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Original Article:

Risk Factors of Diabetes Mellitus in Rural Puducherry

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Abstract: Purpose: Prevalence of type 2 diabetes is increasing in India. Rural area constitutes 80% of India. Hence it is essential to understand the epidemiology for appropriate interventions. Objectives: to identify risk factors of type 2 diabetes mellitus in rural Puducherry. **Methodology:** Cross sectional study in two villages of Puducherry, India. 1403 subjects above 25 years from 2 villages. Study measured demographic variables, Body Mass Index (BMI), physical activity, family history of Diabetes Mellitus, smoking and alcohol consumption. Fasting blood glucose was measured for study subjects. Further, those with >126 mg/dl were subjected for Oral Glucose Tolerance Test. Univariate and multivariate analysis was done. Receiver Operating characteristic Curve was plotted to find out cut off for Diabetic Risk Score. **Findings:** The prevalence of type 2 Diabetes Mellitus (DM) was 5.8%. The response rate was (88%). In univariate analysis age, occupation, Socio Economic Status, BMI, physical activity, family history were significant for DM. In multivariate analysis age, BMI, family history of diabetes and occupation were significant for type 2 DM. The 'diabetes risk score' generated by the study using age, BMI and family history of DM, had specificity, sensitivity and accuracy of 54%, 77% and 76.2% respectively. The area under curve for scoring system was 0.784 (<0.05). **Conclusions**: Identified risk factors are useful for early diagnosis by using 'diabetes risk score' – thus uncovering the iceberg of disease.

Key Words: Type 2 Diabetes; Risk factors; Diabetes risk scoring.

Introduction:

Diabetes mellitus (DM) ranks twelfth in all-cause mortality worldwide.[1] One percent of Disability Adjusted Life Years (DALY) is contributed by Diabetes Mellitus.[2] In India, multicentric studies showed prevalence of diabetes as 5.4% urban and 3.4% rural in 2004.[3] Diabetes Mellitus is multifactorial disease main risk factors include modifiable variables like Body Mass Index (BMI), physical inactivity, diet, infections and non–modifiable variables like age, family history of Diabetes Mellitus.[4]

The WHO has stressed on research on diabetes epidemiology which in turn, would be helpful in carrying out appropriate interventions.[5] On the same lines, National Health Policy (NHP) 2002 recognizes the need to establish, in a longer time-frame, baseline estimates for non-communicable disease like Diabetes. The NHP further envisages that, with access to such reliable data on the incidence of various diseases, the public health system would move closer to the objective of evidence-based policy-making.[6]

Prevalence of type 2 DM in rural population is an important public health issue. There is relatively less number of studies in rural areas. However, India has 80% of its population in rural areas; hence it is important to measure the prevalence in rural areas also. The latest data on prevalence of diabetes in Pondicherry was from a study in 1984.[7] However, periodical strengthening is essential for understanding its epidemiology. The baseline data regarding the prevalence of disease and its risk factors is essential before implementation of National Program for control of Diabetes, Cardio-vascular diseases and Stroke (NPDCS). This will be useful in local modifications in planning, implementation and evaluation of the program. In view of this, the current epidemiological study of DM was under taken.

Objectives:

To study the association of socio demographic characteristics (age, sex, education, occupation, Socio-Economic Status), family history of diabetes, Body Mass Index, Physical Activity, smoking and alcohol intake with diabetes mellitus in rural Pondicherry population.

Materials and Methods:

Study Setting: The study was carried out in the two villages, Ramanathapuram and Pillaiyarkuppam, of the four villages under Rural Health Centre (RHC), the rural field practice area of Department of Preventive and Social Medicine, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry, India during January 2007 to April 2008. These villages were chosen as they were closer to the center, and they would facilitate collecting fasting blood samples in the early mornings.

Study method: Cross Sectional Study

The sample size was calculated using available prevalence studies from adjacent Tamil Nadu (lowest being 6.4%) which are geographically and socio-culturally similar to study area.[8,9] Considering α=0.05 and relative precision of 20%, the sample size was 1403. The age group above 25 years was considered as the study frame based on recommendations of WHO

STEP-wise approach to surveillance for non-communicable diseases.[10] Based on proportion of population >25 years age sample (643 and 760 from Ramanathapuram and Pillaiyarkuppam respectively) from each village was drawn. The pilot study showed that if individual subjects were chosen by random or systematic random sampling method, there was dissatisfaction among the people left out, which made poor community co-operation. Hence, instead of individual subjects as the units of sampling, streets (thereby every one above 25 years in the street) were chosen for study. Thus, of the nine streets each in both the villages, four streets in Ramanathapuram and six streets in Pillaiyarkuppam were chosen randomly using lots, so that the proportionate sampling was satisfied (629 and 794 respectively).

The subjects were interviewed with a pre-tested questionnaire regarding identification, demographic details, social and biological variables and behavioral components. Anthropometry (height and weight) was also done. The details of variables collected during the study were as follows: Education was classified based on International Standard Classification of Education.[11] The occupation of study subjects was classified as workers and non-workers as per census of India 2001. Non workers included home maker, student, elderly who has stopped working. Workers were further classified as per National Classification of Occupations.[12] Socio economic status was classified based on modified Prasad classification. Detailed family history of diabetes was taken. This was verified either by blood glucose measurement of the parents or in the person's absence, by other circumstantial evidences (physician report, diet modifications, consumption of drugs). For purposes of this study, if the response was "diabetes status of parents not known", it was assumed to be "No family history of DM". Physical activity was measured using International Physical Activity Questionnaire.[13] Smoking and alcohol as risk factors were considered only for males. Smoking was measured in terms of frequency (those who were smoking daily for 6 months), and quantum (no. of beedies/cigarettes/cheroots per day).[10] Based on tobacco content of Indian beedis, cigarettes and cheroots, Indian cigarette equivalents of beedi and cheroot was calculated and converted into cigarettes for comparability.[14,15] This was converted into pack years. The alcohol consumption pattern (amount, type and frequency) of current drinkers and past drinkers (who have stopped before 12 months) was noted and converted in terms of average alcohol consumed (g/day). These were further classified as given in table 1.[16] Height was measured using Microtoise tape with sensitivity of 0.1 cm. Weight was measured using Digital weighing machine which was calibrated. BMI was classified as per WHO guidelines.[17] During pilot study it was observed that there was lack of co-operation from people as field visits for filling questionnaire was on evening time and most men were drunk. Hence waist circumference was not included in the study.

WHO recommends glucometer to measure blood glucose for epidemiological purposes.[18] The glucometer was standardized and correlation co-efficient was 0.8. After informed consent, the interviews were made in the evening. Then they were briefed for fasting blood glucose testing in the next morning 6-8.30 AM depending upon their availability. The subjects were explained to be on overnight fasting (minimum 8 hrs). Next morning, after confirming fasting, blood glucose was measured. All those who had Fasting Blood Glucose more than 126mg/dl were subjected to OGTT on a different day as per WHO criteria.[18]

Data was analyzed by SPSS using 't' test, Chi square test/Fischer's Exact test, Somer's d test (for directional measure in ordinal variable contingency tables), Analysis of variance, Logistic regression and Receiver Operating Characteristic curve for appropriate situations.

Results:

The study was approved by JIPMER ethics committee in December 2006. Of the 1403 subjects approached within the data collection period 1223 were available for fasting blood glucose examination. The coverage of target sample was 87.2 %. Reasons for non response included non-availability for blood glucose testing on more than three visits (169) and refusal to give consent.[11] There was no significant difference in demographic distribution of study subjects (1223) with sample frame. There was no significant age difference between those who were contacted and not contacted. Further, there was 100% response for OGTT after three visits for follow up. Other baseline features are as shown in the Table 1.

Table 1: Base line features of study population

Variable	Category of variable	n	%
Age	25- 29	243	19.8
	30-39	356	29.1
	40-49	244	20
	50-59	181	14.8
	≥60	199	16.4
	Total	1223	100
Gender	Male	617	50.5
	Female	606	49.5
	Total	1223	100
Education	Never attended school	380	31.1
	Primary	117	9.6
	Secondary	596	48.7
	Post secondary	69	5.7
	Graduation	61	5
	Total	1223	100
Occupation	Skill I	441	36.1
	Skill II	296	24.2
	Skill III	9	0.7
	Skill IV	19	1.6
	Non workersβ	458	37.4
	Total	1223	100
SES (Rs)	I (>2400)	108	8.8
	II (1200 to 2,399)	300	24.5
	III (720 to 1,199)	375	30.7
	IV (360 to 719)	366	29.9
	V (<360)	73	6.1
	Total	1223	100
BMI	Under weight	276	22.8
	Normal	706	58.3
	Overweight	192	15.8
	Obese	38	3.1
	Total	1212¥	100
Physical activity	Low	259	21.2
	Moderate	604	49.4
	High	360	29.4
	Total	1223	100
Smoking	Non smokers	463	75
	<10	130	21.1
	10.1 to 20	16	2.6
	>20	8	1.3
	Total	617	100
Alcohol	Abstainers	358	58.1
	Level 1 (<39.99gms/day)	150	24.3
	Level 2 (40-59.99gms/day)	33	5.3
	Level 3 (>60gms/day)	76	12.3
	Total	617	100
Family h/o diabetes	No	1109	90.7
	Yes	114	9.3
	Total	1223	100

¥ For 11 individuals BMI could not be calculated as they had Kyphosis which hindered accurate height measurements
Smoking and alcohol only males were considered total males 617.

A total of 71 (40 known and 31 new) diabetics were identified in the study population. The prevalence was 5.8%.

Table 2: Age-Gender Distribution of the sample that could not be contacted				
Age group	**M (%)**	**F (%)**	**Total**	**Column percentage**
25-29	17 (56.7)	13 (43.3)	30	16.7
30-39	36 (52.2)	33 (47.8)	69	38.3
40-49	26 (55.3)	21 (46.7)	47	26.1
50-59	8 (50.0)	8 (50.0)	16	8.9
≥60	8 (44.4)	10 (55.6)	18	10.0
Total	95 (52.8)	85 (47.2)	180	100.0

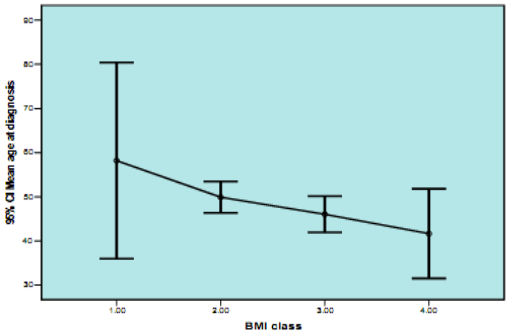
Table 3: Univariate analysis of diabetes prevalence and its possible risk factors				
Variable	**Category of variable**	**Number of DM**	**Prevalence of DM (%)**	**p value**
Age in yrs	25- 29	2	0.8	Somer's d =0.3, p=0.001
	30-39	12	3.4	
	40-49	20	8.2	
	50-59	20	11.1	
	60-69	12	10.3	
	≥70	5	6.1	
	Total	71	5.8	
Gender	Male	34	5.5	NS
	Female	37	6.1	
	Total	71	5.8	
Education	Never attended school	20	5.3	NS
	Primary	4	3.4	
	secondary	44	7.4	
	Post secondary	2	2.9	
	Graduation and above	1	2.2	
	Total	71	5.8	
Occupation	Skill I	12	2.7	Somer's d =0.16, p=0.007
	Skill II	26	8.7	
	Skill III	2	22.5	
	Skill IV	01	5.3	
	Non workers	30	6.6	
	Total	71	5.8	
SES (Rs)	I (>2400)	13	12.0	Somer's d = -0.3, p =<0.0001
	II (1200 to 2,399)	28	9.3	
	III(720 to 1,199)	15	4.0	
	IV (360 to 719)	14	3.8	
	V (<360)	01	1.4	
	Total	71	5.8	
BMI	Under weight	5	1.8	Somer's d =0.3, p<0.0001
	Normal	37	5.2	
	Overweight	21	10.9	
	Obese	6	15.7	
	Total	71	5.8	
Physical activity	Low	21	8.1	Somer's d = -0.2 p =0.005
	Moderate	39	6.5	
	High	11	3.1	
	Total	71	5.8	
Smoking (Pack years)	Non smokers	27	5.9	NS
	<10	7	5.4	
	10.1 to 20	0	0	
	>20	0	0	
	Total	34	5.5	
Alcohol	Abstainers	15	4.7	NS
	Level 1 (<39.99gms/day)	13	7.7	
	Level 2 (40-59.99gms/day)	03	9.1	
	Level 3 (>60gms/day)	03	3.9	
	Total	34	5.5	
Family history of diabetes	No	55	4.95	$\chi2$ = 23.4, p <0.0001
	Yes	16	14	
	Total	71	5.8	

Age, socio economic status, occupation, BMI, physical activity, family history of diabetes were significantly associated with diabetes in univariate analysis whereas gender, education, smoking, alcohol were not. The Prevalence of type 2 diabetes increased significantly with age. The highest prevalence of diabetes was in 50-59 years group. Another point to be noted is the prevalence of glucose intolerance was 0.8% even in 25-29 years group. The increase in Prevalence of type 2 DM across the BMI classes was significant in both males and females (Table 3).

Prevalence of type 2 DM was 3.3% and 10.3%, among subjects with BMI less than 23 kg/m2 and more than 23 kg/m2 respectively. These difference was also significant (p<0.0001). Those with maternal diabetes were at higher risk of diabetes compared those with paternal diabetes. However there was no significant difference in prevalence among those with family history in both parents and only maternal diabetes (Table 4).

Table 4: Prevalence of Diabetes Mellitus according to Family History of Diabetes			
Family history	**N**	**DM**	**Prevalence (%)**
Absent	1109	55	4.95
Present			
Both parents	7	1	14.2
Maternal	68	13	19.1
Paternal	39	2	5.1
Total	1223	71	5.8

Assuming the age at diagnosis as age of onset of diabetes, the mean age of onset of type 2 DM among underweight was 58.2 (±17.2) years, normal 49.9 (±10.6), overweight 46.1 (±9.1), obese 45.8 (±8.2) and morbidly obese 25 (only one case). This difference among various BMI groups was statistically significant (ANOVA, p=0.048) (Figure 1).



The mean difference in age of onset (in years) of DM was significant by ANOVA, F= 2.8, p=0.048
The BMI class 1, 2, 3, and 4 denote under weight, normal, overweight and obese respectively

Fig.1: Age of onset according to BMI

Variables significant in univariate analysis were included for binary logistic regression. Age, BMI, family history of diabetes mellitus and type of occupation were independent risk factors for diabetes status in binary logistic regression. After 25 years age, unit increase in age increased the odds of diabetes by 1.062 times. The Odds of developing type 2 diabetes was 3.1 times among BMI of >23kg/m2 compared those with less BMI. Those with family history of diabetes mellitus had 3.6 times odds of developing diabetes compared to those without. Those with Skill level II and III occupation had 3 times and 13.7 times odds of developing diabetes than those with Skill level I respectively. Physical activity and socio economic status were not statistically significant risk factors for developing diabetes in this study (Table 5).

Table 5: Logistic Regression Analysis of risk factors for diabetes				
Variable	**Categories**	**O R**	**CI**	**P value**
Age		1.062	1.040-1.084	<0.0001
BMI	<23 kg/m2	1		
	>23 kg/m2	3.1	1.8-5.5	<0.0001
Family history	No	1		
	Yes	3.61	1.8-7.2	<0.0001
Physical activity	Low	1.1	0.96-2.1	NS
	Moderate	1.48	0.90-2.3	NS
	High	1		
SES	Class I	2.21	0.32-19.01	NS
	Class (II + III+ IV)	2.43	0.24-13.30	NS
	Class V	1		
Occupation	Non worker	0.96	0.43-2.1	NS
	Skill 4	2.33	0.4-22.38	NS
	Skill 3	13.7	2.2-81.7	0.005
	Skill 2	3.06	1.34-7.5	0.016
	Skill 1	1		
Only those variables which were significant in Univariate analysis were considered for logistic regression. Risk has to be considered for every unit increase in age after 25 years increases				

Only age, family history, BMI and type of occupation were independently significantly associated with diabetes mellitus and occupation was significant in only in skill level II. So, occupation was excluded in the scoring system and the remaining variables (age, family history of DM and BMI) were included in binary logistic regression and beta co-efficient were calculated. The values for beta co-efficient for different age class intervals <34 yrs, 35 to 49 yrs, >50 yrs were 0, 1.73 and 2.57 respectively. Similarly the beta co-efficient values for absence of family history was 0 and presence of family history 1.51 and BMI categories <23 kg/m2 and >23 kg/m2 were 0 and 1.26 respectively. Though theoretically these beta co-efficient values would help in identifying type 2 DM in the population, health workers in the field might find difficulty in using such smaller decimals. Hence these beta co-efficient were multiplied by 10 and further rounded up to the nearest whole number (to avoid decimals). It followed that lowest and highest scores can be 0 and 54. Using these values, the AUC was 0.78 (p<0.0001). Since there cannot be '27' score as per the scoring system, sensitivity and specificity values were calculated for 26 and 28. Score of 28 is considered as cut-off, as it had higher accuracy (Table 6).

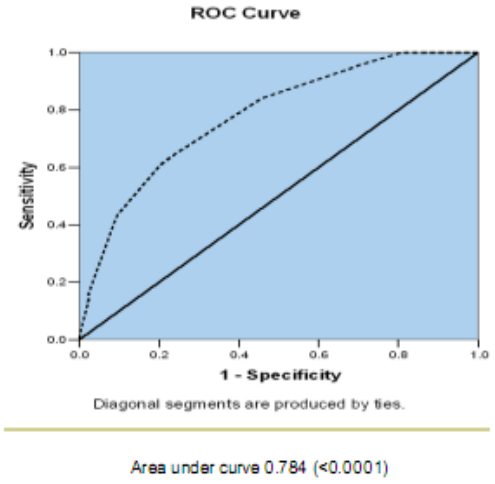


Fig.2: ROC Curve for Diabetes Risk Score (Curve formation was based on cut off values of 0, 6.5, 14, 16, 21.5, 27, 29, 31, 35.5, 40, 43, 49.5, 55 by software)

Table 6: Sensitivity and Specificity at various cut-offs of Diabetes Risk Score					
Cut off levels of Diabetes Risk Score	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**	**Accuracy (%)**
≥13	100	19.2	6.9	100	23.8
≥15	95.6	29.7	7.6	99.1	33.5
≥17	94.2	32.4	7.8	98.9	36.0
≥26	84.1	54.2	10.0	98.2	55.9
≥28	63.7	76.7	14.3	97.2	76.2
≥30	60.1	79.6	15.3	97.1	78.6
≥32	43.4	90.4	21.5	96.3	88.0
≥39	40.5	91.3	22.0	96.2	88.4
≥41	15.9	97.7	29.7	70.2	92.9
≥45	13.0	97.8	26.4	94.9	93.1
≥54	28.9	99.7	40.0	94.4	94.2
The specificity and sensitivity at various cut off levels of diabetes risk scores. Around 26 and 28 score, sensitivity, specificity and accuracy are relevant for cut off of scoring system					

Discussion:

Despite adopting the WHO standards, differential findings compared to other studies could be due to differences in methodologies for measuring blood glucose, definitions of diabetes, age groups considered and geographical situations. The age and gender distribution (as per census 2001), SES, educational status, BMI of study sample was comparable with rural Puducherry.[19,20] The Response rate in the survey was 87.2%. Hence the study results can be generalizable to rural Pondicherry.

The present study showed significant increase in prevalence with increase in age. Similar findings were reported by studies in India.[21-26] This may be due to prolonged exposure to physical inactivity, stress, obesity, genetic factors, with advancement of age. The high prevalence among young adults (20-39 yrs – 2.4%), the most productive age group of the community, is unacceptable and hence focus on prevention of diabetes among young is essential.

There was no significant gender difference in prevalence of diabetes. Similar findings were reported by multicentric studies from India.[9,22,27] However, a few studies showed higher prevalence among females and some other studies showed higher prevalence among males.[8,25] This is possibly due to co-existing risk factors in specific gender; alternatively gender may not be a risk factor in type 2 DM.

There was no significant association between different levels of education. Similar results were obtained from a cohort study among industrial workers.[26] However western studies had reported decrease in prevalence with increase in educational status.[28,29] Low education status may influence the lesser awareness, lesser opportunity for prevention/control, and on the other hand the higher educational status may influence through the life style factors. Hence education may not have a direct relation with development of diabetes.

The present study showed that as the skill level of occupation increased, the prevalence of DM also increased. Similar findings were observed by certain Indian studies.[8,9] This association of diabetes with occupation could be due to combined effect of physical activity and work related stress.

Socio economic status was not independently associated with prevalence of diabetes. Probably this association acts through other variables like diet, BMI and physical activity.

The present study showed that BMI is a significant independent predictor of development of diabetes. Several studies reported independent predictor nature of BMI for development of diabetes.[8,9,25,26,30-33] The present study also supported the evidence that among Asians, even at lower BMI, there was

higher odds of diabetes (adjusted OR 2.2).[9,34-36] Hence early identification of high BMI, would give opportunity for primary prevention and early diagnosis of the diabetes. Also, it would suggest that Indians, especially, have to maintain lower BMI to prevent diabetes. In addition, the present study reported significantly lower age of onset among those with higher BMI. This signifies the importance of surveillance for those with higher BMI. Several explanations have been given related to obesity and diabetes. Khan SE et al reported that in obese individuals, adipose tissue releases increased amounts of non-esterified fatty acids, glycerol, hormones, pro-inflammatory cytokines and other factors that are involved in the development of insulin resistance.[37]

In this study, prevalence of diabetes decreased significantly as the physical activity level increased. This significance (OR 1.4, CI 0.96-2.1) faded under multivariate analysis. Similar findings of significance of association of DM with physical activity were reported only in univariate analysis by certain Indian studies.[8,9,24] Where as a Vellore study reported that there was no association of physical activity and diabetes even in univariate analysis.[25]

Several prospective studies from western countries reported that physical activity was independent risk factor in development of diabetes.[32,38,39] Since in rural area the physical activity did not differ much, this did not emerge as independent risk factor for diabetes.

The present study showed that odds of diabetes among those who had family history of diabetes (in terms of history of parental diabetes) were at 3.8-times compared those without family history of diabetes.

The present study also reported maternal history of diabetes to be stronger risk compared to paternal history of diabetes. Studies reported relatively higher risk with maternal history of diabetes compared to paternal.[40,41] When both parents were diabetic, the risk increased synergistically. However in the present study no such additive effect was observed, probably because there were very few subjects with both parents diabetic. Family history could act through environmental as well as genetic mechanism. Environmentally there is a possibility of being exposed to similar diet, stress, physical activity, socio economic status etc. Genetic mechanism acts through specific genetic expressions.[42]

This would also infer that family history of diabetes could be important public health tool in predicting development of diabetes and hence could help in prevention of diabetes.

The study showed that smoking is not associated with the diabetes. Similarly the Vellore study also showed no association between smoking and diabetes.[25] Few studies from India also reported lack of association between smoking and diabetes also showed that there was no association between diabetes and smoking.[26,42]

Some studies from industrialized countries showed positive association of smoking and diabetes [43-45]; few others reported no association.[46,47]

The present study being cross sectional study, there could be recall bias when recalling the dose and duration of daily smoking. The studies which had proved positive association between diabetes and smoking, found it significant only among those categories with minimum of more than 15 cigarettes per day, and in the present study population there were very few in such category. This may be one of the reasons that among Indians studies showed no association between diabetes and smoking.

In the present study there was no association between alcohol consumption and prevalence of diabetes. Literature shows varied association of alcohol and diabetes like U-shaped association, linear protection effect, protective effect only at low level of alcohol consumption and increased risk of development of diabetes across increasing levels of alcohol. [47-51]

Further two Indian studies reported no association between diabetes and alcohol consumption.[26,43] WHO also have reported that there is insufficient data regarding association of alcohol with diabetes.[5] This shows perhaps alcohol consumption has no effect on diabetes. Another possibility could be of recall bias for quantification of consumption, as the present study was cross sectional study.

The scoring system to detect high risk individuals showed Area under Curve 0.784, which was similar to that of a Chennai study which showed 0.698.[52] The present study showed sensitivity, specificity and accuracy of at cut off score of 28 were better than Chennai study. However the present study had not included physical activity in the scoring as it was not significant in the multivariate analysis. This would make easy assessment even by ASHA.

Similar diabetes risk scoring was formed by Oman study which included age, waist circumference, BMI, family history of diabetes and hypertension status.[53] The AUC was comparable with the present study scoring system. German diabetes risk scoring reported comparable AUC.[54]

Using this scoring system the health workers in the field can rapidly and easily identify the individuals at risk. Thus they can be monitored frequently at field level so that early diagnosis and treatment could be implemented. This could be cost-effective method of screening individuals for diabetes rather for whole population. Hence, this scoring could be used as an important public health tool.

Limitations:

Despite this high coverage, the non-response could have an influence on the findings. However the balance population of 180 had a similarity in age-sex composition to the rest of subjects studied, thereby possibly leading to a similar direction of results. There was difficulty in assessing the role of BMI among 11 individuals with kyphosis since two of them have DM. Most of the studies considered the measurements of waist circumference as marker of abdominal obesity and is an important variable to be measured. However due to reasons stated in methodology we could not measure it. For study purpose we considered those who gave family history as don't know were considered as no family history of diabetes. Further the expired parents' history of diabetes, there was no strong way to cross check.

Recommendations:

Research on community based interventions for physical activity, may be encouraged along with enhancing physical activity in leisure time in community. Those with family history of diabetes life style modifications with regard to physical activity for these individuals from early age so that the occurrence of diabetes can be prevented / postponed. Further research is recommended for cost effectiveness of strategies like 'diabetic risk scoring'.

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