Factors Related to Diabetes Mellitus in Puerto Rican Men

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SUMMARY

Urban-rural comparisons of the prevalence of diabetes were made in a cohort of 2567 rural and 6190 urban participants aged 45 to 64, in the Puerto Rico Heart Health Program. The prevalence of diabetes in the urban population was more than double that in the rural. Consistent with this, blood glucose concentrations were significantly higher in urban than in rural populations.

The prevalence of diabetes increased with age and relative weight. It was associated with elevations of serum cholesterol, blood pressure, and fasting serum triglycerides. A positive family history was found more commonly in diabetics than in nondiabetics. If there was a history in both a sibling and a parent, there was at least a threefold increased prevalence over those with no family history.

The reason for the higher prevalence of diabetes in the urban than in the rural area is elusive. In obese men, the urban and rural prevalence rates are the same, but, among relatively lean men, the prevalence in the urban area is twice that of the rural men. DIABETES *28*:300–307, April 1979.

The Puerto Rico Heart Health Program is a prospective epidemiologic study begun in 1965 to investigate the risk factors of coronary heart disease in a cohort of 8793 men aged 45 to 64. To ensure a representative sample for study, a special house-to-house census was carried out in 1964 by the personnel who conduct the regular decennial census. All men who were 45 to 64 years old and who lived in the urban and rural areas were invited to participate.

One factor studied was diabetes mellitus, defined both by history and by examination. The present report focuses on the prevalence of the disease in urban and rural areas and in relation to a number of other personal attributes of the 8757 men who received a complete evaluation for this condition. By using uniform examination procedures and criteria and applying them to a carefully chosen population sample, the major problems commonly encountered in prevalence studies of diabetes were avoided.[1]

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MATERIALS AND METHODS

The study cohort consisted of men in three urban and four rural municipalities of the northeast region of Puerto Rico. At the time of the census, each Enumeration District was classified as urban if it contained a cluster of 25 or more dwelling units; otherwise, it was classified as rural. In general the urban areas were densely populated. Most of the rural areas were in the hilly interior of the island. A response rate of 80% was achieved in each municipality.[2]

As part of a general history at the time of the initial examination, subjects were asked whether they had diabetes, and, if so, what form of treatment they were receiving. The options were none, diet only, oral hypoglycemic agents, and insulin. Family history of diabetes in the parents and siblings was also recorded. Glucose was determined routinely by the Somogyi-Nelson method on venous whole blood. No preservative was added, as processing of all samples, both urban and rural, was started within 30 min of venipuncture.[3]

A man was considered to be diabetic if either of the following criteria was fulfilled: (1) The subject indicated his diet was modified or he was using insulin or oral hypoglycemic agents for diabetes. To test the validity of this criterion, the mean blood glucose was examined in relation to the type of treatment in those subjects who stated they had been diagnosed and treated previously for diabetes. Table 1 shows that the mean levels of blood glucose are indeed substantially higher for previously diagnosed diabetics than for the remainder of the cohort and are progressively higher the more intensive the treatment; the upper ends of the distributions show a similar progression. These findings lend credence to the assertion that persons who report that they are under treatment for

TABLE 1
Blood glucose distribution at initial examination
Men aged 45–64
Puerto Rico Heart Health Program

	Rural		Urban	
	Fasting	Nonfasting	Fasting	Nonfasting
No History				
Mean (mg/dl)	91	91	94	94
Standard deviation	19	18	26	28
Percent over 140 mg/dl	1.5	1.6	2.4	3.2
Percent over 180 mg/dl	0.8	0.9	1.5	1.4
90th Percentile	106	106	108	111
95th Percentile	111	111	117	125
Number	1551	951	3420	2338
Positive History, Diet				
Mean (mg/dl)	106	89	121	131
Standard deviation	21	1	52	70
Percent over 140 mg/dl	10	0	25	32
Percent over 180 mg/dl	0	0	12	13
Number	10	2	76	38
Positive History, Oral Agents				
Mean (mg/dl)	146	168	143	172
Standard deviation	56	101	51	85
Percent over 140 mg/dl	40	44	42	53
Percent over 180 mg/dl	27	44	23	44
Number	15	9	137	55
Positive History, Insulin				
Mean (mg/dl)	192	0	170	201
Standard deviation	87	0	73	101
Percent over 140 mg/dl	56	100	62	72
Percent over 180 mg/dl	44	100	45	52
Number	16	1	62	25

diabetes are, in fact, diabetics. (2) The subject's casual blood glucose at the Heart Health Program examination was 140 mg/dl or more (about 2 SD above the population mean). Although all subjects were asked to come fasting, only two thirds of them did. Separate cut-off points for fasting and nonfasting groups were considered. However, an analysis of the data showed that mean values for fasting and nonfasting blood glucose were identical among subjects not previously diagnosed as diabetic. This finding may be partially explained by the fact that most nonfasting subjects had had only a light Puerto Rican breakfast, consisting of coffee with milk and sugar, before coming to the examination. Minimum travel time from the rural areas was 1¼ h, the average being much higher. Table 1 shows a slight difference between fasting and nonfasting urban groups at the upper end of the distribution (over 140 mg/dl.). This difference is small and not significant statistically, however (see Figure 1). Only in the diabetic groups, particularly those under oral agent or insulin treatment, was there a difference in blood sugar between fasting and nonfasting subjects. These observations led to the decision that the criteria should not include different cut-off points for glucose specimens obtained while fasting and not fasting.

Our definition of diabetes has the limitations encountered in a large population study, the major purpose of which is the study of heart disease, and in which it was not possible to give subjects a glucose tolerance test. Since prevalence rates are compared only within our own study population, and since the procedures and criteria were the same for all groups, the lack of a universal clinical definition is not an important consideration.

Relative weight was computed as the ratio of the observed weight to the ideal weight for the observed height, expressed as a percentage. The ideal weight was taken from Metropolitan Life Insurance tables.[4] Blood pressure was taken on the left arm with the subject in the sitting position. Serum cholesterol was determined by a modification of the method of Huang et al.[5] and triglycerides by the method of Van Handel and Zilversmit.[6]

Measures instituted to control the quality of the laboratory determinations were blinded reintroduction of samples; repeated analysis of pooled sera; participation in the proficiency programs of the National Center for Disease Control(NCDC) in Atlanta, Georgia; periodic exchange of samples with the Framingham Heart Study laboratories; and periodic analysis of commercial samples of known values.[7] Glucose and cholesterol laboratory results were maintained within the confidence limits established for these procedures.

During routine physical examination, assessment was made of the individual's peripheral vascular system. A diagnosis of peripheral vascular disease (PVD) was made when intermittent claudication was reported, when there was an amputation due to complication of PVD, or when temperature differences in the feet or absent pulses in the legs were found in combination with abnormal venous refilling and recoloration after elevation of the legs (positive Ratschow's test).

RESULTS

PREVALENCE CONTRASTS BY AREA OF RESIDENCE

The total prevalence of diabetes as defined was 7.4%.

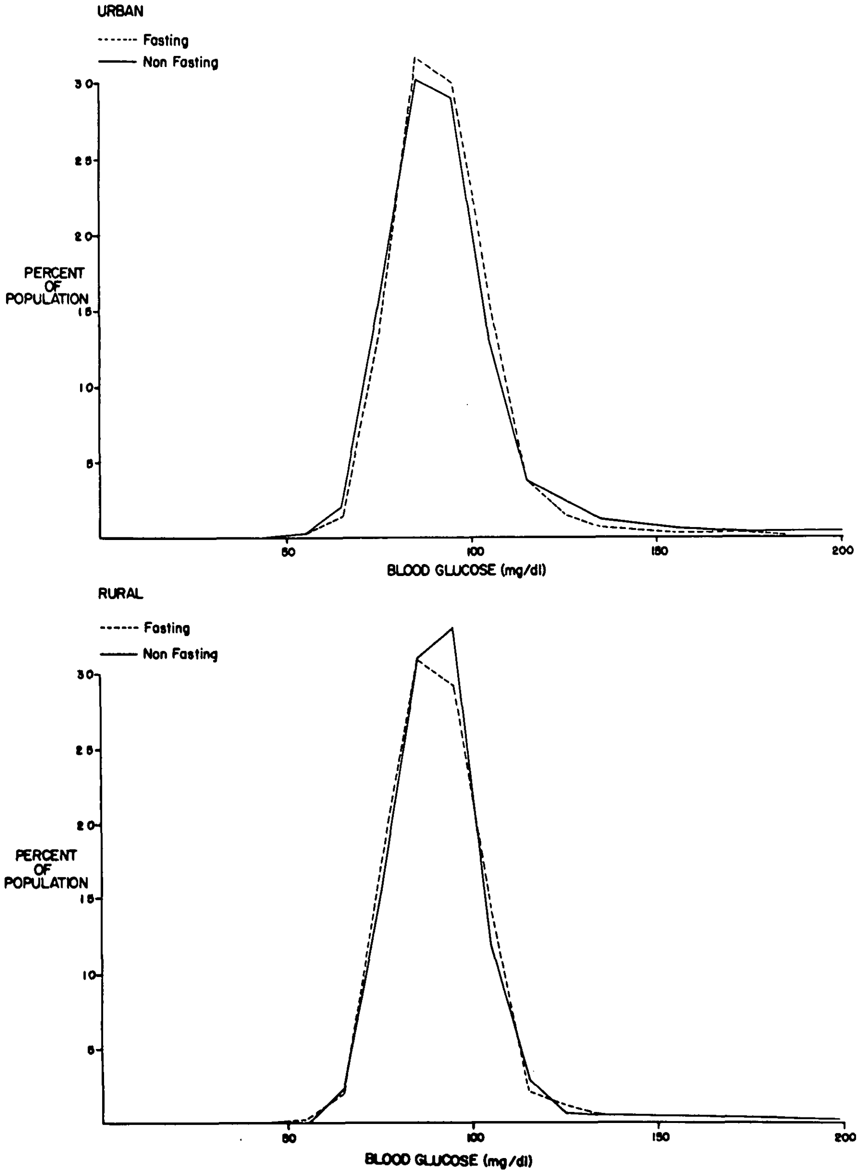


FIGURE 1. Distribution of blood glucose in fasting and nonfasting urban and rural men aged 45 to 64 yr.

Figure 2 shows the prevalence rate by age. A steadily progressive age trend, noted in the urban group, was not observed in the rural, in whom a substantially higher prevalence rate was noted only in the oldest age group. At all ages the prevalence rate among urban men was more than twice that of rural men.

TABLE 2
Comparison of prevalence of diabetes according to various criteria
Men aged 45–64
Puerto Rico Heart Health Program

	Rural		Urban	
Diabetes criteria	Number	Percent of population	Number	Percent of population
Previous diagnosis and history only	33	1.3%	221	3.6%
Elevated blood sugar only	39	1.5%	160	2.6%
Both	21	0.8%	174	2.8%
Total	93	3.6%	555	9.0%

Since the definition of diabetes used includes a history of treatment, the higher urban prevalence rate could be a result of more access to medical care. However, there is no evidence that this is, in fact, the case. On the contrary, even when the diagnosis is made on the basis of the examination blood glucose, the urban prevalence rate is double the rural (5.4% as against 2.3%) (Table 2).

A comparison of the blood glucose distributions among fasting individuals without a history of diabetes highlights the nature of the urban-rural differences (Table 1). The mean value of the blood glucose in the urban area is 3 mg/dl higher than that in the rural area. This difference is small but statistically significant from zero. Since these blood glucose distributions have a long tail to the right, a small shift in the distribution to the right of only 3 mg/dl can result in a large difference in the relative frequencies at the extremes. Thus, the fasting urban group shows 60% more men with blood glucose over 140 mg/dl than the rural and 88% more men with blood glucose over 180 mg/dl. These urban-rural differences in frequencies over 140 mg/dl and 180 mg/dl are statistically significant

TABLE 3
Mean values of relative weight, serum cholesterol, and systolic blood pressure by diabetic status
Men aged 45–64
Puerto Rico Heart Health Program

	Relative weight (% of ideal)		Serum cholesterol (mg/dl)		Systolic blood pressure (mm Hg)	
Age (yr)	Diabetics	Nondiabetics	Diabetics	Nondiabetics	Diabetics	Nondiabetics
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Rural						
45–54	122 (19)	105 (15)	210 (51)	195 (37)	139 (20)	122 (19)
55–64	116 (17)	102 (15)	201 (46)	195 (39)	138 (25)	129 (23)
Urban						
45–54	124 (17)	117 (18)	217 (52)	206 (41)	133 (21)	129 (21)
55–64	121 (18)	114 (19)	213 (46)	202 (42)	141 (26)	136 (24)

All mean differences between diabetic and nondiabetic groups are significant statistically (P < 0.05) except for serum cholesterol in rural men aged 55 to 64.

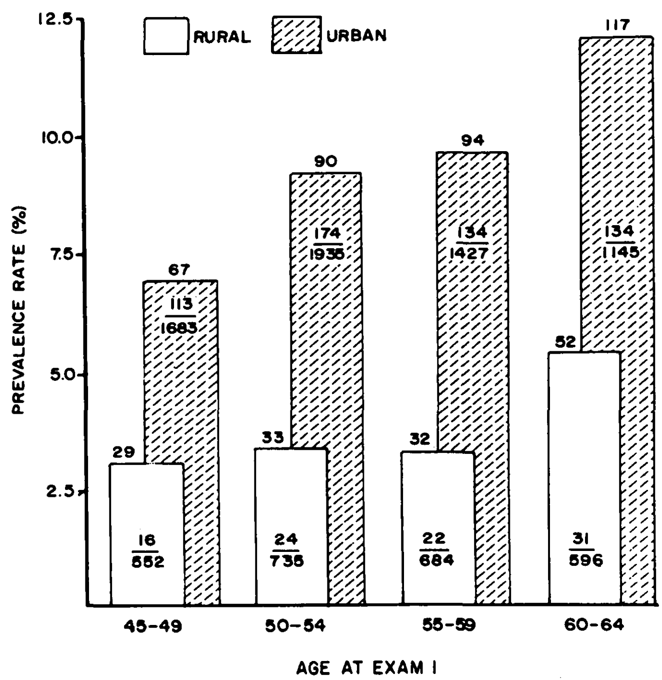
from zero. In addition, as Table 1 shows, among the diagnosed diabetics the percentages on different types of treatment are roughly equal, which indicates comparable severity of diagnosed cases in the two areas.

RELATION TO BIOLOGIC VARIABLES

In Tables 3 and 4 are presented the mean values of several characteristics at the initial examination for diabetics and nondiabetics. On the average, diabetics had higher relative weight, serum cholesterol, blood pressure, and fasting triglyceride. The differences did not appear to vary with age. The triglyceride differences were particularly striking, with diabetics showing a level 50 mg/dl higher than that of nondiabetics.

Prevalence of diabetes rises as sharply as the relative weight at all ages. The lower prevalence of diabetes in the rural area might be attributed to a lesser degree of obesity. However, when classified by relative weight, urban men with relative weights under 125 show a prevalence rate of diabetes twice that of rural men with the same relative weights. In the obese the urban-rural differential disappears, and the prevalence is uniformly high (Figure 3).

FIGURE 2. Prevalence rates of diabetic men aged 45 to 64 yr. Numbers at tops of columns are prevalence rates, numerators are numbers of diabetics in each category, and denominators are numbers of subjects in each category.



FAMILY HISTORY

A history of diabetes in parents or siblings doubles the probability of diabetes (Table 5). If there was a history of diabetes in at least one parent and one sibling, the prevalence rate was multiplied at least threefold. Even among those with a positive family history, diabetes was more prevalent in the urban area.

PERIPHERAL VASCULAR DISEASE

The prevalence of peripheral vascular disease (PVD) was associated with the presence of diabetes. Diabetics had a prevalence rate of PVD five times that of nondiabetics (3.0%, 0.6%). This relationship was observed in both the urban and rural populations.

In Table 6 is shown the prevalence of PVD by age group and diagnostic category for diabetes. Urban and rural groups were similar and have been aggregated

TABLE 4
Mean value of fasting triglycerides by diabetic status
Men aged 45 to 64
Puerto Rico Heart Health Program

	Diabetics			Nondiabetics		
Age (yr)	No. of subjects	Mean	(SD)	No. of subjects	Mean	(SD)
Rural						
45–54	29	166	(67)	771	125	(67)
55–64	37	186	(135)	751	127	(77)
Urban						
45–54	191	232	(241)	1942	164	(133)
55–64	167	190	(151)	1397	143	(93)

All mean differences between diabetic and nondiabetic groups are significant at the 1% level.

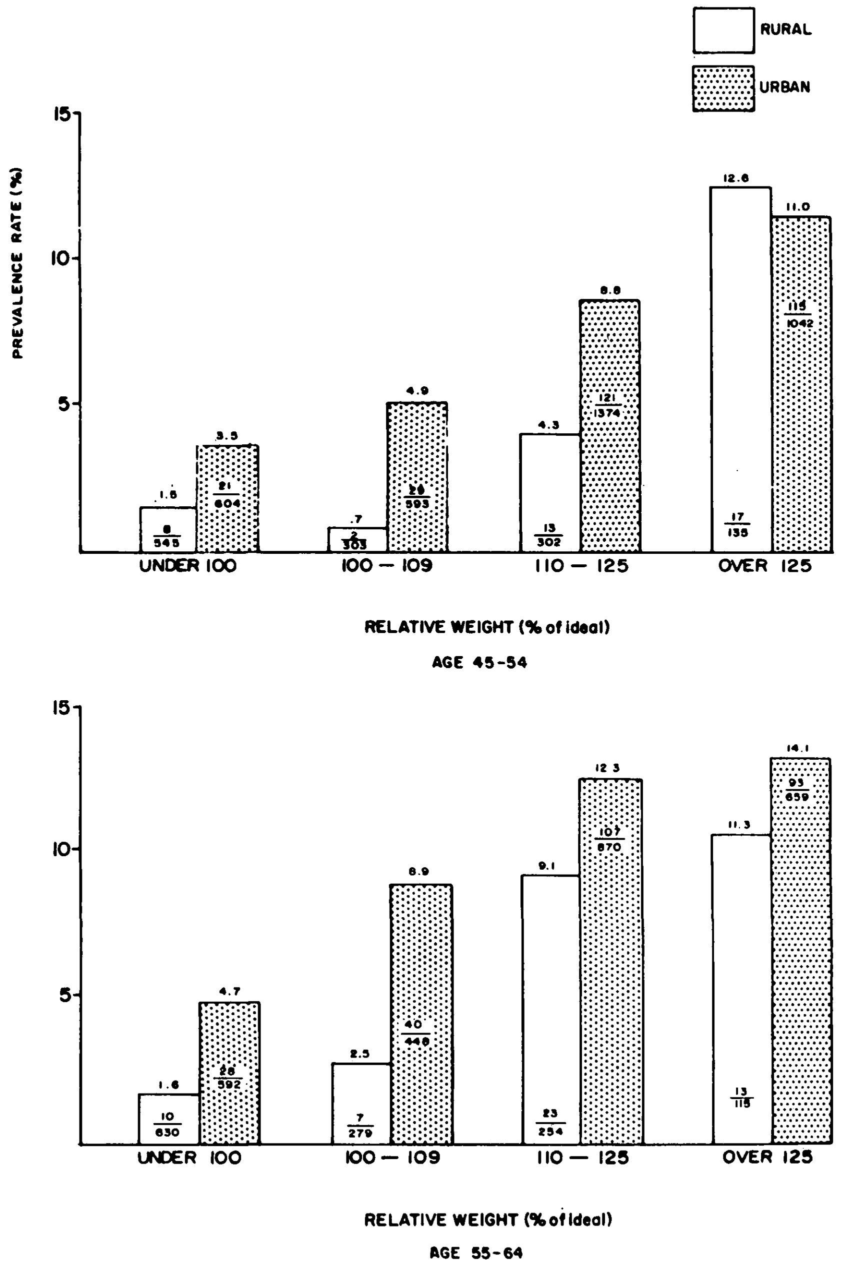


FIGURE 3. Prevalence rates of diabetes by levels of relative weights in men aged 45 to 64 yr. Numbers at tops of columns are prevalence rates. Numerators are numbers of diabetics in each category, and denominators are numbers of subjects in each category.

because of the small numbers. PVD is about three times as common in those with diabetes as in those without.

An analysis of the criteria by which PVD was diagnosed showed that, in each age-residence-diabetes history-blood sugar category, about half the cases were diagnosed by a positive Ratschow's test plus absent pulses or temperature difference. The distribution by criteria is shown in Table 7. Since Ratschow's test was done after the history was taken, there might have been some bias due to the examiner's knowledge of the subject's history. However, the fact that diagnoses by Ratschow's test are equally common in those with and without a history of diabetes indicates that there was little bias of this type.

TABLE 5
Diabetes prevalence rates (%) by family history
Men aged 45 to 64
Puerto Rico Heart Health Program

Age (yr)	Area of residence	Family history			
		No history	Parent(s) only	Sibling(s) only	Parent(s) and sibling(s)
45–54	Rural	2.2	5.5	9.9	18.8*
	Urban	6.3	12.6	12.0	22.0
55–64	Rural	2.7	21.3	9.7	30.8*
	Urban	7.8	17.2	21.9	54.5

* Fewer than 30 subjects in these categories.

DISCUSSION

Diabetes prevalence in this Puerto Rican population has been shown to be associated with systolic blood pressure, serum cholesterol, serum triglyceride, relative weight, family history, peripheral vascular disease, age, and area of residence. These relationships confirm results of epidemiologic studies in other populations. While the prevalence rates per se cannot be compared among studies employing widely varying criteria, interval contrasts *within* the Puerto Rican study and others can be made, since

TABLE 6
Prevalence of peripheral vascular disease by age group and by criterion for diagnosis of diabetes

	No. of cases PVD	Total population	Percent prevalence
Ages 45–54 yr			
No history, BS < 140	12	4578	0.3
No history, BS > 140	3	111	2.7
History, BS < 140	3	135	2.2
History, BS > 140	2	91	2.2
All diabetics	8	337	2.4
Ages 55–64 yr			
No history, BS < 140	36	3531	1.0
No history, BS > 140	4	88	4.5
History, BS < 140	2	119	1.7
History, BS > 140	6	114	5.3
All diabetics	12	321	3.7

(BS, Blood sugar in milligrams per deciliter; PVD, peripheral vascular disease.)

TABLE 7
Number of cases of peripheral vascular disease diagnosed by various criteria

Criterion	Number
Single criterion	
Intermittent claudication	15
Amputation due to PVD	1
Positive Ratschow's test plus temperature difference or absent pulses	35
Multiple criteria	
Intermittent claudication and positive Ratschow's test plus temperature difference or absent pulses	13
Amputation and positive Ratschow's test plus temperature difference or absent pulses	3
Intermittent claudication and amputation	1

standardized criteria are applied uniformly to all population segments within each study.[8] In Israel, diabetes prevalence was associated with age, serum cholesterol, blood pressure, obesity, and peripheral vascular disease.[9] A Jamaican study showed results similar to the Israeli study and also showed a relationship to triglycerides.[10] In the Framingham study, associations with blood pressure, relative weight, and prebeta lipoproteins but not with serum cholesterol were noted.[11] The Framingham study also resulted in an association with cardiovascular diseases that was especially strong for intermittent claudication.

The higher prevalence of diabetes in the urban area was consistent with that found by a study in Trinidad.[12] Using criteria different from ours, even more striking urban-rural differences were found, especially among men of East Indian extraction.

In the Puerto Rican study, there is a substantial correlation between triglyceride and relative weight (r = 0.37 in rural, r = 0.20 in urban), but the triglyceride levels are higher in diabetics at all relative weight levels, even the lean (Figure 4). Thus the elevated triglycerides found in diabetics do not seem to be a consequence of the individual's obese status.

The reason for the twofold diabetes prevalence in the urban area is elusive. While the Puerto Rican study reports higher relative weight in the urban area, this does not account fully for the excess prevalence. At low relative weight, there is still an excess of diabetes in the urban population. On the other hand, in obese men, there is no difference between the urban and rural prevalence rates.

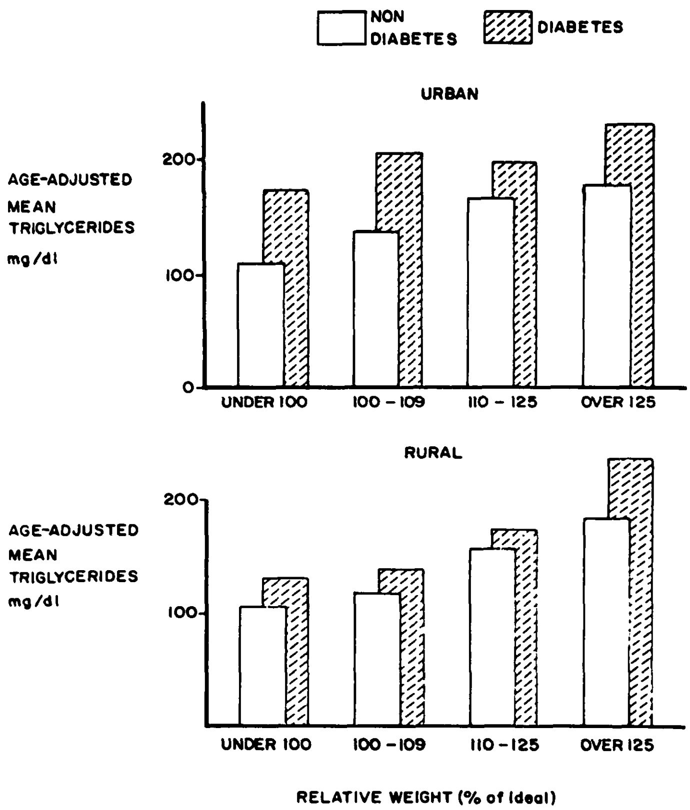


FIGURE 4. Mean values of fasting triglyceride concentrations by levels of relative weights in men aged 45 to 64 yr.

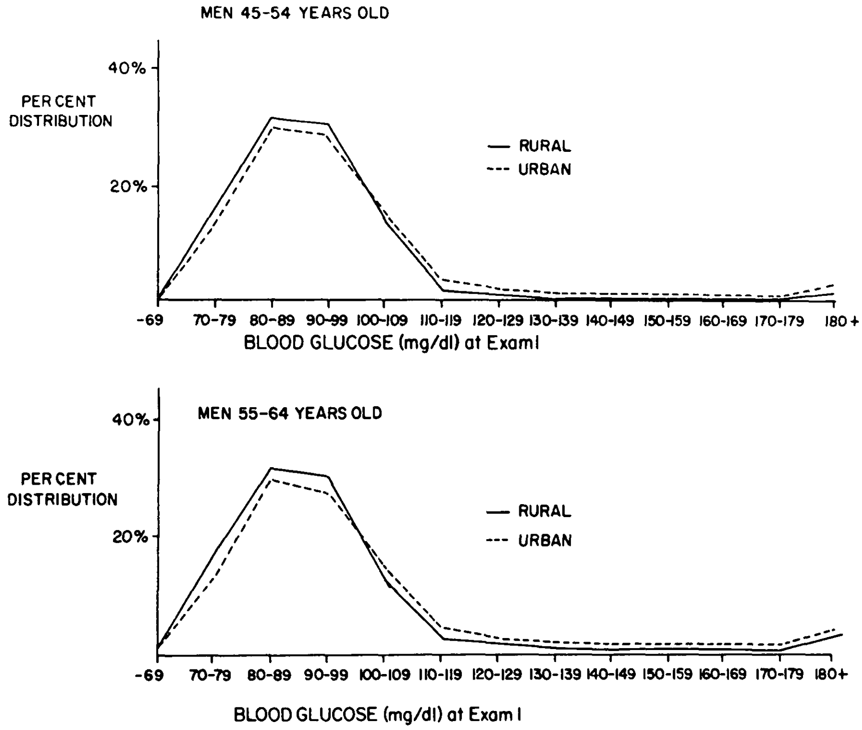


FIGURE 5. Frequency distribution of casual blood glucose concentrations at examination 1.

It appears, then, that some unidentified factor in the urban area increases the prevalence of diabetes, or, conversely, that a protective factor in the rural area reduces the prevalence. This factor is not a spurious result arising from differential case finding, since there is a higher prevalence of diabetes in the urban area on the basis of elevated blood glucose alone.

An examination of the entire distribution of casual blood sugar concentrations in the urban and rural areas suggests that the disparity in the prevalence of diabetes derives almost entirely from a uniform shift upward in the entire distribution of blood sugar in the urban as compared with the rural population (Figure 5). This of course results in a higher proportion appearing above the arbitrary cut-off points designated for diabetes. The differences in mean values and in percentiles at the upper end are significant statistically. This suggests that, whatever factor is responsible, it is one that is probably ubiquitous in the population rather than some specific agent.

One explanation is selective migration. It is possible that the less healthy individuals have left the rural areas to be closer to health services. The rural emigrants have a prevalence rate similar to that of the rest of the urban population, though it is certainly not clear if this is due to the new urban environment or ill health, which precipitated a move to the city (Table 8). Since we do not have information as to when diabetes was diagnosed relative to the migration date, we cannot exclude selective migration as a possible explanation for urban-rural differences. However, the fact that the entire distribution of blood glucose shifts upward in the urban population makes it unlikely that the higher blood sugars are a consequence of selective migration of diabetics from the rural environment. Whatever the explanation of migration differences the urban-rural difference cannot be explained by this emigration, since the prevalence rates of lifetime urban dwellers are still higher than the rate of the combined population of rural residents and emigrants.

TABLE 8
Diabetes prevalence rates by migration status
Men aged 45 to 64
Puerto Rico Heart Health Program

	45–54 yr			55–64 yr		
	Number			Number		
	Diabetics	Population	Prevalence rate (%)	Diabetics	Population	Prevalence rate (%)
Now rural	40	1285	3.1	52	1272	4.1
Now urban						
Moved from rural 0–7 yr ago	19	250	7.6	18	176	10.2
Moved from rural 8+ yr ago	40	555	7.2	49	501	9.8
Moved within urban areas	182	2113	8.6	152	1350	11.3
Never moved	45	686	6.6	49	538	9.1

The data suggest that, in addition to further pursuit of inherent metabolic causes, the search for environmentally related determinants would be fruitful. Whatever the mechanism, the prime candidate for diabetes in Puerto Rico would appear to be an obese, aging, urban dweller with a tendency to hypertension, hyperlipidemia, and a strong family history of the disease.

However, chronic etiologic factors that may be present in the urban environment would not be expected to have the immediate effect of raising the prevalence rates in those recent emigrants to the urban area. Clarification of reasons for differences by migration is not possible with the data available, since it will be necessary to have information on the age of diabetes onset in relation to emigration.

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