Original Article

High prevalence of Diabetes Mellitus in Sri Lankan urban population – Data from Colombo Urban Study.

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Abstract

Background:
In recent decades, Sri Lanka has experienced rapid urbanization, with approximately 30% of the population currently residing in urban areas. We report the age- and sex-specific prevalence of dysglycaemia in an urban population in Colombo, Sri Lanka.
Methods:
Using a stratified random sampling method, 463 subjects (139 men; 324 women) aged 18 years and above were included. Physical activity was quantified using international physical activity questionnaire (IPAQ). Bio impedence was used to estimate body fat. Insulin sensitivity was estimated using the HOMA calculations. Prevalence was estimated using weighted age standardized calculations. Multiple logistic regression analyses were used to study associations to diabetes and prediabetes.
Results:
There were 124 adults in the 18-40 age group (70% female), 209 adults in the 41-60 age group (73% female) and 130 adults in the > 60 age group (63% female). The overall prevalence of diabetes was 27.6% (95% CI: 23.7-31.4). The prevalence of diabetes in those aged 18-40 was 12.4% (95% CI: 6.4 -18.4), 36.1% (95% CI: 29.8 – 42.4) in those aged 41 – 60 and 48.3% (95% CI: 40.7 – 55.8) in those aged >60. Pre-diabetes was detected in 30.3% (95% CI 25.9-34.8) of the population (with either an HbA1c of 5.7-6.4%, FPG of 110-125 mg/dl or 2 Hr PPG of 140-199 mg/dl). Cumulative prevalence of diabetes and pre-diabetes in the population was 57.9%.
Conclusions:
This urban study demonstrates that along with the changes in the socio-demographic status, the metabolic profile of the Sri Lankan adult has transformed, with a high prevalence of dysglycaemia and obesity.

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Background:

Sri Lanka, a middle-income country in Asia with a population of 20 million, has been experiencing rapid and unplanned urbanization over the recent decades with an estimated 30% of the population now living in urban and suburban areas [1]. The urban prevalence of Diabetes, prediabetes and obesity has been rising exponentially over the past three decades. A study in subjects aged over 20 years indicated a population prevalence of dysglycaemia (defined as T2DM or IGT or IFG) of 21.8%, which rose to 30% in urban areas [2]. Metabolic syndrome was found in 27.1% of urban adults [3]. Physical inactivity, elevated body mass index (BMI) and central obesity along with living in an urban area are thought to be strongly associated with the increased risk of dysglycaemia.

Methods:

The study population consisted of adult males and females who were 18 years and above, whose permanent residence was in the Eastern Kuppiyawaththa local government (Grama-Niladhari) division of the Colombo District. The sample represents an urban population living in Colombo. This local government area was selected for the community cohort as it is the closest to the National Hospital of Sri Lanka, which is the main research center. The study was carried out in 2014/2015.

Sample size

Sample size was calculated using the Lwanga and Lameshow 1991 formula of n = z2 p (100-p)D/ d2. Sample size of 600 was arrived at for expected prevalence of dysglycaemia and obesity of 50%, design effect of 1.2 with a precision of 95% and an anticipated 25% non-response rate using the EPI 6 sample calculation software.

Sampling technique

Stratified simple random sampling was used to select a sample of 463 from the total population of 6473 in the GN area registered in who belonged in the age categories of 18-40 years, 40-60 years and above 60 years. People who are included in the voters list of Colombo district or lives in Colombo district continuously for at least three years were included in the sampling process. In order to ensure the precision of the estimates in the subsample analysis (according to the age groups) the sample was divided among the 3 age categories on a weighted basis that took into account the proportion in the population and the expected prevalence of dysglycaemia.

Using a random number generator, study subjects were randomly allocated into the three strata as follows. In the 18-40 age stratum 210 were selected (35% of total sample) whilst in the 40-60 years stratum 240 were selected (40% of the sample) and in the above 60 year stratum 150 were selected (25% of the sample). The resulting disproportionate sample allocation was accounted for, by the use of weighted analysis. The weights were the inversion of the sampling fractions in the analysis.

Data collection

The participants were recruited at their homes by a team of researchers who provided an invitation letter and information documents. On the day of the screening, informed written consent was taken and data was collected using an interviewer-administered questionnaire administered by trained interviewers, to collect data including socio-demographic data, use of alcohol, smoking, food frequency and physical activity, and detailed medical history on previous diagnoses and treatment. Anthropometric measurements were made (weight, height, waist circumference, total body fat estimation and visceral fat percentage using a bio impedance analyzer- OMRON HBF 516). Blood samples were taken in a nine to twelve hours fasting stage and in non-diabetics 75g anhydrous glucose was given and blood was collected for glucose measurement two hours later. Plasma Glucose (GOD- PAP5 method, Olympus AU 480/680/400 analyser), cholesterol (CHOD-PAP method, Olympus AU 480/680/400 analyser), triglyceride (GPO-PAP method, Olympus AU 480/680/400 analyser), glycosylated hemoglobin (HPLC method, Bio-Rad Variant II Turbo analyser), serum insulin (Chemiluminescent enzyme immunoassay, Immulite 1000 analyser), corrected calcium (Arzenso III method, Olympus AU 480/680/400 analyser) and 25-OH Vitamin D level (Direct Chemiluminescence method, Advia centaur analyser) were measured in the blood samples. Once the serum insulin levels were analyzed, insulin resistance and beta cell function were calculated using the HOMA calculator (4).Diabetes mellitus was diagnosed based on the ADA/WHO criteria. This required either a documented prior diagnosis of diabetes or a value above the diagnostic threshold on biochemical testing. The cutoffs included a FPG above 126mg/dl, 2 Hour PPG above 200 mg/dl, or HBA1C above 6.5%. Pre-diabetes was diagnosed with any of the following values: FPG of 110-125 mg/dl or 2 Hour PPG of 140-199 or an A1C of % 5.7-6.4%.

Statistical analysis:

Data analysis was performed in the R programming language version 3.2.2 (5). Community based prevalence rates and means with 95% confidence intervals for the urban study population and for different strata including age and gender were calculated considering the stratified sampling methodology using the "Survey" package in the R programming language (5). Age adjusted prevalence rates were calculated based on direct standardization method using the World Health Organization world standard population. Descriptive data analysis was carried out to describe study population characteristics. Exploratory data analysis was done to identify the risk factors associated with diabetes mellitus. Exposure variables studied were age, gender, ethnicity, education level, smoking habits, alcohol consuming habits, family history of diabetes, hypertension and hyperlipidemia, past medical history of diabetes, hypertension and hyperlipidaemia, weight, height, body mass index (BMI), waist circumference, neck circumference, body fat percentage, visceral fat percentage, physical activity

which was quantified as metabolic equivalent of tasks (METS minutes per week) based on International Physical Activity questionnaire [6], food habits based on one week food recall in the Food Frequency Questionnaire and vitamin D levels. Initially, each study variable was screened with Pearson's Chi-square test and simple logistic regression, and the variables significant at P =0.2 level were subsequently used for multiple variable analysis. Subsequently, multiple logistic regression was carried out to investigate the factors associated with diabetes status and stepwise selection method was adopted to select significant variables. Ethnicity consisted of 4 categories (i.e. Sinhalese, Tamils, Moors and other), the "other" ethnicity had only 4 individuals and this group was not considered in the analysis. P value of 0.05 was considered as significant.

Ethical Issues:

Ethical approval was obtained from the Ethical Review committee of the Faculty of Medicine, University of Colombo. Documents were encoded to avoid any identifying character and measurements were taken to ensure confidentiality.

Results:

A total of 463 subjects gave informed consent and completed the screening. Most of the respondents were females (69%). There were 124 subjects in the 18-40 age group and 70% of these were females. There were 209 subjects in the 41-60 age group and 73% of this stratum were females. In the over 60-year age stratum there were 130 subjects and 63% were females. The response rate in each of the above strata was 59%, 87%, and 87% with an overall response rate of 77.2%. Table 1 summarizes the basic characteristics of this study population.

This study population's mean Body mass index was 25.2 kg/m2 (SD 4.8), mean waist circumference was 87.0 cm (SD 13.0), mean neck circumference was 34.8 cm (SD 3.7), mean total body fat percentage estimated with bio impedance analysis was 34.3 % (SD 8.3) and the estimated visceral fat was 9.2% (SD 5.0). Body mass index was categorized according to global criteria and the recommended Asian and South Asian criteria [7, 8]. 68.2% of the women and 59.1% of the men were overweight or obese based on South Asian criteria. The BMI categorization and distribution are tabulated in Table 2. Community prevalence for abdominal obesity was 58.1% based on International Diabetes Federation cut-off values on waist circumference for determining abdominal obesity in South Asians (WC – male >= 90cm, female >=80cm) [9].

Prevalence of DM and Pre-diabetes

Estimated community mean fasting plasma glucose level was 101.3 mg/dL (95% CI: 97.6 – 105.3), HBA1C level was 6.3% (6.1 – 6.4) and 2 hour PPG in non-diabetic individuals was 124 (119.7 – 129.2). It is notable that these are relatively high and the mean HBA1C is in the prediabetes range. These are tabulated in table 3. Family history of Diabetes Mellitus in at least one first degree relative was reported in 43.2 % (95% CI 38.4-48.2) of the study population and 16.9% (95% CI 13.7-20.1) had previously been diagnosed to have diabetes mellitus.

Estimated community prevalence of diabetes mellitus was 27.6% (95% CI 23.7-31.4) and prediabetes was seen in 30.3% (95% CI 25.9-34.8) of the population. Age adjusted community prevalence of diabetes was 27.1% and prediabetes was 30.1%. The community prevalence of dysglycemia was 57.9%; this was seen in 36.2 % in the 18-40 age stratum, in 70.7% in the 41-60 stratum, and in 83.5% in the over 60 stratum. Thus, population prevalence with normoglycaemia declined from 63.8% in the 18-40 age stratum to 29.3% in the 41-60 age stratum to 16.5% in the over 60 age stratum (Table 4).

Among ethnic groups, Moors had the highest prevalence of Diabetes Mellitus of 36.1% (95%CI 25.5-46.7) followed by Sinhalaese (30%, 95% CI 22.4-31.6) and Tamils (19.4, 95% CI 8.8-29.9). Those with the lowest educational background had the highest prevalence of diabetes (39.1% (95% CI 28.2-50). Current tobacco smokers had higher prevalence of diabetes mellitus (50.1%, 95% CI 33.4-66.7) compared to those who never smoked (25.2%, 95% CI 21.4-29.1). Ex consumers of alcohol had the highest prevalence of diabetes mellitus (52.9%, 95% CI 31-74.8) compared to non-consumers of alcohol or current consumers (Table 5).

Hundred and two subjects (16.9%) had prior diagnosis of diabetes mellitus. We further analyzed this subgroup who were already diagnosed to have diabetes mellitus and estimated level of control. Mean HbA1C in those who had prior diagnosis of diabetes mellitus was 8.3% (95% CI: 7.9 – 8.8) and mean HOMA ß was 47.6 (95% CI: 33.3 -61.8) indicating declining insulin reserve. HBA1C less than 7% was found in 29.3% (19.7 – 38.9%), HBA1C between 7% and 8 % in 29.5% (20.1. % - 38.8%), and HBA1C above 8% was found in 41.2% (31.0% – 51.5%). In the population previously diagnosed with diabetes, blood pressure more than 130/90 mmHg was detected in 33.4% (95% CI: 24.2 -42.6), LDL cholesterol above 100mg/dl was found in 58.1 (48.9 - 69.0), and triglyceride above 150mg/dl was found in 41.6% (31.4 – 51.8).

Explorative analysis

Multiple variable analysis showed increasing age, family history of diabetes, preexisting hypertension, increasing BMI, increasing neck circumference, higher frequency of consuming egg yolk and whole grain and less sweet consumption had significant associations with diabetes. Lifestyle factors such as level of physical activity or amount of sitting time recorded with IPAQ did not demonstrate any significant association with the presence of diabetes in the analysis (Table 6).

Discussion

The incidence and the prevalence of diabetes mellitus is a rapidly rising in Sri Lanka as well as globally. Urban population is at a higher risk due to multiple predisposing factors. This study was done to ascertain the true urban prevalence of diabetes mellitus as increasing numbers of diabetic patients living in urban areas are encountered in clinical settings. There was an alarmingly high prevalence of dysglycemia in the urban population studied. This is of enormous clinical and economic significance as even the younger population in the 18-40 age stratum had a

prevalence of diabetes mellitus of 12.4% and prediabetes of 24.8% with potential to conversion to diabetes in the near future. The high prevalence that has been shown in our study is higher than urban prevalence of 18% according to Katulanda et al nine years ago [2]. It is possible that the prevalence has actually increased, however this study used HBA1C in addition to the FPG and 2 Hour PPG used in the previous study and this may explain part of the increase in prevalence. A previous Colombo suburban study that used all three biochemical parameters reported a prevalence of 20% [10].
Among the factors explored in this study; increasing age, increasing BMI, increasing neck circumference and presence of hypertension as well a family history of diabetes mellitus in a first degree relative, high frequency of consuming egg yolk, whole grain and less sweet consumption are significant in multiple regression analysis. Even though less whole grain consumption and more sweet consumption are believed to be associated with diabetes, our results showed the inverse. This need to be carefully interpreted as already diagnosed diabetics tend to eat less sweets and more whole grain as a diabetes control measure. We also found that Vitamin D level was not significantly associated with diabetes mellitus and the results will be discussed in detail in another article. Several key causative factors have not been explored in this study; they include genetic and epigenetic factors as well as foetomaternal environment, childhood feeding and childhood exercise.

Conclusions

We have detected the highest reported prevalence of diabetes mellitus in the South Asian region and these prevalence rates are alarming. The existing pool of patients with diabetes who are likely to develop significant morbidity over time is a major policy and health planning concern. The presence of a large number of individuals who have prediabetes and can develop diabetes in the future should prompt urgent nationwide interventions as well as personalized interventions such as dietary and exercise counselling. We have previously reviewed possible public health interventions to prevent diabetes and other non-communicable diseases in South Asia (11). In light of the current findings, these interventions may need to be targeted more towards the above high risk groups in the urban population.

List of abbreviations

- BMI - Body mass index
- FPG-Fasting Plasma Glucose,
- 2 Hour PPG- Post prandial Glucose 2 hours after 75 g glucose
- LDL - Low-density lipoprotein cholesterol,
- HOMA ß- Homeostasis Model Assessment estimate of steady state beta cell function
- HDL -High-density lipoprotein cholesterol
- TG- Triglycerides
- HBA1c-Haemoglobin A1c
- TSH-Thyroid stimulating hormone,
- WHO-World health organization
- WC-Waist circumference

Competing interests:

Authors declare no conflict of interest

Ethics approval and consent to participate

Ethical approval was obtained from the Ethical Review committee of the Faculty of Medicine, University of Colombo. All participants who enrolled in the study signed an informed consent form.

Consent for publication

Not applicable.

Availability of data and materials

The data analyzed in this paper can be made available to researchers. Requests for access to the dataset used in this paper should be directed to the corresponding author.

Competing interests

None of the authors have any financial or non-financial competing interests to disclose.

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Authors' contributions

NPS and KG designed the study and were involved in data collection. NPS, DSE, IR and KG were involved in statistical analysis, interpretation of data and drafting the manuscript. All authors read and approved the final manuscript.

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None

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Table 1. Study group characteristics.

	Both sexes (N=463)	Males (N=143)	Females (N=320)
Mean age (SD) years	50.4 (14.8)	50.9 (15.8)	50.2 (14.3)
Mean height (SD) cm	153.3 (9.1)	165.0 (7.5)	152.4 (6.8)
Mean weight (SD) kg	61.5 (12.6)	65.7 (13.0)	59.7 (12.0)
Mean BMI (SD) kg/m2	25.2 (4.8)	24.1 (4.4)	25.7 (4.8)
Mean waist circumference cm	87.0 (13.0)	87.5 (12.9)	86.8 (13.0)
Mean neck circumference cm	34.8 (3.7)	36.3 (3.3)	33.0 (3.4)
Mean body fat %	34.3 (8.3)	26.5 (7.1)	37.8 (6.1)
Mean visceral fat %	9.2 (5.0)	9.8 (5.5)	8.9 (4.7)
Ethnicity			
Sinhala	320 (69.1%)	108 (75.5%)	212 (66.2%)
Tamil	56 (12.1%)	12 (8.4%)	44 (13.8%)
Moor	83 (17.9%)	23 (16.1%)	60 (18.8%)
Other	4 (0.8%)	-	4 (1.2%)
Education			
Below Grade 5	77 (16.7%)	10 (7.1%)	67 (20.6%)
Up to Ordinary Level	240 (51.9%)	77 (53.8%)	163 (51.1%)
Up to Advanced Level	127 (27.5%)	47 (32.9%)	80 (25.1%)
Above Advanced Level	18 (3.9%)	9 (6.2%)	9 (2.8%)
Tobacco smoking			
No	396 (85.6%)	83 (58.0%)	313 (97.9%)

Table 2. Prevalence (%) of underweight, normal weight, over weight and obesity according to Global, Asian and South Asian BMI categories

	Underweight	Normal	Overweight	Obesity
Global BMI cut offs	7.7(4.9-10.4)	39.6(34.8-44.4)	37.0(32.2-41.8)	15.8(12.3-19.3)
Asian BMI cut offs	7.7(4.9-10.4)	26.8(22.4-31.2)	34.3(29.6-39.0)	31.2(26.7-35.8)
South Asian BMI cut offs	7.6 (4.9 – 10)	26.8 (22.4-31.2)	12.7 (9.6-15.9)	52.8 (47.8 – 57.7)

Table 3. Estimated glycaemic indices (95% CI) for the study population

	Both sexes	Males	Females
FBS	101.3 (97.6 – 105.3)	106.2 (97.1 – 115.4)	99.6 (95.4 – 103.7)
OGTT 2 hr*	124.4 (119.7 – 129.2)	122.9 (113.9 – 132.0)	125.1 (119.4 – 130.7)
HBA1C	6.3 (6.1 – 6.4)	6.4 (6.1 – 6.7)	6.2 (6.0 – 6.4)
Plasma Insulin	5.9 (5.2 – 6.7)	5.8 (4.9 – 6.7)	6.0 (5.0 – 7.1)
HOMA IR	1.6 (1.3 – 1.8)	1.5 (1.3 – 1.8)	1.6 (1.2 – 1.9)
HOMA β	89.7 (77.3 – 102.0)	83.0 (68.9 – 97.2)	92.7 (75.9 – 109.4)
Family history of Diabetes	43.2 (38.4 – 48.2)	45.6 (36.7 – 54.5)	42.2 (36.3 – 48.1)
Past medical history of Diabetes	16.9 (13.7 – 20.1)	18.1 (11.9 – 24.2)	16.4 (12.6 – 20.2)

*In non-diabetic individuals

Table 4. Crude prevalence of diabetes mellitus and pre-diabetes

	Normal	Prediabetes	Diabetes
Both sexes			
Community	42.1 (37.5 – 46.8)	30.3 (25.9 – 34.8)	27.6 (23.7 – 31.4)
18-40	63.8 (54.1 – 71.6)	24.8 (16.9 – 32.6)	12.4 (6.4 -18.4)
41-60	29.3 (23.3 – 35.3)	34.6 (28.4 – 40.9)	36.1 (29.8 – 42.4)
60 >	16.6 (10.9 – 22.2)	35.2 (27.9 – 42.4)	48.3 (40.7 – 55.8)
Males			
Community	40.3 (31.4 – 49.2)	27.2 (19.5 – 34.8)	32.5 (24.6 – 40.4)
18-40	61.1 (45.4 – 76.8)	19.4 (6.7 – 32.2)	19.4 (6.7 – 32.2)
41-60	25.4 (14.7 – 36.1)	33.9 (22.3 – 45.6)	40.7 (28.6 – 52.7)
60 >	16.7 (6.8 – 26.5)	33.3 (20.9 – 45.7)	50.0 (36.8 – 63.2)
Females			
Community	43.0 (37.2 – 48.7)	31.8 (26.3 – 37.2)	25.3 (20.8 – 29.7)
18-40	63.6 (53.1 – 74.2)	27.3 (17.5 – 37.1)	9.1 (2.8 – 15.4)
41-60	30.8 (23.6 – 38.0)	34.9 (27.5 – 42.4)	34.2 (26.8 – 41.6)
60 >	16.5 (9.6 – 23.4)	36.1 (27.2 – 45.0)	47.4 (38.2 – 56.7)

Table 5. Prediabetes, diabetes based on categories of education, ethnicity, tobacco, and alcohol

	Normal	Prediabetes	Diabetes
Ethnicity			
Sinhala	41.0 (35.2 – 46.8)	32.0 (26.5 – 37.5)	30.0 (22.4 – 31.6)
Tamil	60.0 (46.7 – 73.2)	20.7 (10.4 – 30.9)	19.4 (8.8 - 29.9)
Moor	32.3 (20.9 – 43.7)	31.6 (21.3 – 41.9)	36.1 (25.5 – 46.7)
Education			
Below Grade 5	26.5 (23.6 – 45.2)	34.4 (15.2 – 37.7)	39.1 (28.2 – 50.0)
Upto Ordinary level	41.2 (25.5 – 37.9)	31.7 (34.5 – 47.9)	27.1 (21.5 – 32.6)
Upto advanced level	46.5 (20.4 – 37.4)	28.9 (37.1 – 55.9)	24.6 (17.4 – 31.9)
Above advanced level	69.5 (0.0 – 26.6)	10.8 (47.3 – 91.7)	19.7 (1.6 – 37.8)
Tobacco smoking			
Never	44.0 (39.0 – 49.0)	30.7 (25.9 – 35.5)	25.2 (21.4 – 29.1)
Current smokers	33.0 (17.0 – 49.0)	16.9 (6.4 – 27.3)	50.1 (33.4 – 66.7)
Ex-smokers	25.7 (6.3 – 45.1)	45.5 (25.1 – 65.9)	28.8 (10.9 – 46.6)
Alcohol consumers			
Never	43.9 (38.6 – 49.1)	30.2 (25.3 – 35.2)	25.9 (21.7 – 30.0)
Current consumers	38.6 (25.9 – 51.3)	31.7 (20.0 - 43.5)	29.7 (19.3 – 40.0)
Ex- consumers	19.5 (3.7 – 35.3)	27.6 (10.0 – 45.2)	52.9 (31.0 – 74.8)

Table 6. Significant variables at Multiple variable analysis for the presence of diabetes mellitus

	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	-9.04	1.479	-6.11	<0.001
Age	0.04	0.009	3.54	<0.001
Hypertension	0.92	0.260	3.54	<0.001
Family History of Diabetes mellitus	0.96	0.236	4.08	<0.001
BMI	0.06	0.029	1.98	0.048
Neck circumference	0.10	0.039	2.46	0.014
Egg york	0.28	0.108	2.62	0.008
Whole grain	0.19	0.077	2.43	0.015
Sweets	-0.27	0.111	-2.46	0.014

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