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Several studies have clearly shown the impact of modernization on the prevalence of diabetes mellitus in susceptible communities. Saudi Arabia has faced a rapid development program over the last two decades. In a recent study, we found a high prevalence of diabetes mellitus in urban Saudi Arabia. A total of 5222 rural subjects of both sexes were involved in a study of the prevalence of diabetes mellitus in the western region of Saudi Arabia. Random capillary blood glucose, body weight and height, and income were recorded. The results showed an overall prevalence of 4.3%. There was a rise of prevalence with age and higher-income groups. Prevalence also differed with sex. The overall prevalence in women (5.9%) was twice that for men (2.9%; $P < .001$). Obesity occurred in 41.2% of our diabetic subjects compared to 29.3% in nondiabetic subjects ($P < .001$). Multiple logistic regression analysis with body mass index (BMI) as the dependent variable showed that sex and income status were significant factors ($P < .0001$ and $P < .04$, respectively). When blood glucose was fixed as the dependent variable, the analysis showed that age, income, and BMI were significant factors ($P < .004$, $P < .0001$, and $P < .045$, respectively). *Diabetes Care* 10:180–83, 1987

Over the last two decades, Saudi Arabia has faced a rapid socioeconomic development that has reflected on many aspects of the life-style of the population and to a great extent on the patterns of diseases generally. In a recent epidemiological study, the prevalence of diabetes mellitus in urban Saudi Arabia was estimated to be 4.95% (1), which is a relatively high rate compared with other developing countries (2). Several epidemiological studies worldwide have clearly shown differences in the prevalence of diabetes mellitus in urban versus rural areas (3,4). We estimate the magnitude of the diabetes mellitus problem in rural Saudi Arabia.

MATERIALS AND METHODS

Our study is part of a major survey regarding the prevalence of diabetes mellitus in the western region of Saudi Arabia. It was performed in the rural districts of Bahrah, Haddah, Asafan, Khulleis, and Leith. The total population in these areas was estimated to be 60,000.

A sample fraction of 10% of the estimated population was used. Because of the unavailability of detailed dwelling maps, populations were sampled by selection of clusters of houses. Twelve hundred families (including ~6000 subjects) were approached, 997 of whom responded. This yielded 5222 subjects, who formed 87% of the target sample population. Of these, 53.1% were men and 46.9% were women.

Interviews and measurements were performed in local health centers. Details such as name, address, age, and sex were recorded. The socioeconomic status of one in every five subjects, determined by occupation and income, was also recorded. Subjects were classified by income according to the Saudi Arabian Civil Service Bureau scheme (5).

Body weight (kg) and height (cm) were recorded for all adult subjects aged ≥15 yr. The body mass index [BMI; calculated as weight (kg)/height (m^2)] was used as an index of obesity. Men and women were considered obese if their BMI was >27.0 and >25.0, respectively (6).

Random blood glucose was estimated in each subject. Blood was obtained by a finger prick with disposable Autoclix lancets. Blood glucose was estimated with Hemo-Glukotest strips (BM-20-800R; Boehringer-Mannheim, Indianapolis, IN) tested with Reflolux machines (Boehringer-Mannheim). All tests were performed in the morning between 0800 and 1200 h. Fasting subjects (i.e., those who did not have breakfast on the day of testing) were excluded.

Subjects who had a random capillary blood glucose of ≥200 mg/100 ml (11 mM) were considered diabetic and

TABLE 1
Frequency of random blood glucose level (mg/100 ml) in different age groups

	<140		140–199		≥200		Total	
Age (yr)	*N*	%	*N*	%	*N*	%	*N*	%
0–14	2006	98.7	24	1.2	3	0.15	2003	100
15–34	1762	96.8	35	1.9	24	1.3	1821	100
35–54	798	96.8	35	5.7	85	9.1	936	100
≥55	358	82.9	31	7.2	43	9.9	432	100
Total	4924	94.3	143	2.7	155	2.9	5222	100

were referred to the King Abdulaziz University Hospital for confirmation of diagnosis and follow-up. Subjects with a random capillary blood glucose of <140 mg/100 ml (8 mM) were considered normal and were not followed up further. Subjects whose random capillary blood glucose was in the range of 140–199 mg/100 ml (8–11 mM) underwent a glucose tolerance test at the King Abdulaziz University Hospital. The morning after an overnight fast, subjects were given a glucose load of 75 g in 300 ml of water. Blood glucose was estimated as fasting, 30 min, 1 h, and 2 h after the glucose load. Plasma glucose was estimated by a glucose analyzer (Beckman, Fullerton, CA) with specific enzymatic glucose assay. The WHO criteria for diagnosis of diabetes mellitus were applied (7).

Data were processed and analyzed at the King Abdulaziz University Computer Centre. χ^2-Tests were used to determine the differences between proportions. Multiple logistic regression analysis was used to assess the variation of blood glucose with age, sex, social class, and BMI as well as the variation of BMI with age, sex, and income status.

RESULTS

Overall prevalence rates. A total of 155 subjects had initial random capillary blood glucose levels ≥200 mg/100 ml (11 mM). All these subjects were confirmed as diabetic by a second blood glucose testing at King Abdulaziz University Hospital. Moreover, 143 subjects had an initial random capillary blood glucose between 140 and 199 mg/100 ml (8–11 mM). After being subjected to an oral glucose tolerance test, this group was further classified: 69 patients (48.3%) proved to be diabetic, 58 (40.6%) had impaired glucose tolerance, and 16 (11.1%) were normal. Thus, the total number of diabetic subjects was 224, forming an overall prevalence rate of 4.3% (Table 1).

Age- and sex-specific prevalence rate. The prevalence of diabetes mellitus rose with age in both sexes. In men the rate rose from 1.04% in subjects aged 0–14 yr to a maximum of 10.2% in subjects ≥55 yr. In women the rate rose from 0.3% (0–14 yr) to a maximum of 18.7% (≥55 yr). The overall prevalence rate was 2.9% in men and 5.9% in women (1:2); the difference was statistically significant ($P < .001$). For subjects ≥15 yr of age, the prevalence was 4.02% for men and 9.5% for women (1:2.4); the difference was statistically significant ($P < .001$) (Table 2).

Prevalence of diabetes mellitus and income. The distribution of 1456 subjects by income is shown in Table 3 (U.S. $1.00 = 3.65 SR). Subjects with monthly income >7500 SR are few (0.4%). On the whole, prevalence of diabetes mellitus tends to be high among high-income groups ($P < .001$).

Obesity. Among adult subjects (≥15 yr) the rate of obesity among diabetic subjects (41.2%) was significantly higher than that among normal subjects (29.3%; $P < .001$). In men the obesity rate was significantly higher among diabetic subjects (39.1%) than in normal subjects (21.3%; $P < .001$). Women did not have a significant difference in the rates of obesity in diabetic (42.1%) and normal (39.3%) subjects (Table 4).

To assess the effect of income levels on BMI, income groups were classified as high (>6000 SR/mo), average (4500–6000 SR/mo), and low (<4500 SR/mo). Obesity rates were calculated for each income group that was subclassified by age. In normal subjects aged 15–34 yr, obesity rates were higher in average- and high-income groups than in the low-income group ($P < .001$ in each group). In subjects aged 35–54 yr, obesity rates showed a similar trend ($P < .02$ and $P < .001$, respectively). In subjects ≥55 yr, there was a stepwise increase in the three income groups, reaching statistical significance in the high-income compared with the low-income group ($P < .05$). A similar pattern emerged in all age groups of diabetic subjects, although the difference in rates did not reach statistical significance.

In regard to the effect of age on obesity in the different income groups, normal subjects showed a higher obesity rate

TABLE 2
Age and sex prevalence of diabetes mellitus in rural Saudi Arabia

	Men			Women			Men and women combined		
Age (yr)	Subjects studied (*N*)	Subjects with diabetes (*N*)	%	Subjects studied (*N*)	Subjects with diabetes (*N*)	%	Subjects studied (*N*)	Subjects with diabetes (*N*)	%
0–14	1058	11	1.04	975	3	0.3	2033	14	0.7
15–34	990	10	1.0	831	31	3.7	1821	41	2.3
35–54	459	32	7.0	477	79	16.6	936	111	11.9
≥55	266	27	10.2	166	31	18.7	432	58	13.4
Total	2773	80	2.9	2449	144	5.9	5222	224	4.3

TABLE 3
Prevalence of diabetes mellitus in various income groups

Monthly income (SR)*	Subjects (N)	%	Diabetic subjects (N)	%
1500	435	29.9	30	6.9
3000	506	34.8	37	7.3
4500	393	26.9	56	14.2
6000	116	7.9	31	26.7
>7500	6	0.4	0	0.0

$\chi^2 = 49.9$, $P < .001$.
*SR, Saudi riyals (U.S. $1.00 = 3.65 SR).

at 35–54 yr than at 15–34 yr in the low-, average-, and high-income groups. The increase was statistically significant only in the low- and average-income groups ($P < .001$ and $P < .05$, respectively). In diabetic subjects there was a similar trend, reaching statistical significance only in the average-income group ($P < .05$).

In normal subjects aged ≥55 yr there was an increased rate of obesity in the low-income group ($P < .001$). However, there was a reduction in obesity rate in the average- and high-income groups. In diabetic subjects the obesity rate was reduced in all income groups (Table 5).

Multiple logistic regression analysis with BMI as the dependent variable showed that sex and income status were significant factors ($P < .0001$ and $P < .04$, respectively). When blood glucose was fixed as the dependent variable, analysis showed that age, income, and BMI were significant factors ($P < .004$, $P < .0001$, and $P < .045$, respectively; Table 6).

DISCUSSION

The general effect of the rapid modernization on the prevalence of diabetes mellitus appears to have affected both rural and urban populations in Saudi Arabia, although it appears to be more evident in the urban population, where the overall prevalence is 4.95% (1) compared to 4.3% in the rural areas. The impact of such rapid improvement in socioeconomic standards has been shown in several susceptible communities (3,4,8).

It is difficult to analyze in detail the aspects and the magnitude of the socioeconomic changes that occurred in the villages screened. The introduction of essential basic amenities such as electric and water supply, roads with easy accessibility to the cities, and educational and health facilities has contributed to the transformation of the villagers' seminomadic life-style, which was still evident until recently. Now, at least one member of a village family is fully or partly employed in the cities. The average income has more than tripled in the last decade, and a large proportion of caloric dietary intake is imported canned and frozen foods. The above factors have led to a dramatic change in life-style, diet, and exercise patterns of the rural population. The magnitude of these changes was discussed by Sebai (9).

In agreement with other studies, obesity appears to be an important underlying factor in diabetic men (10). However, although obesity affected a higher percentage of the population studied, no significant difference was noted between diabetic and nondiabetic women. We also found a concomitant increase in the prevalence with age, a finding previously reported by several workers (11–13).

TABLE 4
Obesity rates in adult diabetics and nondiabetics in rural Saudi Arabia

	Men	Women	Total
Diabetic subjects (N)	69*	141	210
With obesity (N)	27	60	87
%	39.1	42.4	41.4
Nondiabetic subjects (N)	1646	1315	2961
With obesity (N)	351	517	868
%	21.3*	39.3	29.3

*$\chi^2 = 12.22$, $P < .001$.

TABLE 5
Distribution of obesity among normal and diabetic subjects according to income status and age

	Low income (<3000 SR)		Average income (3000–6000 SR)		High income (>6000 SR)	
Age (yr)	Normal	Diabetic	Normal	Diabetic	Normal	Diabetic
15–34						
N	591	10	233	8	51	10
Obese	29	2	66	3	15	7
%	4.9	20.0	28.4	37.5	29.4	70.0
35–54						
N	122	44	74	33	15	19
Obese	29	20	36	28	8	14
%	23.8	45.5	48.6	54.5	53.3	73.7
≥55						
N	161	12	31	15	25	2
Obese	44	1	9	8	12	1
%	27.3	8.3	29.0	53.3	48.0	50.0

Obesity considered >27 BMI for men and >25 BMI for women.
SR, Saudi riyals (U.S. $1.00 = 3.65 SR).

TABLE 6
Results of multiple logistic regression analysis with body mass index (BMI) or blood glucose level as dependent variable

	BMI			Blood glucose		
Source	df	χ^2	P	df	χ^2	P
Intercept	1	0.23	0.6337	1	0.01	0.9138
Age	54	58.23	0.3225	54	85.36	0.0042
Sex	1	45.37	0.0001	1	0.02	0.8772
Income status	4	9.79	0.0442	4	48.59	0.0001
Residual	173	59.20	1.0000	241	98.00	1.0000
BMI				1	4.02	0.0450

We noted a high prevalence rate of diabetes in rural women (5.9%) as opposed to rural men (2.9%). Although this agrees with findings in developed countries (14,15), it differs from the developing countries where males predominate (2). This difference between rural women and men might be because Saudi rural men tend to be active, whereas rural women are more sedentary. Zimmet et al. (4) postulated a similar explanation in their study on rural and urban Polynesians.

The trend of increased prevalence in the lower socioeconomic group observed in urban studies performed in developed countries (16) was not observed in our study. In this respect, our data agree with the pattern observed in developing countries where prevalence of a high rate of diabetes mellitus is found in higher socioeconomic groups (17). However, obesity occurred with greater significance among higher socioeconomic groups in the studied population.

Our results from both urban and rural studies clearly show that the impact of the modernization occurring in the area over the last two decades has probably highlighted the problem of diabetes mellitus in a susceptible community. The changes in life-style, diet, exercise, and urbanization have probably contributed to the higher prevalence of the disease in the area. It is also clear that the area is passing through a transition phase in which diabetes mellitus shows a mixture of the characteristics of the disease as seen in Western societies and developing countries.

Evaluation of the consequences of cultural changes suggests that with increasing urbanization of rural Saudi populations and consequent changes in life-style due to socioeconomic changes, the prevalence of diabetes will increase further, and it might be worthwhile to try to prevent the emergence and entrenchment of social, economic, and cultural patterns of living known to elevate risk factors in the prevalence of diabetes mellitus.

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Address correspondence and reprint requests to Hassan H. Fatani, MRCP(UK), Department of Medicine, King Abdulaziz University Hospital, P.O. Box 6615, Jeddah 21452, Saudi Arabia.

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