Epidemiology of Diabetes in Mexico and Associated Coronary Risk Factors*

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Type 2 diabetes in the Mexican population

The prevalence of type 2 or non-insulin-dependent diabetes varies widely. Most at risk are populations of developing countries, minority groups, and disadvantaged communities in industrialized countries [1]. Projections made from current epidemiological data in Mexican and Mexican-American populations suggest that the incidence of type 2 diabetes in this ethnic group will continue to escalate, being closely related to increased rates of obesity, genetic background, and the trend for diminished physical activity [2–4]. Diabetes-related complications will occur more frequently because of the early appearance of the disease, its underdiagnosis and undertreatment, and the high prevalence of other coronary risk factors such as hypertension, dyslipidemias and smoking [5–8].

The population of Mexico is currently estimated at 100 million. During the last few decades the country has undergone dramatic and very rapid socioeconomic changes that have led to profound demographic and epidemiological changes. Internal migration has been massive, the proportion of the population in urban areas having increased from 42.6% in 1950 to 71.4% in 1990. Infant mortality dropped by 14.4% from 1970 to 1990 and life expectancy rose from 63.5 to 73.9 years during the same period. While around 50% of the Mexican population are youngsters, in the 65 years and older age group the growth rate is 4%, i.e., twice the actual growth of the total population. Current estimates suggest that by the year 2030 there will be 14 millions Mexicans in this age group [9].

Mexico is on the ascending limb of the diabetes epidemic. There has been a stepwise increase in the prevalence from 2–3% in 1963 when the first available data were obtained to around 8–9% in the most recent surveys [10–13]. According to the Chronic Diseases National Survey, the distribution of diabetes increased in states with the largest urban concentrations, was associated with advanced age and increased body mass index, and affected mostly the lowest income groups with the lowest levels of education. Almost 25% of people aged 65 and above are diabetics, however 0.5% of the population in the 20–30 age group and 3.0% in the 30–40 age group have diabetes. Based on our current population pyramid with its large base of younger individuals, extrapolation of these data allow a calculation of approximately 300,000 diabetics in the 20–40 age group, which represents a tremendous impact on our public health facilities in the years to come [13].

The thrifty genotype

Newly arrived migrants to the large cities in Mexico rapidly adapt to the urban milieu, losing their rural nutritional and activity habits. In addition, it is well known that Mexicans, particularly those of Indian or mixed origin, share with other Indian-American groups a high genetic susceptibility to type 2 diabetes [14]. Considering diabetes prevalence rates separately, one sees almost a fivefold difference between rural and urban communities.

The thrifty genotype hypothesis proposes that in traditional populations subject to periods of "feast and famine," a survival advantage was conferred on those whose metabolism stored energy with maximum efficiency [15]. With modernization and the accompanying assured supply of highly refined calories, coupled with a sedentary lifestyle, the thrifty genotype became disadvantageous, leading to obesity, hyperinsulinemia, insulin resistance, and eventually to pancreatic beta cell decompensation and diabetes [16]. This is evident in the Mexican population where the genotype probably has a high prevalence and penetration.

Of great concern is how changes in the physical environment and lifestyle, such as have occurred in Mexican-Americans, can result in the major causes of morbidity and mortality [14] and even override genetic susceptibility in the expression of type 2 diabetes and other traits. Unfortunately, as demonstrated by recent surveys, the conditions that predispose to an increased prevalence of diabetes and related complications are already present in Mexico [8,12,17–19].

Diabetes and coronary heart disease

Cardiovascular disease represents the greatest burden of diabetes, at both the individual and population level. Approximately 75% of patients with diabetes will die from cardiovascular disease [20–22]. Diabetic patients have more extensive

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atherosclerosis than non-diabetics, a higher incidence of multi-vessel disease, a greater propensity for suffering cardiovascular sequelae, and a poorer short-term and one year prognosis after a first myocardial infarction. The mortality rate from CHD is at least three times greater, the numbers being particularly high for women [23,24]. In a recent study, the 7 year incidence of myocardial infarction in non-diabetic subjects (age 45–64 years) with a prior myocardial infarction at baseline was shown to be similar to that of diabetic subjects without a prior myocardial infarction (18.8% vs. 20.2% respectively) [25,26].

While the role of diabetes as a risk factor for cardiovascular disease is well established, several epidemiological and clinical studies have also shown an association between increased insulin concentrations and the metabolic syndrome with an increased risk for atherosclerotic heart disease [27–29]. There are important associated coronary risk factors that may coexist in diabetic patients, such as hyperglycemia, dyslipidemia, insulin resistance, platelets and hemostatic abnormalitiies, oxidative stress, vascular dysfunction, advanced glycosylation of proteins, hypertension, smoking, obesity, lack of exercise, and a positive family history of premature CHD [20–22]. A decline in CVD mortality has been shown in the general U.S. population, but not in diabetic patients, particularly in women; therefore, aggressive management of cardiovascular risk factor in diabetic subjects must be initiated before the onset of overt CHD.

Cardiovascular diseases are the leading cause of death in Mexico. Results of the National Survey of Chronic Diseases [13] showed that arterial hypertension was twice as common and myocardial infarction and stroke three to four times more frequent in diabetic than in non-diabetic individuals. Some conditions, such as peripheral vascular disease, are more prevalent in Mexican than in non-Hispanic whites [5]. Haffner et al. [30] compared the prevalence of hypertension in 1,500 Mexican Americans who participated in the San Antonio Heart Study and 2,280 low income Mexicans who participated in the Mexico City Study. The crude prevalence of mild hypertension was 17.1% and 17.4% in Mexican men and women, compared to 24.4% and 22.0% in Mexican American men and women ($P < 0.001$ and $P < 0.005$ respectively). These differences could be related to greater physical activity, lower body mass index, and the consumption of a high carbohydrate low fat diet in the Mexican population.

The results of cross-cultural epidemiological studies on changes in mortality and morbidity from CHD related to changes in lifestyles and coronary risk factors give strong support to the concept that environment and lifestyle are powerful determinants of the frequency of CHD in populations [6,7,16,18,28,31].

Diabetes and associated coronary risk factors in Mexico

An epidemiological survey in Mexico City to determine the prevalence of diabetes and associated coronary risk factors [12] was conducted in a sample of 805 individuals aged 20–90 years, who were selected by the method of multistage cluster sampling with proportional allocation. The crude rate prevalence of type 2 diabetes was 8.7%, with an age-adjusted rate of 10.6% for females and 6.0% for males. Although age strongly influenced the prevalence of diabetes, a significant proportion (5.9%) of younger individuals (35–44 years of age) was affected by the disease. Diabetes was associated with advanced age, had a greater impact in the low income classes, and showed increased odds ratios for hypertension, dyslipidemias and myocardial infarction in men and women and for obesity only in women. Diabetics from the poor income class had increased BMI and a trend for higher triglycerides and lower high density lipoprotein-cholesterol values. Individuals with impaired fasting glucose or newly diagnosed diabetes with fasting plasma glucose between 126 and 140 mg/dl had a higher atherogenic risk profile than individuals with a normal carbohydrate metabolism.

The prevalence of insulin-resistant related metabolic disorders was high in this random sample of the Mexico City population [Table 1]. The mean values of BMI, waist measurement, waist-to-hip ratio, systolic and diastolic blood pressure, triglycerides, glucose and the atherogenic index increased significantly at higher insulin levels. A significant inverse tendency was observed for the mean concentration of HDL-cholesterol. Other variables like age, lipoprotein(a), total and LDL-cholesterol had no association with insulin levels. A

Table 1. Anthropometric and metabolic variables according to insulin quartile in males from Mexico City

	Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**	***P* ***
Insulin (μU/ml)	< 5.6	5.6-8.5	8.5-12.7	> 12.7	
N	99	99	101	97	
Age (yr)	41 ± 14	37 ± 13	39 ± 12	41 ± 13	NS
BMI (kg/m^2)	24.3 ± 2.6	25.1 ± 2.5	26.6 ± 3.0	28.7 ± 4.2	< 0.001
WHR	0.94 ± 0.07	0.94 ± 0.05	0.95 ± 0.06	0.98 ± 0.08	< 0.001
SBP (mmHg)	118 ± 17	119 ± 13	122 ± 17	125 ± 18	< 0.05
DBP (mmHg)	75 ± 10	75 ± 10	77 ± 12	80 ± 11	< 0.005
TC (mg/dl)	206 ± 44	205 ± 51	205 ± 38	212 ± 36	NS
TG (mg/dl)	141 ± 75	154 ± 97	172 ± 91	206 ± 107	< 0.001
LDL-C (mg/dl)	140 ± 39	139 ± 45	140 ± 33	141 ± 33	NS
HDL-C (mg/dl)	43 ± 11	41 ± 10	38 ± 9	38 ± 9	< 0.001
Lp(a) (mg/dl)	19.6 ± 28.3	16.0 ± 21.3	19.1 ± 28.5	13.6 ± 29.7	< 0.05
Glucose (mg/dl	89 ± 10	97 ± 24	102 ± 34	99 ± 22	< 0.001

WHR = waist-to-hip ratio, SBP = systolic blood pressure, DBP = diastolic blood pressure, TC = total cholesterol, TG = triglycerides.
The values are expressed as mean ± standard deviation. * ANOVA

CHD = coronary heart disease
CVD = coronary vascular disease
BMI = body mass index

similar pattern was observed in women, however statistical significance was only obtained for BMI, waist measurement, triglycerides, glucose and HDL-cholesterol concentrations. In this study, there was a three- to fivefold increase in the risk of presenting two, three or more cardiovascular risk factors in subjects with higher fasting insulin levels. Lp(a) mean levels were inversely related to fasting insulin concentrations [18].

Mexican Americans are known to have a prevalence of type 2 diabetes three times higher than non-Hispanic whites, as well as higher mean plasma insulin levels and a more centralized upper body adiposity. An anthropometric and metabolic profile was consistent with our findings in the Mexico City population. The rich carbohydrate diet that is characteristic of the Mexican population has been linked to increased insulin and triglyceride values, however the clustering of metabolic disorders cannot be explained solely on the basis of diet, obesity or body fat distribution [27].

Diabetes in the elderly

In the elderly age group in Mexico, diabetes is the second cause of mortality after cardiovascular disease and the main cause of mortality and hospitalization documented by the Mexican Institute of Social Security [32]. These data must be tempered by two parallel tendencies: the change in age distribution to greater absolute numbers of older people, who have higher prevalence and incidence rates of diabetes and its complications; and the increasing urbanization of the rural population.

A study was recently undertaken to determine the prevalence of diabetes and to examine its association with food intake, anthropometric and metabolic variables and other coronary risk factors in urban and rural elderly Mexican populations [33]. In this cross-sectional study of three different Mexican communities (urban area of medium-low income, urban area of low income, and a rural area), individuals were randomly selected and a personal interview assessed demographic information, personal medical history and functional status. A 24 hour diet recall was obtained. The physical examination included anthropometric and blood pressure measurements, and a fasting blood sample was obtained for measurements of lipids, insulin and glucose. Findings showed that diabetes prevalence was higher in males than females for all age groups – 16.7 vs. 9.5% in adults and 30.8 vs. 22.8% in the elderly. Using a multivariate stepwise logistic regression, elderly individuals had the following variables independently associated with diabetes: male gender odds ratio 2.1, $P<0.009$), diminished carbohydrate intake (OR 0.77 $P<0.03$), central distribution of the adiposity (OR 1.9, $P<0.03$) and functional disability (OR 2.3, $P<0.01$).

Rural-urban comparisons offer an exceptional opportunity to study the spectrum of socioeconomic and environmental factors and their relationship to the health of the population. Table 2 presents data related to the macronutrient intake and metabolic variables of the elderly population of both sexes from the three communities. Individuals living in the rural area had significantly lower mean values for BMI, % body fat, systolic blood pressure and glycemia for both sexes, and lower mean diastolic blood pressure, total and LDL-cholesterol and insulin levels and higher HDL-cholesterol levels only for males. This community was characterized by a very low educational level (95% were illiterate or had just a few years of elementary school), a very low income, and a high fiber and carbohydrate diet with a proportionally lower fat intake – the traditional Mexican meal pattern that is beneficial to the population.

The association of type 2 diabetes with other variables was also estimated by unconditional logistic regression analysis using odds ratios [Table 3]. Diabetes was significantly associated with hypertriglyceridemia, partial or total disability and increased prevalence of ischemic heart disease in the elderly, and with LDL hypercholesterolemia, hypertriglyceridemia and a proportionally higher fat intake in adults.

HDL = high density lipoprotein
LDL = low density lipoprotein
Lp(a) = lipoprotein (a)

Table 2. Food intake and metabolic variables in elderly men and women distributed in the three communities

Variables	Urban: Middle-low	Urban: Low	Rural
Men	n = 45	n = 36	n = 40
Fiber (g/day)	$10\pm6^{++}$	93	20 ± 11
% total protein	$15\pm0.04^{++}$	13 ± 0.03	13 ± 0.01
% CHO	$52\pm0.11^{++}$	$60\pm0.09^{\delta\delta}$	70 ± 0.08
% fat	$33\pm0.10^{++}$	$27\pm0.08^{\delta\delta}$	18 ± 0.07
Alcohol intake (%)	13.3^{++}	$13.9^{\delta\delta}$	47.5
Glucose (mg/dl)	$114\pm49^{+}$	$108\pm51^{\delta}$	83 ± 37
Cholesterol (mg/dl)	$213\pm41^{+}$	$208\pm30^{\delta}$	191 ± 37
HDL-C (mg/dl)	$41\pm11^{+}$	$42\pm9^{\delta}$	50 ± 14
LDL-C (mg/dl)	$151\pm40^{++}$	$142\pm28^{\delta}$	122 ± 35
Triglycerides (mg/dl)	183 ± 157	165 ± 60	147 ± 130
Insulin (mU/ml)	$42\pm68^{+}$	26 ± 47	12 ± 10
Women	n = 103	n = 64	n = 56
Fiber (g/day)	9 ± 4	$7\pm3^{\delta\delta}$	18 ± 11
% Protein	15 ± 0.03	14 ± 0.03	14 ± 0.03
% CHO	52 ± 0.03	$57\pm0.09^{\delta\delta}$	65 ± 0.10
% Fat	33 ± 0.09	$28\pm0.08^{\delta\delta}$	20 ± 0.08
Alcohol intake (%)	1.0^{++}	$0.0^{\delta\delta}$	37.0
Glucose (mg/dl)	86 ± 27	$123\pm62^{\delta}$	94 ± 52
Cholesterol (mg/dl)	225 ± 42	212 ± 42	209 ± 45
HDL-C (mg/dl)	51 ± 12	43 ± 12	48 ± 11
LDL-C (mg/dl)	155 ± 42	141 ± 38	139 ± 44
Triglyceride (mg/dl)	155 ± 42	141 ± 38	139 ± 44
Insulin (mU/ml)	23 ± 36	18 ± 21	13 ± 11

CHO% of total = carbohydrate percent of total, alcohol intake = significant alcohol intake.

Data are presented as means SD. Mean comparisons between two groups were perfomed by Student's *t*-test for independent variables.

Urban middle-low vs. urban low $^{*}P<0.05$, $^{**}P<0.001$

Urban middle vs. rural $^{+}P<0.05$, $^{++}P<0.001$;

Urban low vs. rural $^{\delta}P<0.05$, $^{\delta\delta}P<0.001$.

Table 3. Diabetes mellitus and associated coronary risk factors in adults and elderly people

Variable	DM (%)	No DM (%)	OR	95%CI	*P*
Adults					
> 30% fat diet	56.3	37.3	2.2	1.0-4.6	0.04
BMI > 27	60	49.4	1.5	0.7-3.3	0.27
Hypertension	50.0	38.4	1.6	0.8-3.4	0.21
Smoker	32.3	25.1	1.4	0.6-3.2	0.39
HC LDL-C	40.6	16.5	3.5	1.6-7.6	0.001
Low HDL-C	40.6	53.6	0.6	0.3-1.3	0.17
HTG	53.1	26.6	3.1	1.5-6.6	0.002
Elderly					
30% fat diet	48.2	41.4	1.3	0.8-2.2	0.27
History of MI	14.5	5.8	2.8	1.2-6.2	0.01
BMI > 27	40.2	37.3	1.1	0.7-1.9	0.64
Hypertension	42.4	36.1	1.3	0.7-2.4	0.38
Smoker	14	12.6	1.1	0.6-2.3	0.74
HC-LDL-C	33.3	34.3	1.0	0.5-1.7	0.89
Low-HDL-C	41.9	37.2	1.2	0.7-2.1	0.49
HTG	35.5	21.2	2.0	1.1-3.7	0.02

DM = diabetes mellitus, CI = confidence intervals, MI = myocardial infarction, HC = hypercholesterolemia, HTG = hypertriglyceridemia.

Conclusions

The prevalence of diabetes in the Mexican population is high, particularly in urban areas, and is associated with an increased prevalence of other coronary risk factors. Gradual genetic dilution and progressive socioeconomic ascension will eventually lessen the predisposition of the Mexican people to diabetes, but not before the disease and its complications have taken their toll among many of them. Clearly, preventive strategies directed at preventing the rise in morbidity and mortality due to atherosclerosis-related disorders are urgently needed in our population.

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