Introduction

Globe is witnessing a rapid socioeconomic and epidemiological transition. As a result, there has been a reversal trend in communicable diseases, whereas, the noncommunicable diseases such as cardiovascular diseases, diabetes mellitus (DM), and obesity are taking the toll of major mortality and morbidity. This is evident across all the regions, ethnic and classes of people. Lack of effective health programs for primordial and primary prevention of these diseases and ineffective screening methods has been one of the reasons for the rising burden. Materials and Methods: The cross-sectional study was conducted among 400 adults aged between 30 and 60 years residing in a settled slum of Rukmini Nagar area of Belagavi city, Karnataka. Data were collected after taking written informed consent from each participant using a pretested questionnaire that included demographic information and details of the risk factors. Risk of developing diabetes was assessed by using Indian Diabetes Risk Score. Results are expressed as proportions, and analysis was done using Chi-square test and multiple logistic regression analysis. Results: The mean age of participants was 44.3 ± 8.7 years. The proportion of low, moderate, and high risk of developing diabetes mellitus was 7%, 63%, and 30%, respectively. The prevalence of newly diagnosed cases was 10.25%. Moreover, 57.1% of them with positive family history were in the high risk category; 76.9% of the sedentary workers were at higher risk; overweight and obese individuals had a higher proportion of the high and moderate risk (P < 0.0001). Correlation coefficient (R) was 0.782, and coefficient of determination (R^2) was 0.61. Conclusions: Our study demonstrated that advancing age, low physical activity, family history, overweight, and obesity were the prominent factors that predicted the risk of diabetes in the near future. Hence, focused interventions for urban slum dwellers are imperative and draw special attention.

Keywords: Community based, diabetes mellitus, focused interventions, Indian Diabetes Risk Score, risk, urban slum
Numerous studies in India have shown that the prevalence of diabetes is more in urban regions than in rural regions.\(^{[2]}\) The prevalence diabetes is also noticed to be more among south Indians than in north Indians.\(^{[1]}\) Diabetes cauasion is multifactorial and includes genetic factors coupled with environmental influences such as obesity associated with rising living standards, steady urban migration, and lifestyle changes, which has resulted in a rapid increase in its prevalence.\(^{[3]}\) Madras Diabetic Research Foundation has proposed a score called “Indian Diabetes Risk Score” (IDRS).\(^{[4]}\) This technique will enable the family physicians to stratify the risk for DM and will aid the proper management to deliver appropriate health care services at primary care level to the targeted populations in a cost-effective manner.

In the current decade, the migration of rural community to the urban area has resulted in an increase in the proportion of urban slum residents. They lack all the basic amenities that are available for urban people, and they lack the natural benefits that people who stay in rural places enjoy. So adding up all these factors, they constitute “vulnerable population.” Family physicians are the primary contact of care for these groups of individuals. Studies done in north India showed increase in prevalence of risk factors for diabetes among the urban slum residents.\(^{[6]}\) A study done in urban slums of Chennai city showed prevalence of diabetes to be 20.8%.\(^{[8]}\) Due to epidemiological and social transition, people living in urban slums will continue to increase in India with unplanned urbanization and rural unemployment.\(^{[10]}\) Therefore, tools such as IDRS will help us in formulating effective screening strategies to unmask the hidden burden of this disease and also help us use our resources in a cost-effective manner. Hence, this study focuses on assessment of the risk of developing diabetes and its prevalence among urban poor south Indian population using IDRS.

### Materials and Methods

The community-based cross-sectional study was conducted in a settled slum of Rukmini Nagar area under city corporation limits of Belagavi city, Karnataka. The sample size was calculated using the formula: \(n = \frac{4pq}{d^2}\). By taking prevalence of overweight and obesity as 57.3% (one of the important risk factors for diabetes mellitus)\(^{[9]}\) and absolute error of 5%, the total sample size obtained was \((n) = 392\), rounded off to 400. Adults aged between 30 and 60 years and who were residing in the urban slum of Rukmini Nagar area for ≥1 year were included in the study. Persons already diagnosed with diabetes mellitus in the past were excluded. Sampling frame was prepared by enlisting all the adults aged between 30 and 60 years residing in the urban slum of specified area using voters list. By using random number table, study subjects were selected by simple random sampling method.

Data were collected after taking written informed consent from each participant. Ethical clearance was obtained from the Institutional Ethics Committee of Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research, Belagavi. Data collection instrument used was a pretested questionnaire that included demographic information and details of the risk factors for diabetes mellitus viz. family history of diabetes mellitus, tobacco and alcohol use, diet, and physical activity.

Physical measurements including height, weight and hip circumferences, and body mass index (BMI) were calculated. Based on WHO and International Obesity Task Force BMI cut-off standards for Asians, obesity was defined as BMI \(\geq 25.0\) kg/sq.m.\(^{[11]}\) Blood pressure was measured twice using mercury sphygmomanometer, 5 min apart and average of both readings was noted. Systolic blood pressure >140 mm of Hg and diastolic blood pressure >90 mm of Hg were classified as hypertensive.\(^{[12]}\) Random blood glucose levels were measured by using capillary blood.\(^{[13]}\) Participants with blood glucose levels more ≥200 mg/dL were considered to be newly diagnosed as diabetic.\(^{[14]}\)

Risk of developing diabetes was assessed by using IDRS including scores for each of the risk factors as given in the chart below:\(^{[16]}\) Age was categorized into three groups: participants with age <35 years was scored as 0, 35–49 years as 10, and ≥50 years as 20. Abdominal obesity was scored based on gender; Males: Individuals with waist circumference ≥90–99 cm as 10, those with ≥100 cm as 20, and the rest as 0; Females: individuals with waist circumference ≥80–89 cm as 10, those with ≥90 cm as 20, and the rest as 0. Family history of diabetes was scored as follows: individuals with no family history of diabetes were 0, those with one diabetic parent as 10, and those with both parents diabetic as 20. For physical activity, individuals were scored as 0 if they did leisure time exercise and in addition had physically demanding work in their occupation; individuals who either did exercise or performed physically demanding work were scored as 10 and the rest as 20. The participants were classified based on the total scores as follows: Score ≥60: Very HIGH RISK of having diabetes; Score 30–50: The risk of having diabetes is MODERATE, and Score <30: Risk of having diabetes is probably LOW.\(^{[6]}\) Health education was given to the persons, who are found to be having high risk of developing diabetes, and participants with blood glucose level ≥200 mg/dL were referred to tertiary care hospital attached to the medical college, for further evaluation and appropriate management [Table 1].

Data were expressed as proportions. Statistical analysis was done using the Statistical Package for Social Sciences (SPSS) Software version 21.0. Chi-square test was used for the categorical variables. Multiple logistic regression analysis was done using newly detected diabetes as the dependent variable and the various risk factors as independent variables to obtain the risk scores. Correlation coefficient and Beta coefficient were calculated. “\(P\)” value ≤0.05 was considered as statistically significant.

### Results

In the study, men constituted 38% (152) and women constituted 62% (248) of the participants. Most study participants were self-employed (48.5%) followed by homemakers (39.0%).
Considering the highest level of education of the study participants, nearly half of the study participants did not receive any kind of formal education (49.5%), and only 4.5% of them were graduates. Among the participants, 28 (7.0%) of them had low risk of developing DM; most of them, that is, 252 (63.0%) were in the moderate risk category, and 120 (30.0%) of them were in the high risk category.

The mean age of the study participants was 44.3 ± 8.7 years. Age distribution of the study participants was as follows: 48.5% of them were between 31 and 40 years, 25.0% of them were between 41 and 50 years, and 26.5% of them were between 51 and 60 years. Among the participants, 14% had a family history of DM. Among them, 75.5% had single parental history, 13.2% of them had both parents with diabetes, and 11.3% of them had positive history among their siblings. Overweight and obesity constituted important risk factors for diabetes and were assessed using BMI categories. Moreover, 36.5% of them were obese, 23.0% of them were overweight, 33.0% of them had normal weight, and 7.5% of them were underweight. Job-related physical activity was assessed among the participants as follows: 19.5% of them were sedentary, 66.5% were involved in moderate activity, and 14.0% of them were vigorous workers. Newly diagnosed diabetics (Random Blood Sugar (RBS) ≥ 200 mg/dL) were 41 (10.25%).

**Table 1: Details of Indian diabetes risk score assessment**

| Particulars of IDRS assessment | Score |
|-------------------------------|-------|
| Age (years)                   |       |
| <35                           | 0     |
| 35-49                         | 20    |
| >50                           | 30    |
| Abdominal obesity             |       |
| Waist<80 cm (female), <90 cm (male) | 0    |
| Waist>80-89 cm (female), 90-99 cm (male) | 10   |
| Waist>80-89 cm (female), 90-99 cm (male) | 20   |
| Physical activity             |       |
| Exercise regular + strenuous work | 0    |
| Exercise regular or strenuous work | 20   |
| No exercise or sedentary work | 30    |
| Family history                |       |
| No family history             | 0     |
| Either parent                 | 10    |
| Both parents                  | 20    |
| Minimum score                 | 0     |
| Maximum score                 | 100   |

When risk categories were cross tabulated with age group, it was found that the risk of developing diabetes increases with increasing age. This was well evident that 71.7% of the participants between 51 and 60 years were in the high risk category as compared to 7.2% of them in the age group of 31–40 years. This difference was found to be statistically significant ($P < 0.0001$). Family history of diabetes was an important predictor of diabetes occurrence. Moreover, 57.1% of the individuals with positive family history were in the high risk category, and 32.2% of them were in the moderate risk category. This difference was found to be statistically significant ($P < 0.0001$) [Table 2].

Sedentary activity is an important risk factor for diabetes. In our study, 76.9% of the sedentary workers were at high risk of developing diabetes as compared to vigorous workers, where only 3.6% of them were in the high risk. This difference was found to be statistically significant ($P < 0.0001$). In our study, the proportion of the individuals with high and moderate risk was more with overweight and obese individuals, and this difference was found to be statistically significant ($P < 0.0001$) [Table 3].

The correlation coefficient for the multiple logistic regression analysis using newly detected diabetics as the dependent variable and the various risk factors as independent variables was 0.782. Coefficient of determination was 0.61. Thus, the IDRS will predict the diabetes in 61.0% of the individuals with these risk factors. Among the risk factors, lack of physical activity (26.48%) and the advancing age (25.41%) are the best predictors as compared to BMI (6.79%) and family history (3.06%). $P$ value was < 0.001 at 95% confidence interval for all the variables [Table 4].

The prevalence of tobacco use among the study participants in any form was found to be 43.5% (174). Among them, 85.0% (148) used smokeless forms of tobacco viz. chewing tobacco and ghtuka were the common ones. Among the study participants, 14.0% (56) consumed alcohol and among them 53.6% (30) consumed more than five times a week. Prevalence of systolic hypertension was found to be 20.0% and diastolic hypertension was found to be 31.5%.

**Table 2: Association between IDRS risk categories with participants age and family history of diabetes mellitus (n=400)**

| Risk factors | Low risk (%) | Moderate risk (%) | High risk (%) | Total (%) | $\chi^2$ | $P$ |
|--------------|--------------|-------------------|---------------|-----------|--------|-----|
| Age categories (in years) | | | | | | |
| 31-40        | 22 (11.3)    | 158 (81.4)        | 14 (7.2)      | 194 (100) | 138.60 (Df=4) | <0.0001 |
| 41-50        | 4 (4.0)      | 66 (66.0)         | 30 (30.0)     | 100 (100) | 106 (100)    | 106 (100) |
| 51-60        | 2 (1.9)      | 28 (26.4)         | 76 (71.7)     | 106 (100) | 27.11 (Df=2) | <0.0001 |
| Family history of diabetes mellitus | | | | | | |
| Present      | 6 (10.7)     | 18 (32.2)         | 32 (57.1)     | 56 (100)  | 27.11 (Df=2) | <0.0001 |
| Absent       | 22 (6.4)     | 234 (68.0)        | 88 (25.6)     | 344 (100) | 27.11 (Df=2) | <0.0001 |

**Discussion**

The study used the IDRS to identify the individuals at risk for diabetes and to determine the association of various risk factors with their risk status. IDRS is a cost-effective, simple, noninvasive,
and accurate tool for screening of diabetes, which can be used at the community and the primary care settings. The assessment at primary care level is imperative to stratify the persons with risk factors and decide the accessibility and affordability, so as to implement the primary preventive strategies.

This study also elucidates the need for assessment of risk for type 2 diabetes in urban slum dwellers. Comparing the risk categories with a study done by Choudary R, et al., 46% had moderate risk (IDRS: 30–50), 31.5% had high risk (IDRS ≥60), and 22.5% had low risk (IDRS <30). Moreover, when compared to our study, participants with low risk were 6%, 64% had moderate risk, and 30% were at high risk. Similar findings were published by Gupta SK, et al., who reported that 31.2% of the population in urban Pondicherry had a high risk score. A study conducted in an Urban Resettlement Colony of Delhi reported a lower proportion (5.3%) of low risk and 94.6% of the individuals with moderate and high risk. Although both results were similar, our study had more participants with moderate risk followed by high risk. However, study conducted in the urban slums of Pune by Dudeja P, et al., reported a higher proportion (77.4%) of high risk individuals.

In our study, 36.5% of participants were obese and 23.0% of them were overweight. The INDIAB (India-Diabetes) Study done in four states revealed a similar prevalence of generalized obesity in Tamil Nadu state, 31.3%. However, our study involved more number of female participants, and most of them were homemakers. In a study on derivation and validation of diabetes risk score for urban Asian Indians by A Ramachandran et al., it was proved that a low risk threshold for age, BMI, upper body adiposity, and a high propensity of familial aggregation of diabetes are well known in Indians, which was consistent with our study. The proportion of newly diagnosed diabetes among the urban slum dwellers in our study was lower (10.25%) as compared to a similar study done by Vigneswari A, et al. (20.8%) in Chennai and Dudeja P, et al. in Pune. However, this does not represent the true prevalence as all the known diabetic patients were excluded. Also, in another study done in urban slums of Bangalore, the prevalence was 12.33%. Moreover, in a similar study done in Pune urban slum dwellers, the prevalence of newly diagnosed diabetes was 9.88%. Study conducted in the North Indian state of Punjab reported the prevalence to be 8.3%. There was a wide variation in the prevalence of diabetes in various urban slums probably due to different demographic profiles.

Our study demonstrated that the risk of developing diabetes increases with increasing age. It was evident as more number of individuals in the age group of 51–60 years were in the high risk category (71.7%), and was consistent with the study conducted in the urban slums of Pune. Family history of diabetes was an important predictor of diabetes mellitus. Studies done at Bengaluru and Pune showed significant association of family history and risk of diabetes (P < 0.05). Our study findings were consistent with both of these studies. In our study, 76.9% of the sedentary workers were at high risk of developing diabetes as compared to vigorous workers, and 3.6% of them were in the high risk category. Two studies conducted in Pune also demonstrated that sedentary activity is an important risk factor for diabetes. The proportion of the individual with high and moderate risk was more with overweight and obese individual in our study, which also showed the significant difference among the groups. The chance of diabetes risk score was low (6.38%) among individuals who are underweight than obese (44.54%) with a statistical significant difference in the study done by Gupta SK, et al. Similarly, study conducted in

| Table 3: Association between IDRS risk categories with job-related physical activity and BMI of the participants (n=400) |
|---------------------------------------------------------------|
| Risk factors                                            | Low risk (%) | Moderate risk (%) | High risk (%) | Total (%) | χ² | P     |
|---------------------------------------------------------------|
| Job-related physical activity                                |              |                  |              |          |    |       |
| Sedentary                                                  | 4 (5.1)      | 14 (18.0)        | 60 (76.9)    | 78 (100) | 187.16 (Df=4) | <0.0001 |
| Moderate                                                  | 4 (1.5)      | 204 (76.7)       | 58 (21.8)    | 266 (100) | 14.63 (Df=4)     | <0.0001 |
| Vigorous                                                  | 20 (55.7)    | 34 (60.7)        | 2 (3.6)      | 56 (100)  | 0.64 (Df=4)     | 0.404    |
| BMI categories (kg/m²)                                      |              |                  |              |          |    |       |
| Underweight (<18.5)                                        | 8 (26.7)     | 18 (60.0)        | 4 (13.3)     | 30 (100)  | 35.39 (Df=6)     | <0.0001 |
| Normal (18.5-22.9)                                         | 14 (10.6)    | 80 (60.6)        | 38 (28.8)    | 152 (100) | 10.17 (Df=4)     | 0.301    |
| Overweight (23.0-24.9)                                     | 4 (4.3)      | 66 (71.8)        | 22 (23.9)    | 92 (100)  | 0.2 (Df=4)       | 0.64     |
| Obese (≥25.0)                                              | 2 (1.4)      | 88 (60.3)        | 56 (38.3)    | 146 (100) | 0.21 (Df=4)     | 0.64     |

| Table 4: Multiple logistic regression analysis of the risk factors and the IDRSs |
|-----------------------------------------------|
| Risk factor variables | Unstandardized coefficients | Standardized coefficients | t | P | 95.0% confidence interval for B |
|-----------------------------------------------|
| (Constant) | 14.63 | 5.108 | - | 2.86 | 0 | 4.58 | 24.67 |
| Age | 0.76 | 0.07 | 0.404 | 11.38 | 0.0001 | 0.62 | 0.89 |
| BMI | 0.90 | 0.13 | 0.213 | 6.75 | 0.0001 | 0.64 | 1.17 |
| Physical activity | -12.23 | 1.01 | -0.430 | -12.16 | 0.0001 | -14.21 | -10.25 |
| Family history | 5.58 | 1.17 | 0.150 | 4.77 | 0.0001 | 3.28 | 7.87 |
Lucknow by Khan MM, et al., also suggested the association of risk of diabetes with BMI.[24]

Multiple logistic regression analysis of the risk factors as the independent variables predicted 61.0% of the diabetes risk among the undiagnosed individuals. Physical activity and advancing age were the best predictors, and this finding was consistent with the study done among urban slum residents in Pune.[25] However, a study conducted in the urban area of Rohtak, by Rajput M, et al., reported that the age, family history of diabetes, and BMI were independent predictors of diabetes.[26]

The prevalence of tobacco use among the study participants in any form was found to be 43.5%. A study done by Gupta A, et al., also showed a similar overall prevalence of tobacco usage of 41.0%, with higher proportion of use of smoking form unlike in our study 85.0% of them used smokeless forms of tobacco.[27] Prevalence of systolic hypertension was found to be 20.0% and that of diastolic hypertension was found to be 31.5%. In a study done in Chennai reported an overall prevalence of hypertension as 24.2%.[8] The risk factor assessment and stratification at the primary care level especially in the urban slums will complement the appropriate referral to the higher care and thereby combat the rising burden of diabetes mellitus.

**Limitations**

Only one slum of a single urban area was selected due to constraints of time and resource; hence, the results cannot be generalized. Fasting and postprandial blood glucose estimation would have been better predictors for the estimation of prevalence of diabetes as well as prediabetes (Impaired Fasting Glucose and Impaired Glucose Tolerance) that could not be measured.

**Implications**

Urban slum dwellers lack the health care benefits available in urban area due to a variety of constraints including the low socioeconomic status and lack of education. The results of this study have provided necessary inputs to categorize individuals with risk factors and to assess the risk of developing diabetes mellitus using a simple, safe, and inexpensive tool. Moreover, it will also act as a guiding tool for the primary care physicians to do selective screening instead of universal screening. Thus, targeted interventions can be undertaken to minimize modifiable risk factors and hence combat the problem of increasing diabetes-related mortality and morbidity in the economically disadvantaged group of the society.

**Conclusions**

Diabetes mellitus is no more a “rich man’s disease.” Our study demonstrated higher proportion of moderate and high risk of diabetes using IDRS. Advancing age, low physical activity, family history of diabetes, overweight, and generalized obesity were the prominent factors associated in predicting the risk of diabetes in the near future. Our study also demonstrated the ease of use of IDRS for risk prediction in the community-based settings. Furthermore, our study throws light on the need for the “focused interventions” for urban slum dwellers, as they are also at a higher risk for developing diabetes mellitus.

**Ethical approval**

Ethical clearance was obtained from the Institutional Ethics Committee of Jawaharlal Nehru Medical College KLE Academy of Higher Education and Research, Belagavi (Ref. No. MDC/DOME/502 dated 18.03.2016). All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed written/thumb print consent was obtained from all respondents after a full explanation of the nature, purpose, and procedures used for the study.

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**Author contributions**

AK developed the protocol, conceptualized the project design, analyzed and interpreted the data, and drafted the article; AO developed the idea, collected the data, and assisted in analysis and writing the manuscript; PRW supervised and monitored all aspects of this study and revised the manuscript critically for important intellectual content, and finally approved the version to be published. All authors have read and approved the final draft of the manuscript.

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**Conflicts of interest**

There are no conflicts of interest.

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