Diabetes mellitus in Saudi Arabia

Mansour M. Al-Nozha, *MD, FRCP,* ***Mohammed A. Al-Maatouq,*** *MD, FRCP,* ***Yaqoub Y. Al-Mazrou,*** *MBBS, PhD,* ***Saad S. Al-Harthi,*** *FACHARZT,* ***Mohammed R. Arafah,*** *MD, FACC,* ***Mohamed Z. Khalil,*** *MD, MRCP(UK),* ***Nazeer B. Khan,*** *PhD,* ***Akram Al-Khadra,*** *MD, FRCP,* ***Khalid Al-Marzouki,*** *MD, FACHARZT,* ***Mohammed S. Nouh,*** *MD,* ***Moheeb Abdullah,*** *FRCP,* ***Omer Attas,*** *BSc, PhD,* ***Maie S. Al-Shahid,*** *FRCP,* ***Abdulellah Al-Mobeireek,*** *MD, FRCP.*

ABSTRACT

Objective: Diabetes mellitus (DM) is a major public health problem worldwide, and it is a known risk factor for coronary artery disease (CAD). New recommendations for the diagnosis of diabetes have changed the epidemiology of DM. Therefore, we designed this study with the objective to determine the prevalence of DM among Saudis of both sexes, between the ages of 30-70-years in rural as well as urban communities. This work is part of a major national project: Coronary Artery Disease in Saudis study (CADISS) that is designed to look at CAD and its risk factors in Saudi population.

Methods: This study is a community-based national epidemiological health survey, conducted by examining Saudi subjects in the age group of 30-70-years of selected households over a 5-year period between 1995 and 2000. Data were obtained from history, fasting plasma glucose levels, and body mass index. The data were analyzed to classify individuals as diabetic, impaired fasting glucose and normal, using 1997 American Diabetes Association (ADA) criteria, which was adopted by the World Health Organization (WHO) in 1998, to provide prevalence of DM in the Kingdom of Saudi Arabia (KSA).

Results: A total of 17232 Saudi subjects were selected in the study, and 16917 participated (98.2% response rate). Four thousand and four subjects (23.7%), out of 16917 were diagnosed to have DM. Thus, the overall prevalence of DM obtained from this study is 23.7% in KSA. The prevalence in males and females were 26.2% and 21.5% ($p<0.00001$). The calculated age-adjusted prevalence for Saudi population for the year 2000 is 21.9%. Diabetes mellitus was more prevalent among Saudis living in urban areas of 25.5% compared to rural Saudis of 19.5% ($p<0.00001$). Despite the readily available access to healthcare facilities in KSA, a large number of diabetics 1116 (27.9%) were unaware of having DM.

Conclusion: The overall prevalence of DM in adults in KSA is 23.7%. A national prevention program at community level targeting high risk groups should be implemented sooner to prevent DM. We further recommend a longitudinal study to demonstrate the importance of modifying risk factors for the development of DM and reducing its prevalence in KSA.

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Diabetes mellitus (DM) is a medical problem that can affect individual's health through involvement of several body systems. With its inevitable complications, a diabetic patient may end up crippled in a way or another, for instance: losing sight, having leg amputation, hooked up on hemodialysis machine, or suffering from congestive cardiac failure due to coronary artery disease (CAD). Therefore, healthcare providers have addressed the impact of DM and the magnitude of the problem in many countries. Fascinatingly, the prevalence of DM is highly variable among

From the Department of Medicine (Al-Nozha, Al-Maatouq, Al-Harthi, Arafah, Khalil, Nouh, Al-Mobeireek), College of Medicine and King Khalid University Hospital, Ministry of Health (Al-Mazrou), College of Dentistry (Khan), College of Science (Attas), King Saud University, Department of Adult Cardiology (Abdullah), Prince Sultan Cardiac Center, Department of Cardiovascular (Al-Shahid), King Faisal Specialist Hospital and Research Centre, Riyadh, Department of Medicine (Al-Khadra), King Fahad University, Dammam, Department of Medicine (Al-Marzouki), King Abdul-Aziz University, Jeddah, *Kingdom of Saudi Arabia*.

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Address correspondence and reprint request to: Prof. Mansour M. Al-Nozha, President, Taibah University, PO Box 344, Madina, *Kingdom of Saudi Arabia*. Tel. +966 (4) 8461172. Fax. +966 (4) 8460020. E-mail: malnozha@hotmail.com

different populations; however, it is consistently increasing with aging.[1-16] The Kingdom of Saudi Arabia (KSA) is rapidly developing country with a change that influenced the lifestyle of the people towards urbanization, particularly over the past 3 decades. Previous surveys from KSA suggested that diabetes is present in epidemic proportions throughout the country with exceedingly high rates concentrated in urban areas.[17]

Moreover, new recommendations for the classification, diagnosis and screening of diabetes, announced at the American Diabetes Association (ADA) meeting in 1997, have changed the epidemiology of DM.[18] The new diagnostic criteria suggest that the diagnosis of DM be made on the basis of fasting plasma glucose only, in-contrast to the old criteria, which were based upon an oral glucose tolerance test (OGTT).[19,20] Furthermore, it has been suggested that the OGTT should not be used for epidemiologic research, as it is an imprecise test with poor reproducibility.[21] The main purpose of the new criteria is to allow better classification of individuals and lead to fewer therapeutic misjudgments. The definitions proposed by ADA and adopted by World Health Organization (WHO) are as follows: an individual is said to have normal blood glucose when fasting plasma glucose (FPG) is <6.1 mmol/L (110 mg/dL), impaired fasting glucose (IFG) when FPG is between 6.1-6.9 mmol/L (110 and 125 mg/dL), and DM when FPG is ≥7.0 mmol/L (126 mg/dL) or a random value at or above 11.1 mmol/L (200 mg/dL).[22] None of the earlier studies of diabetes prevalence in KSA applied recommended WHO/ADA new criteria for classification of DM. Therefore; we designed this community based study, a national epidemiological health survey, to assess the prevalence of DM in KSA.

Methods. The Kingdom of Saudi Arabia encompasses four-fifths of the Arabian Peninsula has inhabitants of 20.8,000,000 with 15.6,000,000 of local population (Saudis).[23] A 5-year National epidemiological health survey to study CAD and its risk factors was conducted between 1995 and 2000. Male and female Saudi subjects aged (30-70-years), in rural and urban areas of KSA formed the target population for this study. For the purpose of the study, a Saudi is identified as a person holding (or a dependent of a holder) of a Saudi nationality identification card (SNIC). Most previous studies on DM from other part of the world focused on similar population that allows for inter-countries comparison. A sample size of 20,000 participants was the target of the study to ensure a high reliability of our estimates of the prevalence of CAD and DM. The subjects were selected using a 2 stage, stratified cluster sampling procedure, urban and rural being the stratifying factors. For practical and logistic reasons, the study population was drawn from the local primary health care centers' catchment's areas. The catchment's population of each primary care center was taken as a cluster. The Kingdom of Saudi Arabia is subdivided into 14 administrative regions and samples were selected from each region. The first stage-sampling units were 1,623 primary health centers (PHC) uniformly distributed in KSA. Since the establishment of the primary health centers was dictated by the population in each region, the allocation of the required number of PHCS were made proportional to be the number of PHCS in each region. Then, each region was stratified into urban and rural communities and a simple random sample of PHCS was selected. The number of PHCS to be selected from each community was based on the total number of PHCS in each rural and urban community. A total of 66 PHCS were selected from urban and 58 from rural areas. Then block (blocks) was randomly selected from the catchments areas of each selected primary care center and used as cluster. One hundred households from urban PHCS and 50 households from rural PHCS were selected from these blocks. All subjects of age group of 30-70-years of selected households were interviewed and examined. The questionnaire was developed, pre-tested, and validated in a pilot study. The questionnaire included basic demographic data, as well as detailed history of DM. A clinical examination was performed, which included height, weight, blood pressure, and waist circumferences. Laboratory data included fasting plasma glucose (FPG), and fasting lipids. Well-trained primary care physicians conducted a clinical examination including measurement of blood pressure. Weight was measured with ordinary scales with indoor clothing on without shoes on to the nearest 0.1 kg. Height, waist and hip measurements were carried out to the nearest mm by using measuring tape. Trained technicians, under the supervision of primary care physicians, collected a 20 cc of fasting blood (12 hour fasting), in 2 tubes of 10 cc each. Tubes were immediately kept in refrigerator for at least 30 minutes and no more than 4 hours before centrifugation. Centrifugation was carried out for 30-minutes at 3000 RPM in refrigerated centrifuger at 4°C. Plasma and serum were separated and were frozen at -20°C immediately. These samples were transported frozen in ice to the co-coordinating laboratory in the region where they were kept frozen at -20°C. At the end of the sample collection from all participants in the region, it was transferred frozen in ice in incubators to the central laboratory at the College of Science, King Saud University, Riyadh, KSA. Glucose test was performed using a method that employs glucose oxidase and modified

Trinder color reaction catalyzed by the enzyme peroxidase. All biochemical parameters were analyzed on a clinical analysis (Konelab, Intelligent Diagnostics system, Helsinki, Finland). The instrument was calibrated prior to analysis using quality control samples provided with the solutions Standard International Units (mmol/L) were used to record the results. The intra and inter assay coefficients of variation were 1.7% and 2.6%. The number of patients who were diagnosed to have DM was established according to the new ADA/WHO criteria.[22]

The data were analyzed using the Statistical Package for Social Sciences (Version 10.0) on PC. The estimate of DM prevalence rate is calculated for the total sample, and sub groups of gender, area of residence and age groups.

Results. Four thousand and four subjects, out of 16917 were diagnosed to have DM (FPG ≥7.0 mmol/L). Thus, the overall prevalence of DM obtained from this study is 23.7%. The number of subjects who had FPG in the impaired fasting glucose range (6.1-6.9 mmol/L) was 2388 (14.1%). **Table 1** shows the prevalence of DM and impaired fasting glucose (IFG) categorized by gender. Diabetic male subjects were overall having higher prevalence of 26.2% [95%CI: (25.2-27.2)] compared to female subjects of 21.5% [95% CI: (20.6-22.4)] and this was statistically significant (p<0.0001). The age adjusted DM prevalence for male and female by age group of year 2000 were 22.4% and 21.5%. There were no significant statistical difference between males and females in the overall prevalence of IFG, and the age adjusted rate is 13.9%. **Table 2** shows the prevalence of DM as well as IFG by gender, age groups, residence, and region. The prevalence of DM is shown to be increasing proportionally with age reaching 36.5% at age 60-70 years, while subjects in the age range between 40-59 years are having higher rate of IFG (p<0.0001). The data in **Table 2** also demonstrate an alarming 14.1% of Saudis have impaired fasting glucose (IFG) leaving 62.2% with normal fasting plasma glucose levels. Comparing the prevalence of DM by gender at different age groups shows that male subjects in the age range of 30-49-years had higher prevalence than female subjects in the corresponding age range that makes the prevalence of male subjects significantly higher than female subjects. Clearly, as females get older than 50-years their DM prevalence increases to nearly equalize or slightly higher rates than that of males in similar age range. Diabetes mellitus was found to be significantly more prevalent among Saudis living in urban areas of 25.5% compared to those in rural areas of 19.5% (p<0.0001). Moreover, comparing different regions of KSA revealed the highest prevalence of DM is observed in the northern region of 27.9%, while the southern region has the lowest prevalence of 18.2% (p<0.0001).

The central obesity defined as waist circumference ≥102 cm for males and ≥ 88 cm for females, is well correlated with higher prevalence of DM as well as IFG as shown in **Figures 1a & 1b**. The prevalence of DM in females is doubled in subjects with central obesity (p<0.0001). Similarly, the prevalence of DM was found to be nearly 40% higher for males with larger waist circumference (≥102 cm), and it was statistically significant (p<0.0001). **Figure 2** shows that the mean BMI was 29.6 Kg/m^2 for diabetic subjects, which is significantly different than subjects with normal FPG with mean BMI of 28 Kg/m^2. A comparison with previous studies carried out in KSA is presented in **Table 3** which demonstrate a strikingly higher prevalence in our study.

Table 1 - Prevalence of diabetes mellitus (fasting plasma glucose ≥7.0 mmol/L) and impaired fasting glucose (fasting plasma glucose: 6.1 to 6.9 mmol/L) categorized by gender.

Prevalence	Male (%)	Female (%)	Total (%)	*p* value
Diabetic (≥7.0mmol/L)				
Crude prevalence	26.2	21.5	**23.7**	
95% confidence interval	(25.2-27.2)	(20.6-22.4)	**(23.1 - 24.3)**	p<0.0001
Adjusted by age group*	22.4	21.5	**21.9**	
Impaired fasting glucose (6.1 - 6.9 mmol/L)				
Crude prevalence	14.4	13.9	**14.1**	
95% confidence interval	(13.6-15.2)	(13.2-14.6)	**(13.6-14.6)**	p=0.396
Adjusted by age groups*	14.2	13.9	**13.9**	

*The position of respective age groups of census report of year 2000 was used for age adjustment

Table 2 - Prevalence of impaired fasting glucose and diabetes mellitus categorized by different demographic factors.

Factors	Normal ≤6 mmol (%)	Impaired 6.1-6.9 (%)	Diabetic ≥7 mmol (%)	*p*-value
Gender				
Male	4754 (59.4)	1149 (14.4)	2099 (26.2)	*p*<0.0001
Female	5691 (64.6)	1224 (13.9)	1889 (21.5)	
Age groups				
30-39	4387 (75.8)	700 (12.1)	701 (12.1)	
40-49	2959 (62)	716 (15)	1099 (23)	*p*<0.0001
50-59	1714 (50.5)	532 (15.7)	1149 (33.8)	
60-70	1385 (48.6)	425 (14.9)	1039 (36.5)	
Gender				
Male 30-39	1538 (73.5)	283 (13.5)	271 (13)	
40-49	1303 (61.7)	305 (14.4)	504 (23.9)	
50-59	978 (51)	296 15.4)	642 (33.5)	*p*<0.0001
60-70	935 (49.7)	265 (14.1)	682 (36.2)	
Female 30-39	2849 (77.1)	417 (11.3)	430 (11.6)	
40-49	1656 (62.2)	411 (15.4)	595 (22.4)	
50-59	736 (49.8)	236 (16)	507 (34.3)	*p*<0.0001
60-70	450 (46.5)	160 (16.5)	357 (36.9)	
Residence				
Urban	6971 (59.9)	1701 (14.6)	2975 (25.5)	*p*<0.0001
Rural	3554 (67.4)	687 (13)	1029 (19.5)	
Region				
Central	2461 (63.4)	503 (13)	919 (23.7)	
Northern	847 (58)	206 (14.1)	408 (27.9)	
Southern	2348 (68.3)	465 (13.5)	627 (18.2)	*p*<0.0001
Western	3344 (60.9)	791 (14.4)	1353 (24.7)	
Eastern	1525 (57.7)	423 (16)	697 (26.4)	
Total	**10525 (62.2)**	**2388 (14.1)**	**4004 (23.7)**	

Table 3 - Prevalence of diabetes mellitus in the Kingdom of Saudi Arabia.

Author	Prevalence of diabetes mellitus %	Age of subjects	Sample size	Year published	Reference
Fatani et al	Overall=4.3%		5222	1987	27
Al-Nuaim	***Urban*** Males 12% Females 14% ***Rural*** Males 7% Females 7.7%	>15 years	13177	1997	32
El-Hazmi et al	Males 5.86% Females 4.83%	2-77 years	25337	1998	31
Warsy et al	Males 9.7% Females 7%	>14 years	14660	1999	32
Al-Nozha et al	Overall 23.7% Males 26.2% Females 21.5%	30-70 years	16917	2004	Present study

Discussion. The data obtained from this community based study report an overall prevalence of DM of 23.7% in KSA. Clearly, a substantially higher prevalence than what has been reported by previous studies for KSA. The observed increase in diabetes prevalence in KSA obtained from our study is likely to be explained by several factors. In comparison to previous studies that looked at the prevalence of DM among Saudi population, our subjects are selected in older age group of 30-70-years. Obviously, this plays an important factor of the higher prevalence of DM, as it is well known that diabetes prevalence increases with age. Another possible reason is the fact that risk factors for developing DM are also increasing in KSA, particularly, obesity and sedentary life with lack of physical activity. Moreover, the diagnosis of DM, obtained from our study, was based on the new criteria endorsed by the ADA and adopted by WHO in 1998. It has been shown that the new criteria classified more subjects to be diabetics compared to the old fasting criteria.[24] Probably, the proposed change in the diagnostic criteria for diabetes has lead to earlier diagnosis among individuals who are destined to develop the disease. Nonetheless, the higher prevalence of DM shown by our study is likely to be attributed to increasing incidence of DM in KSA reflecting a true increase in prevalence. We conducted this study by examining Saudi population from selected households in all regions of KSA (central, northern, southern, western, and eastern). Diabetes mellitus prevalence is shown by our data to be highest among the Northern Saudi population of 27.9% followed by the Eastern region of 26.4%, then Saudis from the Western region of 24.7%, and from the Central region of 23.7%, whereas the lowest prevalence was from the Southern region of 18.2% ($p<0.00001$). The possible causes to explain lower prevalence of DM in the southern region is probably due to more individuals live in rural areas with more physical activity and lower rates of obesity. Furthermore, the data obtained from our study indicate a higher prevalence of DM among Saudis living in urban areas of 25.5% compared to rural Saudis of 19.5% ($p<0.00001$). Apparently, the reported figures from this study is alarming, demonstrating an epidemic of diabetes striking the Saudi population in all areas. Several previous studies on the prevalence of DM in KSA have reported high rates of diabetes, however, much lower than reported by our data.[25-32] Moreover, reported figures on DM prevalence from gulf region revealed variable but consistently high rates as in Bahrain of 25.7%,[33] and in Oman of 16.1%.[34] Our study showed a higher prevalence of DM among males of 26.2% compared to 21.3% in females ($p<0.0001$). Interestingly, despite the readily available access to healthcare facilities in KSA, a large number of diabetics representing 27.9% (n=1116) were unaware of having DM. Previous study on DM in KSA reported by Al-Nuaim[35] (using WHO old criteria on subjects older than 15-years) has reported DM prevalence of 12% in males, and 14% in females from urban areas, compared to 7% in males, and 7.7% in females from rural areas. In his survey, nearly half of the diabetics were newly diagnosed at the time of the study. Moreover, in the study of DM prevalence in Sultanate of Oman only one-third of Omani diabetic subjects knew that they had diabetes.[34] This improvement in the awareness of diabetes by Saudi diabetics, as shown in our study, may be explained by better screening and diagnosis of the disease reflecting the advances made in the healthcare system in KSA. Furthermore, the subjects in our study are clearly older (age range 30-70-years) indicating higher chances of being screened for DM, as well as having better health education enabling them of being aware of their health problems. Our results are consistent with data from the United States of America that showed similar improvement in the awareness of DM, as nearly half of diabetic Americans were unaware of having the disease in 1987 compared to 29% in year 2000.[36,37] We further looked at the effect of age on the development of diabetes. Our data demonstrate an increasing prevalence of DM with advancing age, ranging from 12.1% at ages 30-39-years 23% at 40-49-years, 33.8% at 50-59-years and 36.5% at 60-70-years ($p<0.00001$). The fact that diabetes is increasing with age is consistent with previous studies; nonetheless, this partially explains the observed conspicuous increase in prevalence.[38-40] Therefore, it is imperative to find plausible explanations for the rise in the number of diabetics in KSA and to formulate a strategy addressing modifiable risk factors for the development of DM that may halt its rapidly increasing prevalence. Our data show that 33.1% of male Saudis with waist circumference >102 cm, studied in this survey, are diabetics (**Figure 1a & 1b**), demonstrating an association between higher rates of DM with central obesity. This association was more evident among female subjects as 27% of those with large waist circumference (≥88cm) were having twice as much of DM compared to females of normal waist circumference (13.4%). As expected, our study shows a higher prevalence of obesity reaching 35.6% in KSA compared to the figures reported from previous data, which were lower than the current figures indicating a rise in the prevalence of obesity that goes hand in hand with the increasing prevalence of diabetes.[32,41,42] Clearly, subjects with higher BMI are likely to be either diabetics or with IFG as shown in **Figure 2**. It is well documented that obesity is a strong risk factor for the development of DM as shown by several studies.[43-49]

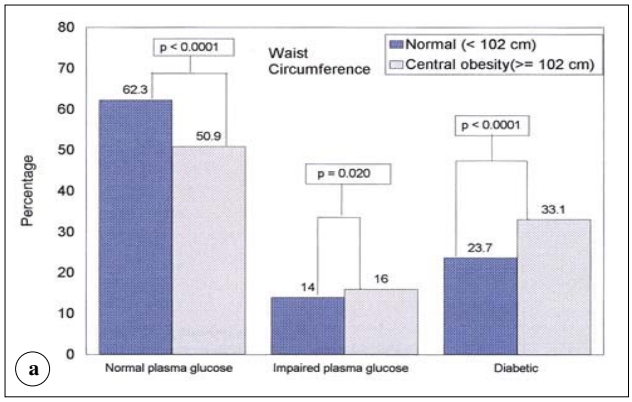

Figure 1 - Correlation of waist circumference with fasting plasma glucose **(a)** male **(b)** female.

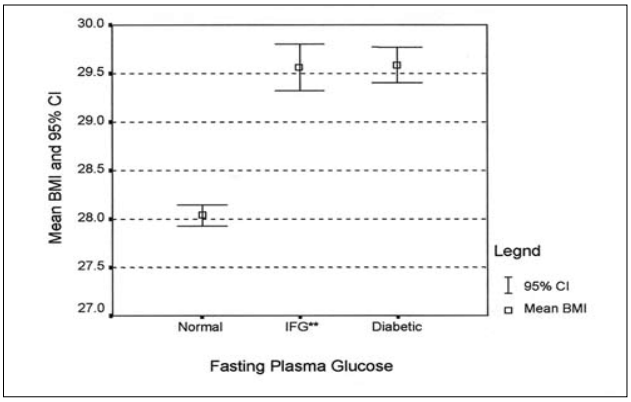

Figure 2 - Mean body mass index and 95% confidence interval for fasting plasma glucose groups. IFG - impaired fasting glucose, BMI - body mass index, CI - confidence interval.

The data obtained from our survey are representative of a major health problem evolving in KSA. Therefore, we recommend a national program targeting high risk groups to implement a preventive strategy in the form of modifying lifestyle by increasing physical activity, reducing obesity and overweight, as well as adopting healthier eating habits. It is important that we should act now, as healthcare providers, to halt the epidemic of diabetes. Furthermore, screening and management of diabetes should be the role of primary care clinics for early detection and intervention. Unless we provide the necessary funding for promoting health education and implementing a national campaign fighting diabetes, we probably remain the prey for the vicious attack of DM. Current evidence is supporting that diabetes can be prevented by changes in the lifestyles of high risk subjects.[50-52] Similarly, we recommend a large prospective trial enforcing the modification of known risk factors for the development of DM to show the significance of such intervention in reducing the prevalence of DM in KSA.

In conclusion, the overall prevalence of DM is rising in KSA reaching an alarming figure of 23.7%. A substantial number of diabetics are unaware of the diagnosis despite availability of medical care. The delay in the diagnosis of DM will eventually result in complications that impair the productivity of a person in the community increasing the burden of disease. More emphasis should be made on the role of primary healthcare clinics in the screening, management and promoting public awareness of DM. A large prospective trial is recommended to enforce the role of modifying lifestyle by increasing exercise, reducing weight, and adopting healthier eating habits on reduction of the increasing prevalence of DM in KSA.

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