Hispanic whites was 56%, with 44% of incident cases in the latter ethnic group categorized as being due to IDDM[67].

Surveillance data on replacement therapy for ESRD from Colorado also support an increased risk of ESRD in Hispanics with NIDDM. Diabetic Hispanics age ≥45 years have a higher incidence of treatment for diabetes-related ESRD than diabetic non-Hispanic whites[68] (Figure 32.15). Unfortunately, these data cannot be directly compared with those presented in Table 32.33, since the latter present incidence of diabetes-related ESRD treatment for the population as a whole rather than for persons with diabetes. In contrast to

Table 32.34
Risk of Death in Mexican Americans and African Americans with ESRD Compared with Non-Hispanic Whites with ESRD in Texas

ESRD etiology	No.	Hazard ratio, African American	Hazard ratio, Mexican American
All etiologies	11,963	0.72 (0.70-0.75)	0.94 (0.88-1.00)
Diabetes	3,260	0.56 (0.49-0.64)	0.79 (0.71-0.88)
Hypertension	2,951	0.65 (0.58-0.73)	0.82 (0.70-0.96)
Glomerulonephritis	1,841	0.88 (0.72-1.08)	0.86 (0.71-1.04)
Other	3,911	0.86 (0.77-0.97)	0.90 (0.80-1.01)

Age-adjusted hazard ratios were computed from Cox proportional hazards model; numbers in parentheses are 95% confidence intervals; ESRD, end-stage renal disease.

Source: Reference 69

Table 32.35
Percent Survival Among Patients with End-Stage Renal Disease in Texas

ESRD etiology	1-year survival			5-year survival		
	Non-Hispanic white	Mexican American	African American	Non-Hispanic white	Mexican American	African American
Hypertension	76	82	88	35	46	54
Glomerulonephritis	89	90	93	55	64	65
Diabetes mellitus	75	76	83	31	31	41
Other	79	83	85	46	52	54

Source: Reference 69

the Texas results, the incidence of diabetes-related ESRD treatment in Colorado was higher in diabetic blacks age 45-74 years than in diabetic Hispanics in the same age range. This excess persisted even when the rates were presented as incidence rates for the general population and may reflect an interaction between diabetes and hypertension, the prevalence of which is exceedingly high among blacks.

Surprisingly, the survival of diabetic Mexican Americans with ESRD in Texas is superior to the survival of diabetic non-Hispanic whites with ESRD[69]. This survival advantage is observed for all ESRD etiologies and in blacks as well as Mexican Americans (Table 32.34). Etiology-specific survival rates by ethnic group are presented in Table 32.35. In a retrospective surveillance study involving medical record review, diabetic Mexican Americans beginning renal dialysis had more severe kidney disease and more non-renal diabetic complications than diabetic non-Hispanics entering renal dialysis. Thus, the survival advantage of Mexican Americans could not be explained by a lesser degree of severity of ESRD at onset of replacement therapy[70]. This unanticipated finding remains unexplained.

NEUROPATHY

Diabetic neuropathy was diagnosed in the San Luis Valley Diabetes Study on the basis of a screening examination that included a symptom questionnaire and testing of cold sensation and deep tendon reflexes in the lower extremities[71]. Neuropathy was diagnosed if the patient demonstrated at least two of the following three findings: pain or discomfort such as numbness, burning, or tingling in both legs or feet; absent or decreased ankle reflexes bilaterally; and lack of cold sensation over the dorsum of both feet. The screening examination was carried out by a nurse clinician and was validated against a standard neurological examination by a neurologist. There was 90% agreement (34/38) between the two approaches and the kappa statistic was 0.79. Using the screening examination, there was no significant difference in the prevalence of diabetic neuropathy in Hispanics and non-Hispanic whites[61] (Table 32.36).

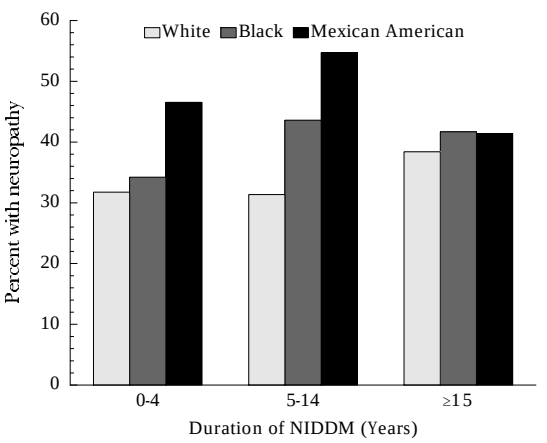
Table 32.36
Prevalence of Distal Symmetrical Sensory Neuropathy, San Luis Valley, CO, 1984-86

Glucose tolerance status	Hispanic		Non-Hispanic white	
	No.	%	No.	%
Normal glucose tolerance	188	4.8	298	2.7
Impaired glucose tolerance	48	12.5	41	9.8
NIDDM	186	26.9	91	29.7
NIDDM (duration-adjusted*)		26.3		31.6

*Directly adjusted with duration distribution of all subjects as standard.

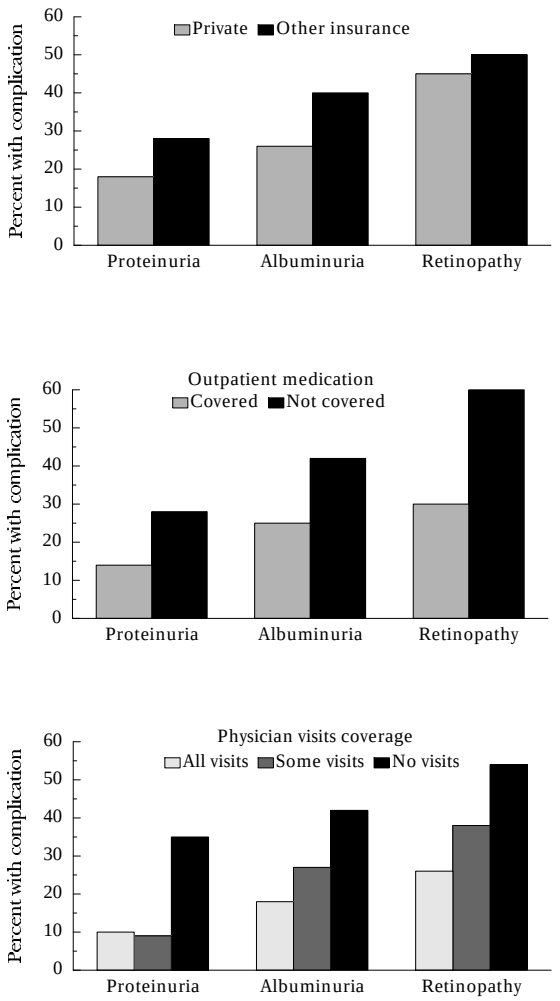
Source: Reference 61

Figure 32.16
Prevalence of Sensory Neuropathy, by Race and NIDDM Duration, U.S., 1989



Source: Reference 72

Figure 32.17
Prevalence of Microvascular Complications by Health Insurance Coverage, San Antonio, TX



Source: Reference 73

In the 1989 National Health Interview Survey, the prevalence of sensory neuropathy was defined as a self-report of numbness, loss of feeling, pain, tingling, or decreased ability to feel hot or cold[72]. Compared with non-Hispanic whites with NIDDM, the prevalence of sensory neuropathy was higher in Mexican Americans with 0-4 and 5-14 years duration of diabetes and in blacks with 5-14 years duration (Figure 32.16). These differences were not statistically significant, however. For diabetic persons with duration >15 years, there were no racial or ethnic differences in neuropathy prevalence.

HEALTH INSURANCE AND DIABETIC COMPLICATIONS

The relationship between health insurance and microvascular complications has been studied in Mexican Americans with diabetes in San Antonio[73]. Clinical proteinuria, microalbuminuria, and retinopathy (defined as above) were consistently less frequent in individuals with private health insurance and individuals whose health insurance included reimbursement for outpatient medications and at least some outpatient physician visits (Figure 32.17). Since these results are cross-sectional, they do not conclusively indicate the direction of cause and effect, i.e., patients with complications may suffer loss of employment with resultant loss of health insurance, rather than the inadequate health insurance leading to development of diabetic complications.

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REFERENCES

1. U.S. Bureau of the Census: The Hispanic population in the United States: March 1991. Current Population Reports. Series P-20, no. 455. Washington DC: U.S. Govt. Printing Office
2. U.S. Bureau of the Census: How we're changing: Demographic state of the nation, 1993. Current Population Reports: Special Studies. Series P-23, no. 184. Washington DC: U.S. Govt. Printing Office, February 1993
3. Stern MP, Gaskill SP, Allen CR, Garza V, Gonzales JL, Waldrop RH: Cardiovascular risk factors in Mexican Americans in Laredo, Texas: I. Prevalence of overweight and diabetes and distribution of serum lipids. *Am J Epidemiol* 113:546-55, 1981
4. Hanis CL, Ferrell RE, Barton SA, Aguilar L, Garza-Ibarra A, Tulloch BR, Garcia CA, Schull WJ: Diabetes among Mexican-Americans in Starr County, Texas. *Am J Epidemiol* 118:659-72, 1983
5. Mitchell BD, Stern MP, Haffner SM, Hazuda HP, Patterson JK: Risk factors for cardiovascular mortality in Mexican Americans and non-Hispanic whites: The San Antonio Heart Study. *Am J Epidemiol* 131:423-33, 1990
6. Hamman RF, Marshall JA, Baxter J, Kahn LB, Mayer EJ, Orleans M, Murphy JR, Lezotte DC: Methods and prevalence of non-insulin-dependent diabetes mellitus in a biethnic Colorado population: The San Luis Valley Diabetes Study. *Am J Epidemiol* 129:295-311, 1989
7. Samet JM, Coultas DB, Howard CA, Skipper BJ, Hanis CL: Diabetes, gallbladder disease, obesity, and hypertension among Hispanics in New Mexico. *Am J Epidemiol* 128:1302-11, 1988
8. Flegal KM, Ezzati TM, Harris MI, Haynes SG, Juarez RZ, Knowler WC, Perez-Stable EJ, Stern MP: Prevalence of diabetes in Mexican Americans, Cubans, and Puerto Ricans from the Hispanic Health and Nutrition Examination Survey, 1982-84. *Diabetes Care* 14 (Suppl. 3):628-38, 1991
9. Hanis CL, Hewett-Emmett D, Bertin TK, Schull WJ: Origins of U.S. Hispanics: Implications for diabetes. *Diabetes Care* 14 (Suppl. 3):618-27, 1991
10. Harris MI: Epidemiologic correlates of NIDDM in Hispanics, Whites, and Blacks in the U.S. population. *Diabetes Care* 14 (Suppl. 3):639-48, 1991
11. Haddock L, Torres de Conty I: Prevalence rates for diabetes mellitus in Puerto Rico. *Diabetes Care* 14 (Suppl. 3):676-84, 1991
12. Cruz-Vidal M, Costas R Jr, García-Palmieri MR, Sorlie PD, Hertzmark E: Factors related to diabetes mellitus in Puerto Rican men. *Diabetes* 28:300-07, 1979
13. Stern MP, González C, Mitchell BD, Villalpando E, Haffner SM, Hazuda HP: Genetic and environmental determinants of type II diabetes in Mexico City and San Antonio, TX. *Diabetes* 41:484-92, 1992
14. Baxter J, Hamman RF, Lopez TK, Marshall JA, Hoag S, Swenson CJ: Excess incidence of known non-insulin-dependent diabetes mellitus (NIDDM) in Hispanics compared with non-Hispanic whites in the San Luis Valley, Colorado. *Ethnicity & Disease* 3:11-21, 1993
15. Stern MP, Morales PA, Valdez RA, Monterrosa A, Haffner SM, Mitchell BD, Hazuda HP: Predicting diabetes: Moving beyond impaired glucose tolerance. *Diabetes* 42:706-14, 1993
16. Stern MP, Gaskill SP, Hazuda HP, Gardner LI, Haffner SM: Does obesity explain excess prevalence of diabetes among Mexican Americans? Results of the San Antonio Heart Study. *Diabetologia* 24:272-77, 1983
17. Marshall JA, Hamman RF, Baxter J, Mayer EJ, Fulton DL, Orleans M, Rewers M, Jones RH: Ethnic differences in risk factors associated with the prevalence of non-insulin-dependent diabetes mellitus. The San Luis Valley Diabetes Study. *Am J Epidemiol* 137:706-18, 1993
18. Haffner SM, Stern MP, Hazuda HP, Pugh JA, Patterson JK: Do upper body and centralized adiposity measure different aspects of regional body fat distribution? Relationship to non-insulin dependent diabetes mellitus, lipids and lipoproteins. *Diabetes* 36:43-51, 1987
19. Haffner SM, Stern MP, Hazuda HP, Pugh JA, Patterson JK: Hyperinsulinemia in a population at high risk for non-insulin dependent diabetes mellitus. *New Engl J Med* 315:220-24, 1986
20. Boyko E, Keane EM, Marshall JA, Hamman RF: High insulin and C-peptide concentrations in a Hispanic population at high risk for NIDDM. The San Luis Valley Diabetes Study. *Diabetes* 40:509-15, 1991
21. Haffner SM, Hazuda HP, Mitchell BD, Patterson JK, Stern MP: Increased incidence of type II diabetes mellitus in Mexican Americans. *Diabetes Care* 14:102-08, 1991
22. Hazuda HP, Haffner SM, Stern MP, Eifler CW: Effects of acculturation and socioeconomic status on obesity and diabetes in Mexican Americans: The San Antonio Heart Study. *Am J Epidemiol* 128:1289-1301, 1988
23. Marshall JA, Hamman RF, Baxter J: High-fat, low-carbohydrate diet and the etiology of noninsulin-dependent diabetes mellitus: The San Luis Valley Diabetes Study. *Am J Epidemiol* 134:590-603, 1991
24. Marshall JA, Weiss NS, Hamman RF: The role of dietary fiber in the etiology of non-insulin dependent diabetes mellitus: The San Luis Valley Diabetes Study. *Ann Epidemiol* 3:18-26, 1993
25. Mitchell BD, Kammerer CM, Reinhart LJ, Stern MP: NIDDM in Mexican American families: Heterogeneity by age of onset. *Diabetes Care* 17:567-73, 1994
26. Stern MP, Haffner SM: Type II diabetes and its complications in Mexican Americans. *Diabetes Metabolism Reviews* 6:29-45, 1990
27. Gardner LI, Stern MP, Haffner SM, Gaskill SP, Hazuda HP, Relethford JH, Eifler CW: Prevalence of diabetes in Mexican Americans: Relationship to percent of gene pool derived from native American sources. *Diabetes* 33:86-92, 1984
28. Chakraborty R, Ferrell RE, Stern MP, Haffner SM, Hazuda HP, Rosenthal M: Relationship of prevalence of non-insulin dependent diabetes mellitus with Amerindian admixture in the Mexican Americans of San Antonio, Texas. *Genetic Epidemiology* 3:435-54, 1986
29. Stern MP, Ferrell RE, Rosenthal M, Haffner SM, Hazuda HP: Association between non-insulin-dependent diabetes mellitus, Rh blood group, and haptoglobin phenotype: Results from the San Antonio Heart Study. *Diabetes* 35:387-91, 1986
30. Mitchell BD, Kammerer CM, O'Connell P, Harrison CR, Manire M, Shipman PA, Moyer M, Stern MP, Frazier ML: Evidence for linkage of post-challenge insulin levels with intestinal fatty acid binding protein (FABP2) in Mexican Americans. *Diabetes*, in press, 1995

31. Iyengar S, Hamman RF, Marshall JA, Baxter J, Majumder PP, Ferrell RE: Genetic studies of Type 2 (non-insulin dependent) diabetes mellitus: Lack of association with seven genetic markers. *Diabetologia* 32:690-93, 1989

32. Raboudi SH, Mitchell BD, Stern MP, Eifler CW, Haffner SM, Hazuda HP, Frazier ML: Type II diabetes mellitus and polymorphism of insulin-receptor gene in Mexican Americans. *Diabetes* 38:975-80, 1989

33. Elbein SC, Corsetti L, Ulrich A, Permutt MA: Multiple restriction fragment length polymorphisms at the insulin receptor locus: A highly informative marker for linkage analysis. *Proc Natl Acad Sci USA* 83:5223-27, 1986

34. Boerwinkle E, Chen S, Visvikis S, Hanis CL, Siest G, Chan L: Signal peptide-length variation in the human apolipoprotein B gene: Molecular characteristics and association with plasma glucose levels. *Diabetes* 40:1539-44, 1991

35. Iyengar S, Hamman RF, Marshall JA, Majumder PP, Ferrell RE: On the role of Vitamin D binding globulin in glucose homeostasis. *Genetic Epidemiol* 6:691-98, 1989

36. Haffner SM, Stern MP, Hazuda HP, Mitchell BD, Patterson JK: Increased insulin concentrations in non-diabetic offspring of diabetic parents. *New Engl J Med* 319:1297-1301, 1988

37. Mitchell BD, Kammerer CM, Stern MP: Differences in body mass index between nondiabetic first and second degree relatives of diabetic probands. *Am J Hum Genet* 51(Suppl.):A155, 1992

38. Mitchell BD, Kammerer CM, Hixson JE, Atwood LD, Hackleman S, Blangero J, Haffner SM, Stern MP, MacCluer JW: Evidence for a major gene affecting post-challenge insulin levels in Mexican American families. *Diabetes* 44:284-89, 1995

39. Lorenzi M, Cagliero E, Schmidt NJ: Racial differences in incidence of juvenile-onset Type 1 diabetes: Epidemiologic studies in southern California. *Diabetologia* 28:734-38, 1985

40. Hamman RF, Gay EC, Cruickshanks KJ, Cook M, Lezotte DC, Klingensmith GJ, Chase HP: Colorado IDDM Registry: Incidence and validation of IDDM in children aged 0-17 yr. *Diabetes Care* 13:499-506, 1990

41. Gay EC, Hamman RF, Carosone-Link PJ, Lezotte DC, Cook M, Stroheker R, Klingensmith G, Chase HP: Colorado IDDM Registry: Lower incidence of IDDM in Hispanics. Comparison of disease characteristics and care patterns in biethnic population. *Diabetes Care* 12:701-08, 1989

42. Kostraba J, Gay EC, Cai Y, Cruikshanks KJ, Rewers MJ, Klingensmith GJ, Chase HP, Hamman RF: Incidence of insulin-dependent diabetes mellitus in Colorado. *Epidemiology* 3:232-38, 1992

43. Kostraba J, Cruikshanks KJ, Neville TG, Lawler-Heavner J, Chase HP, Klingensmith GJ, Gay EC, Hamman RF: Clinical characteristics of IDDM in Hispanics and non-Hispanic whites. *Diabetes Care* 15:1303-09, 1992

44. Zeidler A, Loon J, Frasier SD, Kumar D, Penny R, Terasaki P: HLA-DRw antigens in Mexican-American and Black-American diabetic patients. *Diabetes* 29:247-50, 1980

45. Zeidler A, Frasier SD, Kumar D, Loon J: Histocompatibility antigens and immunoglobulin G insulin antibodies in Mexican-American insulin-dependent diabetic patients. *J Clin Endocrinol Metab* 54:569-73, 1982.

46. Patel R, Ansari A, Covarrubias CL-P: Leukocyte antigens and disease. III. Association of HLA-B8 and HLA-BW15 with insulin-dependent diabetes in three different population groups. *Metabolism* 26:487-92, 1977

47. Stern MP, Patterson JK, Mitchell BD, Haffner SM, Hazuda HP: Overweight and mortality in Mexican Americans. *Int J Obes* 14:623-29, 1990

48. Schoen R, Nelson VE: Mortality by cause among Spanish-surnamed Californians, 1969-71. *Soc Sci Q* 62:259-72, 1981

49. Polednak AP: Mortality in the Hispanic population of Suffolk County, New York. *NY State J Med* 90:442-46, 1990

50. Sorlie PD, Backlund E, Johnson NJ, Rogot E: Mortality by Hispanic status in the United States. *JAMA* 270:2464-68, 1993

51. Carter JS, Wiggins CL, Becker TM, Key CR, Samet JM: Diabetes mortality among New Mexico's American Indian, Hispanic, and non-Hispanic white populations, 1958-87. *Diabetes Care* 16 (Suppl. 1):306-09, 1993

52. Hanis CL, Chu HH, Lawson K, Hewett-Emmett D, Barton SA, Schull WJ, Garcia CA: Mortality of Mexican Americans with NIDDM: Retinopathy and other predictors in Starr County, Texas. *Diabetes Care* 16:82-09, 1993

53. Mitchell BD, Hazuda HP, Haffner SM, Patterson JK, Stern MP: Myocardial infarction in Mexican Americans and non-Hispanic whites: The San Antonio Heart Study. *Circulation* 83:45-51, 1991

54. Rewers M, Shetterly SM, Baxter J, Marshall JA, Hamman RF: Prevalence of coronary heart disease in subjects with normal and impaired glucose tolerance and non-insulin-dependent diabetes mellitus in a biethnic Colorado population. The San Luis Valley Diabetes Study. *Amer J Epidem* 135:1321-30, 1992

55. Haffner SM, Mitchell BD, Stern MP, Hazuda HP: Macrovascular complications in Mexican Americans with type II diabetes. *Diabetes Care* 14 (Suppl. 3):665-71, 1991

56. Diehl AK, Stern MP: Special health problems of Mexican Americans: Obesity, gallbladder disease, diabetes mellitus, and cardiovascular disease. *Adv Int Med* 34:79-86, 1989

57. Haffner SM, Fong D, Stern MP, Pugh JA, Hazuda HP, Patterson JK, Van Heuven WAJ, Klein R: Diabetic retinopathy in Mexican Americans and non-Hispanic whites. *Diabetes* 37:878-84, 1988

58. Haffner SM, Hazuda HP, Stern MP, Patterson JK, Van Heuven WAJ, Fong D: Effect of socioeconomic status on hyperglycemia and retinopathy levels in Mexican Americans with NIDDM. *Diabetes Care* 12:128-34, 1989

59. Haffner SM, Mitchell BD, Moss SE, Stern MP, Hazuda HP, Patterson JK, Van Heuven WAJ, Klein R: Is there an ethnic difference in the effect of risk factors for diabetic retinopathy. *Ann Epidemiol* 3:2-8, 1993

60. Hamman RF, Mayer EJ, Moo-Young GA, Hildebrandt W, Marshall JA, Baxter J: Prevalence and risk factors for diabetic retinopathy in non-Hispanic Whites and Hispanics with NIDDM: San Luis Valley Diabetes Study. *Diabetes* 38:1231-37, 1989

61. Hamman RF, Franklin GA, Mayer EJ, Marshall SM, Marshall JA, Baxter J, Kahn LB: Microvascular complications of NIDDM in Hispanics and non-Hispanic whites: San Luis Valley Diabetes Study. *Diabetes Care* 14(Suppl. 3):655-64, 1991

62. Harris MI, Rowland M, Klein R: Racial differences in the prevalence of diabetic retinopathy in the U.S. Third National Health and Nutrition Examination Survey, 1988-91

63. Haffner SM, Mitchell BD, Pugh JA, Stern MP, Kozlowski MK, Hazuda HP, Patterson JK: Proteinuria in Mexican Americans and non-Hispanic whites with NIDDM. *Diabetes Care* 12:530-36, 1989

64. Haffner SM, Morales PA, Gruber MK, Hazuda HP, Stern MP: Cardiovascular risk factors in non-insulin-dependent diabetic subjects with microalbuminuria. *Arterio and Thromb* 13:205-10, 1993

65. Haffner SM, Stern MP, Kozlowski MK, Hazuda HP, Mitchell BD, Patterson JK: Microalbuminuria: A potential marker for increased cardiovascular risk factors in non-diabetic subjects. *Arteriosclerosis* 10:727-31, 1990

66. Pugh JA, Stern MP, Haffner SM, Eifler CW, Zapata M: Excess incidence of treatment of end-stage renal disease in Mexican Americans. *Amer J Epidemiol* 127:135-44, 1988

67. Jameel N, Pugh JA: Ethnic/racial differences in incidence of treatment of diabetic end-stage renal disease (ESRD) by diabetic type. *Diabetes* 39 (Suppl. 1):39A, 1990

68. Morbidity and Mortality Weekly Reviews: Incidence of treatment for end-stage renal disease attributed to diabetes mellitus by race/ethnicity W Colorado, 1982-89. Vol. 41, Nov. 6, 1992, p. 845-47

69. Pugh JA, Tuley MR: Survival among Mexican Americans, non-Hispanic whites, and African Americans with end-stage renal disease: The emergence of a minority pattern of increased incidence and prolonged survival. *Am J Kidney Dis* 23: 803-07, 1994

70. Medina RA, Pugh JA, Ramirez ML: Tri-ethnic comparisons in severity of disease at onset of treatment for noninsulin-dependent diabetes-related ESRD. SGIM Abstracts. *Clin Res* 41:589A, 1993

71. Franklin GM, Kahn LB, Baxter J, Marshall JA, Hamman RF: Sensory neuropathy in non-insulin-dependent diabetes mellitus: The San Luis Valley Diabetes Study. *Amer J Epidemiol* 131:633-43, 1990

72. Harris M, Eastman R, Cowie C: Symptoms of sensory neuropathy in adults with NIDDM in the U.S. population. *Diabetes Care* 16:1446-52, 1993

73. Pugh JA, Tuley M, Hazuda HP, Stern MP: The influence of outpatient insurance coverage on the microvascular complications of non-insulin-dependent diabetes in Mexican Americans. *J Diab Comp* 6:236-41, 1992

APPENDIX

Appendix 32.1

Values for Metabolic Variables in Hispanic and Non-Hispanic Subjects Age 40-64 Years with NIDDM in U.S. Population Samples and in Community-Based Studies

	HHANES		San Luis Valley		San Luis Valley		San Antonio		San Antonio	
	Mexican American men	Mexican American women	Hispanic men	Hispanic women	Anglo men	Anglo women	Mexican American men	Mexican American women	Anglo men	Anglo women
Previously diagnosed diabetes										
Mean fasting plasma glucose			191.8	197.8	184.0	171.5	181.9	188.2	162.8	167.7
Mean 2-hour plasma glucose			309.8	331.6	299.5	287.0	326.8	333.5	308.0	288.5
Mean fasting insulin			21.8	24.5	22.7	26.2	24.6	29.8	25.7	26.6
Mean 2-hour insulin			87.6	98.7	79.3	116.7	57.6	78.5	52.2	73.6
Mean number of years since diagnosis of diabetes	6.8	8.0	7.6	7.7	6.0	9.1	6.6	10.1	8.8	9.9
Newly discovered diabetes										
Mean fasting plasma glucose	141.6	125.2	164.6	143.4	125.5	165.3	155.2	151.6	161.8	120.5
Mean 2-hour plasma glucose	268.1	260.1	269.2	267.0	244.3	280.2	295.0	289.6	298.4	235.3
Mean fasting insulin			19.2	23.6	25.2	22.7	22.2	28.0	19.8	23.8
Mean 2-hour insulin			101.4	108.2	105.3	84.4	98.9	139.4	84.1	151.3
All diabetes combined										
Percent with self-reported history of diabetes in mother and/or father			43.5	46.9	37.3	37.5				
Mean BMI	28.0	31.4	27.6	30.4	29.0	31.1	29.7	32.1	28.6	31.3
Percent with BMI ≥25	83.0	94.0	74.0	84.9	83.0	82.9	83.1	87.4	81.3	79.4
Percent with BMI ≥30	27.4	52.2	31.5	47.2	35.8	48.6	41.9	58.7	25.0	52.9
Percent with BMI ≥35	3.2	22.8	2.7	17.9	9.4	31.4	14.5	26.7	9.4	23.5
Mean subscapular-to-triceps skinfold ratio	1.89	1.15	1.74	1.19	1.77	1.02	1.93	1.32	1.72	1.33
Mean waist-to-hip ratio			1.00	0.91	0.99	0.91	0.98	1.00	0.98	1.16
Mean systolic blood pressure	134.5	131.0	134.1	136.8	134.5	134.8	132.0	129.4	132.2	129.6
Mean diastolic blood pressure	83.6	77.1	82.5	79.8	81.1	77.7	75.9	73.4	77.6	71.9
Percent with hypertension	25.0	22.8	45.2	52.8	49.1	71.4	25.8	22.3	31.3	47.1
Mean total cholesterol	220.3	224.5	206.6	244.3	207.2	220.8	215.7	218.8	216.2	221.4
Mean LDL cholesterol	132.5	127.5	126.3	148.2	132.6	123.3	138.0	137.7	137.9	138.0
Mean HDL cholesterol	43.2	46.6	41.2	47.1	40.1	43.7	38.0	43.9	39.6	44.4
Mean fasting triglycerides	197.9	185.0	212.4	268.9	186.1	246.0	262.4	198.5	276.6	212.6
Percent with total cholesterol ≥240	27.9	28.0	22.2	45.7	15.1	31.4	20.2	25.7	18.8	26.5
Percent with LDL cholesterol ≥160	18.1	20.8	16.7	33.0	18.8	18.8	23.4	25.7	21.9	29.4
Percent with HDL cholesterol <35	20.6	16.6	27.8	15.2	40.4	25.7	48.4	22.3	53.1	20.6
Percent with triglycerides ≥250	12.9	6.7	27.8	35.2	17.0	37.1	33.9	22.3	31.3	20.6

Hypertension defined as systolic blood pressure ≥160 mmHg or diastolic blood pressure ≥95 mmHg or using antihypertensive medication; values for blood pressure include values for subjects using antihypertensive medications; values for lipids are in mg/dl; for empty cells, data were not available. HHANES, 1982-84 Hispanic Health and Nutrition Examination Survey; BMI, body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

Source:1982-84 Hispanic Health and Nutrition Examination Survey, unpublished data; Richard Hamman, University of Colorado, San Luis Valley Diabetes Study, unpublished data; Michael Stern, University of Texas, San Antonio Heart Study, unpublished data