DOI: http://doi.org/10.4038/gmj.v27i2.8119

The prevalence and associated risk factors of pre-diabetes and diabetes among adults in the Batticaloa District, Sri Lanka

M Thayaparan[1], G Kisokanth[2], K Arulanandem[3], KT Sundaresan[4], DARK Dayarathne[5]

[1]*Department of Human Biology, Faculty of Health Care Sciences, Eastern University, Sri Lanka.*

[2]*Department of Clinical Nursing, Faculty of Nursing, University of Colombo, Sri Lanka.*

[3]*Department of Primary Health Care,* [4]*Department of Clinical Sciences, Faculty of Health Care Sciences, Eastern University, Sri Lanka.*

[5]*General Hospital, Ampara, Sri Lanka.*

Correspondence: Dr. G Kisokanth
e-mail: *kiso@dcn.cmb.ac.lk*
https://orcid.org/0000-0002-5956-4463
Submitted on 01.03.2022 and accepted for publication on 30.05.2022

ABSTRACT

Introduction: The prevalence of pre-diabetes and diabetes in Sri Lanka has gradually increased over the last few decades. This study aimed to determine the prevalence and risk factors of pre-diabetes and diabetes among adults in randomly selected Divisional Secretariat divisions in Batticaloa district, Sri Lanka.

Methods: A cross-sectional community-based descriptive study was conducted among 582 adults aged ≥ 18 years. A pre-tested and validated interviewer administrated questionnaire was used and a blood sample was obtained to assess the glycosylated hemoglobin level. Statistical analysis was performed using SPSS v 20.

Results: Nearly 78% of them were females and mean age of the participants was 50.5 (SD±13.2) years. Pre-diabetes plus diabetes (HbA_1c ≥ 5.7%) was observed among 63% (95% CI = 33.0 to 41.0). The overall prevalence of pre-diabetes and diabetes was 34.2% (95% CI = 30.3 to 38.2) and 28.9% (95% CI = 25.2 to 32.8) respectively. The mean BMI of the participants was significantly higher among pre-diabetes and diabetes category (dysglycaemia) when compared to the normal category (M = 1.81, 95% CI = 1.01 to 3.01, p = 0.001). Age ≥ 50 years (AOR = 5.88, 95% CI = 2.99 to 11.55), overweight/obesity (AOR = 2.43, 95% CI = 1.18 to 4.97), consumption of white rice (AOR = 2.77, 95% CI = 1.20 to 4.29), and family history of diabetes (AOR = 2.95, 95% CI = 1.51 to 5.77) were found to be the risk factors for dysglycaemia (HbA_1c of ≥ 5.7%) in the binary logistic regression model.

Conclusions and recommendations: The prevalence of pre-diabetes and diabetes was high in the Batticaloa district. Promotion of health awareness on risk factors for pre-diabetes; weight reduction and healthy lifestyles are necessary. Furthermore, screening programs are needed to detect pre-diabetes and more of the undiagnosed diabetes cases.

Keywords: *Glycosylated heamoglobin, diabetes mellitus, pre-diabetes, prevalence.*

Introduction

The World Health Organization (WHO) has reported that nearly 41 million people die of non-communicable diseases (NCDs) in the world each year which is equal to 71% of all deaths globally (1). Over 15 million dies prematurely (age 30 - 69 years) from NCDs, of whom 85% live in lower- and middle-income countries (1). The majority of these deaths are due to four common categories of non-communicable diseases such as cardiovascular diseases (heart attack and stroke), diabetes, cancer, and chronic respiratory diseases (2). Diabetes is considered as most common and worst NCDs and associated with significant morbidity and mortality (3).

The incidence of diabetes is increasing rapidly worldwide. Nearly 8.5% of adults aged more than 18 years had diabetes in 2014 and 1.5 million deaths occurred directly due to diabetes globally in 2019 (4). The estimated global prevalence of diabetes was 463 million in 2019 and projected to be 578 million by 2030. Further, 3 in 4 people with diabetes live in low- and middle-income countries (5). Further, the overall prevalence of diabetes for Sri Lankans aged above 20 years was 10.3% in 2006 with a projected prevalence of 13.9% for the year 2030 (6).

The prevalence of pre-diabetes and diabetes globally and in Sri Lanka has been gradually increasing over the last few decades. Further, it has been highlighted that one in five adults in Sri Lanka has pre-diabetes or diabetes, and one-third of them were found to be undiagnosed and the overall prevalence of some form of dysglycaemia was 21.8% (6). A recent Sri Lankan study reported a rise of the urban prevalence of diabetes and pre-diabetes compared to a study conducted before 10 years (6,7). In addition, Sri Lankan study reported that the cumulative prevalence of pre-diabetes and diabetes was 57.9% in urban Colombo in 2019.

In addition, mortality and morbidity from macrovascular and microvascular diseases due to diabetes have shown an alarming increases in Sri Lanka (9). It is important to note that the number of hospital deaths in 2019 due to diabetes was 714 (3.3 deaths per 100,000 population) and the death rate was relatively high in Batticaloa district when compared to other districts (10).

Due to the silent nature of diabetes, a significant percentage of diabetic patients are unaware of their status. Screening and detection of pre-diabetes and diabetes among the public would help to prevent its associated mobility and mortality which is associated with the country's economy. Estimation of glycosylated haemoglobin (HbA_1c) has been recommended for the diagnosis of abnormalities in glucose tolerance including prediabetes and diabetes (11). Thus, the study was aimed to determine the prevalence and risk factors of pre-diabetes and diabetes among adults in selected Divisional Secretariat divisions in Batticaloa district, Sri Lanka.

Methods

A community-based cross-sectional descriptive study was conducted among selected Divisional Secretariat (DS) divisions, in the Batticaloa District, Sri Lanka. Batticaloa District has fourteen Divisional Secretariat (DS) divisions and among those, only 4 DS divisions were randomly chosen namely Kattankudy, Manmunai North, Eravurpattu, Koralaipattu based on the feasibility. Male and female adults aged ≥ 18 years and who had lived permanently at least for 2 years in selected DS divisions of Batticaloa district were included in the study. Those who refused to give consent for participating and suffering from severe chronic diseases were excluded.

The sample size was calculated using Lwanga & Lemeshow formula (1991) (12) and the absolute error or precision of the estimate (d^2) was 0.05, Z = Standard normal deviation for the selected level of confidence, was 1.96 for a confidence level of 95%. The prevalence of diabetes (39%) from a pilot study was used to calculate the sample size. The calculated sample size was 366. The design effect for the population study was unknown. Thus, the design effect was considered as 1.5. The calculated sample size after applying the design effect was 549. The non-response rate was assumed as 10%. Thus, the sample size after correction for non-responders was 604. Finally, a total of 582 subjects were recruited from all four DS divisions. The number of subjects was decided from each DS division based on the proportions in the population of each DS division. A Grama Niladari division (GND) was considered as a cluster. Voters' registers (updated annually for those aged ≥ 18 years) were used to randomly select the first household in each cluster. The selected household was visited by the study team. The one closest to the right side of the front door of the first house was visited next. This procedure was repeated until the required number of respondents was interviewed in each cluster. In each house visited, all eligible males and females were listed and the person to be interviewed was selected randomly using the lottery method. Written consent was obtained from all potential study participants in each household after providing information before random selection. If any of them refused to participate in the study, that household was not selected.

A validated and pretested interviewer-administered questionnaire (IAQ) was used to collect the data. The IAQ developed in the English language was translated into the Tamil and Sinhala languages using the back-to-back translation method. This IAQ was pretested with a group of subjects who are similar in characteristics in other DS divisions which were not included in the study. Wording problems, the way the questions are asked, length of the questionnaire, language, sequence of the questions were checked during the pretesting, and modifications were done. In addition, anthropometric measurements such as weight and height were also obtained from each participant according to the standard methods (13). In addition, a venous blood sample was collected in heparinized tubes from each participant for HbA_1c measurement by a registered nurse. Biochemical tests were performed in the certified laboratory using a method that is National Glycohaemoglobin Standardization Programme (NGSP) certified and standardized to the Diabetes Control and Complications Trial (DCCT) assay. Data collection was carried out by a field team of medical and nursing graduates who were trained properly before commencing data collection. Before the beginning of the data collection, trained data collectors were explained about the aim of the research. They were also informed about the anonymity of the information and their privacy of storage.

Data were analyzed using a statistical package for social sciences (*SPSS*) version 20. Descriptive statistics were used to calculate percentage, mean and standard deviation determined for variables. Continuous variables were tested for normality and one-way analysis of variance (ANOVA) was used to assess the mean differences between three or more dependent variables. χ^2 and unadjusted odds ratio with their 95% confidence interval (95% CI) test were used to check the significance of the differences observed. Univariate and multivariate analyses were used to identify the factors associated with glycaemic status. A probability level of $p < 0.05$ was set as statistical significance. HbA_1c values were classified as 5.7% - 6.4% - pre-diabetes while a value of ≥ 6.5% was defined as diabetes (11).

Ethical approval for conducting the study was obtained from the Ethics Review Committee of the Faculty of Health Care Sciences, Eastern University, Sri Lanka. Written informed consent for participation was sought prior to recruitment for the study. Permission was obtained from the Divisional Secretary of the selected DS divisions after obtaining permission from Government Agent, Batticaloa District.

Results

Of the 582 participants, nearly 78% were females and 47% were in the age group of 50 – 69 years with the mean age of 50.5 (SD±13.2) years range from 18 -83 years. Further, 90% of participants were Sri Lankan Tamil and 79% were married. Nearly 39% of participants had completed primary education and more than half of them were living in rural areas.

The mean HbA1c was 6.47% (SD±1.69). Out of 582 participants, higher than normal blood glucose level (HbA1c ≥ 5.7%) was observed amongst 63% (95% CI = 33.0 to 41.0). The overall prevalence of pre-diabetes and diabetes was 34.2% (95% CI = 30.3 to 38.2) and 28.9% (95% CI = 25.2 to 32.8) respectively. Further, there were no statistically significant differences between gender and glycaemic status ($p = 0.25$) (Table 1).

A statistically significant difference was observed in the mean differences of BMI across the groups [F (2,579) = 6.64, p = 0.001]. Bonferroni post-hoc comparisons of the three groups indicate that the normal group had a significantly lower BMI (M= 1.81, 95% CI = 1.01 to 3.01, p = 0.001) when compared to diabetes group. Further, there was a statistically significant difference observed in the mean differences of HbA1c level across the groups [F (2,579) = 5.95, p = 0.000]. Bonferroni post-hoc comparisons of the three groups indicated that mean HbA1c level was significantly higher in diabetes group compared to pre-diabetes (M = 2.66, 95% CI = 2.41 to 2.90, p = 0.000) and normal group (M = 3.31, 95% CI = 3.07 to 3.55, p = 0.000) respectively (Table 2).

There was a statistically significant association between glycaemic status and ethnic background, age group, and marital status (p<0.05). In addition, family history of DM, BMI and smoking were also significantly associated with the glycaemic status of the participants (p<0.05) (Table 3).

There was a statistically significant association between glycaemic status and usage of soft drink and type of rice use among participants (p<0.05) (Table 4).

Participants' age of ≥ 50 years was 3.5 times more likely to have dysglycaemia than those who were < 50 years (OR 3.59, 95% CI = 2.52 to 5.12). The presence of the family history of diabetes (OR 2.40, 95% CI = 1.62 to 3.55) and overweight/obesity (OR 2.01, 95% CI = 1.40 to 2.89) were nearly 2 times more likely to have dysglycaemia when compared to their counterparts. Usage of soft drinks and using only white rice were nearly 1.5 times (OR 1.45, 95% CI = 1.03 to 2.05) and 3 times (OR 2.97, 95%, CI = 1.84 to 4.77) more likely to have dysglycaemia respectively compared to their counterparts (Table 5).

Multivariate logistic regression was applied to control the confounding factors and to predict the risk factors for dysglycaemic status (HbA_1c of ≥ 5.7%). Age of ≥ 50 years (AOR = 5.88, 95% CI = 2.99 to 11.55), Overweight/obesity (AOR = 2.43, 95% CI = 1.18 to 4.97), usage of white rice (AOR = 2.77, 95% CI = 1.20 to 4.29), and family history of diabetes (AOR = 2.95, 95% CI = 1.51 to 5.77) were found to be the risk factors for dysglycaemia (Table 6).

Table 1: Prevalence of pre-diabetes and diabetes

Status	Male (n, %)	Female (n, %)	Total (n, %)	95% CI
Normal (HbA1c ≤ 5.6%)	41 (31.5)	174 (38.5)	215 (36.9)	33.0 – 41.0
Pre-diabetes (HbA1c 5.7 - 6.4%)	45 (34.7	154 (34.1)	199 (34.2)	30.3 – 38.2
Diabetes (HbA1c ≥ 6.5%)	44 (33.8)	124 (27.4)	168 (28.9)	25.2 – 32.8

Table 2: Mean anthropometric measures and HbA1c value based on glycaemic category

Characteristic	Normal (n=215)	Pre-diabetes (n=199)	Diabetes (n=168)	*p* value*	Post hoc test (*p* value)
Bodyweight (±SD) Kg	60.25 (±13.68)	61.91 (+11.65)	64.54 (+12.34)	0.004	0.003£
Height (±SD) cm	155.67 (± 8.29)	155.16 (± 9.22)	155.82 (± 8.90)	0.745	-
BMI (±SD) Kg/m^2	24.81 (± 4.99)	25.78 (± 4.71)	26.62 (± 4.86)	0.001	0.001£
HbA1c (±SD) %	5.29 (± 0.24)	5.94 (± 0.21)	8.60 (± 1.76)	0.000	<0.001&, £

* - ANOVA, BMI – Body mass index, £ - Normal group was significantly different to diabetes group, & - Pre-diabetes group was significantly different to diabetes group

Table 3: Factors associated with glycaemic status of the participants

Factors	Responses	Normal (n=215) n (%)	Pre-diabetes (n=199)	Diabetes (n=168) n (%)	Total (n=582) n (%)	*p* value
Gender	Male	41 (19.1)	45 (22.6)	44 (26.2)	130 (22.3)	0.25*
	Female	174 (80.9)	154 (77.4)	124 (73.8)	452 (77.7)	
Ethnic Background	Sinhalese	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.2)	<0.01#
	Tamils	202 (94.0)	173 (87.0)	151 (89.9)	526 (90.3)	
	Muslim	9 (4.2)	20 (10.0)	16 (9.5)	45 (7.8)	
	Burgers	3 (1.4)	6 (3.0)	1 (0.6)	10 (1.7)	
Age group (years)	18 – 49	142 (66.0)	79 (39.7)	50 (29.8)	271 (46.5)	<0.01#
	50 – 69	60 (30.7)	104 (52.3)	105 (62.5)	275 (47.3)	
	≥ 70	7 (3.3)	16 (8.0)	13 (7.7)	36 (6.2)	
Area of residence	Urban	95 (44.2)	91 (45.7)	88 (52.4)	274 (47.1)	0.25*
	Rural	120 (55.8)	108 (54.3)	80 (47.6)	308 (52.9)	
Marital Status	Single	18 (8.4)	7 (3.5)	3 (1.8)	28 (4.8)	<0.01#
	Married	171 (79.5)	151 (75.9)	136 (81.0)	458 (78.7)	
	Divorced/ Widowed	26 (12.1)	41 (20.6)	29 (17.3)	96 (16.5)	
Education level	Primary	135 (62.8)	133 (66.8)	114 (67.9)	382 (65.6)	0.53*
	≥ Secondary	80 (37.2)	66 (33.2)	54 (32.1)	200 (34.4)	
Family history of DM	Yes	44 (22.2)	52 (26.1)	88 (52.4)	184 (31.6)	<0.01*
	No	171 (44.5)	147 (73.9)	80 (47.6)	398 (68.4)	
BMI Category	Underweight	14 (6.5)	8 (4.0)	6 (3.6)	28 (4.8)	0.01#
	Normal	71 (33.0)	46 (23.1)	30 (17.9)	147 (25.3)	
	Overweight	71 (33.0)	78 (39.2)	70 (41.6)	219 (37.6)	
	Obesity	59 (27.5)	67 (33.7)	62 (36.9)	188 (32.3)	
$Consumption of alcohol	Yes	23 (56.1)	15 (33.3)	18 (40.9)	56 (43.1)	0.15*
	No	18 (43.9)	30 (66.7)	26 (59.1)	74 (56.9)	
$Smoking (n=130)	Yes	12 (29.3)	11 (24.4)	3 (6.8)	26 (20.0)	0.02*
	No	29 (70.7)	34 (75.6)	41 (93.2)	104 (80.0)	
¥Perform regular physical activity	Yes	92 (42.8)	85 (42.7)	71 (42.3)	248 (42.6)	0.99*
	No	123 (57.2)	114 (57.3)	97 (57.7)	334 (57.4)	

* - Pearson Chi-square test, # - Likelihood ratio, $ - only among all male participants, ¥- Perform any kind of physical activities ≥ 5 days per week

Table 4: Dietary related factors associated with glycaemic status of the participants

Dietary factors	Response	Normal (n=215) n (%)	Pre-diabetes (n=199) n (%)	Diabetes (n=168) n (%)	Total (n=582) n (%)	*p* value
Are you a	Vegetarian	3 (1.4)	6 (3.0)	6 (3.6)	15 (2.6)	0.37*
	Non-vegetarian	212 (98.6)	193 (97.0)	162 (96.4)	567 (97.4)	
Frequency usage of wheat flour foods	3 meals per day	22 (10.2)	28 (14.1)	16 (9.5)	66 (11.3)	0.68*
	2 meals per day	37 (17.2)	36 (18.0)	38 (22.6)	111 (19.2)	
	1 meal per day	122 (56.8)	106 (53.3)	90 (53.6)	318 (54.6)	
	No use	34 (15.8)	29 (14.6)	24 (14.3)	87 (14.9)	
Frequency of outside food	Most of the time	80 (37.2)	73 (36.7)	70 (41.7)	223 (38.3)	0.63*
	Frequently	37 (17.2)	37 (18.6)	19 (11.3)	93 (16.0)	
	Occasionally	20 (9.3)	17 (8.5)	14 (8.3)	51 (8.8)	
	Never	78 (36.3)	72 (36.2)	65 (38.7)	215 (36.9)	
Usage of instant food	Yes	130 (60.5)	102 (51.3)	86 (51.2)	318 (54.6)	0.10*
	No	85 (39.5)	97 (48.7)	82 (48.8)	264 (45.4)	
Frequency of instant food usage	1 meal/day	112 (52.2)	89 (44.8)	74 (44.0)	275 (47.3)	0.48*
	2 meals/day	13 (6.0)	11 (5.5)	10 (6.0)	34 (5.8)	
	3 meals/day	5 (2.3)	2 (1.0)	2 (1.2)	9 (1.5)	
Family salt usage/month	< 1 Kg	189 (87.9)	161 (80.9)	136 (81.0)	486 (83.5)	0.37*
	1.0 – 2 Kg	21 (9.8)	23 (11.6)	23 (13.7)	67 (11.5)	
	2.1 – 3 Kg	4 (1.9)	12 (6.0)	7 (4.1)	23 (4.0)	
	> 3 Kg	1 (0.4)	3 (1.5)	2 (1.2)	6 (1.0)	
Usage of soft drink	Yes@	123 (57.2)	124 (62.3)	118 (70.2)	365 (62.7)	0.03*
	No£	92 (42.8)	75 (37.7)	50 (29.8)	217 (37.3)	
Type of rice use	White	25 (11.6)	31 (15.6)	72 (42.9)	128 (22.0)	<0.01*
	Brown	190 (88.4)	168 (84.4)	96 (57.1)	454 (78.0)	

* - Pearson chi-square test, @ - yes includes every day, once a week and once in 2 weeks, £ - No means 'not at all'.

Table 5: Risk factors associated with dysglycaemic status (pre-diabetes and diabetes) of the participants

Variables	**Dysglycaemia (= 5.7%) (n=367) n (%)**	**Normal (< 5.7%) (n=215) n (%)**	**Unadjusted Odds Ratio (95% CI)**
Age group (years)			
≥ 50	238 (64.9)	73 (34.0)	3.59 (2.52-5.12)
< 50	129 (35.1)	142 (66.0)	
Marital Status			
Married	287 (78.2)	171 (79.5)	0.92 (0.61-1.40)
Other	80 (21.8)	44 (35.5)	
Family history of DM			
Yes	140 (38.1)	44 (20.5)	2.40 (1.62-3.55)
No	227 (61.9)	171 (79.5)	
BMI			
Overweight / obese	277 (75.5)	130 (60.5)	2.01 (1.40-2.89)
Underweight / normal	90 (24.5)	85 (39.5)	
Smoking (n=130)			
Yes	14 (15.7)	12 (29.3)	0.45 (0.19-1.09)
No	75 (84.3)	29 (70.7)	
Usage of soft drink			
Yes	242 (65.9)	123 (57.2)	1.45 (1.03-2.05)
No	125 (34.1)	92 (42.8)	
Type of rice consumed			
White	103 (28.1)	25 (11.6)	2.97 (1.84-4.77)
Brown	264 (71.9)	190 (88.4)	

Table 6: Binary logistic regression analysis of significant variable for good glycaemic control

Predictor variables	**Coefficient (B)**	**Wald statistics**	***p* value**	**AOR**	**95% CI for AOR**
Married	0.10	0.06	0.81	1.11	0.48 – 2.54
Age of ≥ 50 years	1.77	26.43	**0.00**	**5.88**	**2.99 – 11.55**
Overweight/obesity	0.89	5.88	**0.01**	**2.43**	**1.18 – 4.97**
Usage of soft drinks	0.32	0.75	0.38	0.72	0.35 – 1.50
Usage of white rice	**0.82**	**6.29**	**0.01**	**2.27**	**1.20 – 4.29**
Family history of diabetes	**1.08**	**9.93**	**0.00**	**2.95**	**1.51 – 5.77**
Smoking	1.60	1.75	0.19	0.20	0.02 – 2.21

AOR – Adjusted odds ratio

Discussion

The results revealed that the estimated prevalence of pre-diabetes and diabetes among the study participants was 34% and 29% respectively. A study conducted in most areas of Sri Lanka except the Northern and Eastern areas, the estimated prevalence of pre-diabetes and diabetes was 11.5% and 10.3% respectively (6). Further, the prevalence of diabetes in the Jaffna district in 2015 was 16.4% (14). In addition, the cumulative prevalence of pre-diabetes and diabetes was 63% in the present study which is higher when compared to previously reported studies in Sri Lanka, 21.8% by Katulanda *et al.*, 2008 and 57.9% by Somasundaram *et al.,* 2019 (6,8). This increase can be due to many potential factors such as the increased prevalence of obesity, aging, ethnicity, physical inactivity, socioeconomic status, education, and urbanization (15,16). Further, the high prevalence of pre-diabetes and diabetes in this study could be explained by the accuracy of the screening test (HbA1c testing) that was used as American Diabetes Association recommended HbA1c testing is a better diagnostic tool for prediabetes and diabetes screening (11) where other studies use the fasting blood sugar as screen tool. In addition, HbA1c has the potential to reflect the history of mean insulin sensitivity over the preceding period and it serves as a marker of insulin sensitivity in those who have an abnormal glucose tolerance (17).

According to the binary logistic regression, age, BMI, Family history of diabetes and consumption of white rice were found to be the risk factors for development of diabetes. Advanced age was found to be a significant risk factor for the glycaemic status of the participants. Increasing prevalence in advanced age can be due to lack of exercise, increase in psychosocial stress of retirement that has proportionately increased risk of the disease (18). Further, fat deposition and development of insulin resistance are high among the aging population (19). Similarly, the finding is comparable with the Sri Lanka Diabetes and Cardiovascular Study where higher prevalence was observed in participants with advanced age (6).

Further, the BMI of the participants was found to be a risk factor for pre-diabetes and diabetes. Similarly, many studies have shown that increased BMI has been linked to an increased prevalence of diabetes (15). An increased prevalence of obesity has been resulted due to urbanization and many people might be exposed to sedentary lifestyle, higher frequent usage of a vehicle for transportation, watching television frequently and less physical inactivity.

The prevalence of pre-diabetes and diabetes was relatively high among participants who are having a family history of diabetes. Family history of diabetes and history of consanguinity have been identified as risk factors for impaired fasting glucose in Southeast Asians (20). Further, Asian Indians have a strong familial association of diabetes with a high prevalence of diabetes among the first-degree relatives and vertical transmission through two or more generations (21). People having a family history of diabetes should adopt healthy lifestyles from an early age to prevent or retard the development of diabetes (18).

In addition, white rice consumption was found to be the dietary risk factor for the development of pre-diabetes and diabetes in this study. Usage of white rice was 3 times more likely to develop pre-diabetes and diabetes when compared to brown rice. Similarly, a meta-analysis and systematic review published in the *British Medical Journal* found that higher consumption of white rice was significantly associated with increased risk of development of type 2 diabetes especially among Asian population (22). Another large cohort study conducted in US found that substituting brown rice for white rice was associated with a 16% lower risk of developing type 2 diabetes (23). In addition, a South Indian study shows a potential benefit on HbA_1c when substituting brown rice for white rice among overweight adults with metabolic syndrome (24). This difference can be explained that during the processing, majority of the bran and some of the germ are removed from white rice and this grain consists of numerous phytochemicals, minerals, essential fatty acids and fibre which are believed to be the protective factors against type 2 diabetes (25). Also, a meta-analysis found that consumption of brown rice improves the insulin sensitivity due to its insoluble cereal fibre and thereby reduce the risk of type 2 diabetes (26).

Limitations

The study was initially planned for a larger population throughout the Batticaloa District. However, only 4 DS divisions were included due to some financial constraints and feasibility. Further, the HbA1c is not reliable when there is anaemia. Mild anaemia has little impact on the HbA_1c level, whereas moderate to severe anemia can increase the level of HbA_1c.

Conclusions

The prevalence of pre-diabetes and diabetes was high in selected Divisional Secretaries of Batticaloa district, Sri Lanka and associated with modifiable risk factors such as diet and obesity. Strong health promotion on lifestyle modification towards weight reduction and regular physical activity is recommended. In addition, health promotion activities need to be specific and should be carried out by competent healthcare team is also recommended.

Conflict of interest statement

The authors have declared that no competing interest exists.

Acknowledgements

The authors convey their sincere thanks to the participants and the data collectors of the study. Further, this work was funded by the Research and Publication committee, Eastern University, Sri Lanka.

Funding

The study was funded by the Eastern University, Sri Lanka

References

1. World Health Organization (2021). Noncommunicable diseases. Available at https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases. Accessed on 17th April 2021.
2. STEPS survey, Sri Lanka (2015). Available at https://www.who.int/ncds/surveillance/ steps/STEPS-report-2015-Sri-Lanka.pdf. Accessed on 20th January 2021.
3. Siyambalapitiya S, Gunathilake G, Perera I. Exercise: an essential component of diabetes management. *Sri Lanka Journal of Diabetes Endocrinology and Metabolism.* 2012; **2**(2): 57-60.
4. World Health Organization (2021a). Diabetes. Available at https://www.who.int/news-room/fact-sheets/detail/diabetes. Accessed on 17th April 2021.
5. International Diabetes Federation (2019). IDF diabetes Atlas. 9th edition. Available at https://www.diabetesatlas.org/upload/resources/material/20200302_133351_IDFATLAS9e-final-web.pdf. Accessed on 22nd August 2020.
6. Katulanda P, Constantine GR, Mahesh JG, Sheriff R, Seneviratne RD, Wijeratne S, Wijesuriya M, McCarthy MI, Adler AI, Matthews DR. Prevalence and projections of diabetes and pre-diabetes in adults in Sri Lanka - Sri Lanka Diabetes, Cardiovascular Study (SLDCS). *Diabetes Medicine.* 2008; **25**(9): 1062-9. DOI: https://doi.org/10.1111/j.1464-5491.2008.02523.x.
7. Gunawardane PTK, Somasundaram NP, Thalagala N & Fernando KRAS. The prevalence of diabetes, pre diabetes and obesity among adults living in an urban setting in Colombo, Sri Lanka. Endocrine Society of Sri Lanka, Annual Academic Sessions 2014 – Abstracts 49.
8. Somasundaram NP, Ranathunga I, Gunawardana K, Ediriweera DS. High prevalence of diabetes mellitus in Sri Lankan urban population – data from Colombo urban study. Sri Lanka Journal of Diabetes Endocrinology and Metabolism. 2019; 9(2): 8-15. DOI: http://doi.org/10.4038/sjdem.v9i2.7393
9. Diabetes management guideline Sri Lanka (2018). Available at https://www.ccp.lk/wp-content/uploads/guidelines-diabetes-guidelines.pdf. Accessed on 20th January 2021.
10. Annual Health Statistics Sri Lanka (2019). Available at http://www.health.gov.lk/moh_final/english/public/elfinder/files/publications/AHB/AHS%202019.pdf. Accessed on 3rd August 2020.
11. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Standards of Medical Care in Diabetes. *Diabetes Care.* 2019; **42**(Suppl 1): S13-28.

12. Lwanga S, Lemeshow S. (1991). Sample size determination in health studies: A practical Manual, World Health Organization, Geneva.

13. Wijewardene K, Mohideen MR, Mendis S, Fernando DS, Kulathilaka T, Weerasekara D, Uluwitta P. Prevalence of hypertension, diabetes and obesity: baseline findings of a population based survey in four provinces in Sri Lanka. *Ceylon Medical Journal.* 2005; **50**(2): 62-70. DOI: https://doi.org/10.4038/cmj.v50i2.1571

14. Amarasinghe S, Balakumar S, Arasaratnam V. Prevalence and risk factors of diabetes mellitus among adults in Jaffna District. *Ceylon Medical Journal.* 2015; **60**(3): 107-110.

15. Satman I, Omer B, Tutuncu Y, Kalaca S, Gedik S, Dinccag N, Karsidag K, Genc S, Telci A, Canbaz B, *et al.* TURDEP-II Study Group. Twelve-year trends in the prevalence and risk factors of diabetes and prediabetes in Turkish adults. European Journal of Epidemiology. 2013; **28**(2): 169-80. DOI: https://doi.org/10.1007/s10654-013-9771-5.

16. Jan Mohamed HJB, Yap RWK, Loy SL, Norris SA, Biesma R, Aagaard-Hansen J. Prevalence and determinants of overweight, obesity, and type 2 diabetes mellitus in adults in Malaysia. *Asia Pacific Journal of Public Health.* 2014; **27**(2): 123-35. DOI: https://doi.org/10.1177/1010539514562447.

17. Borai A, Livingstone C, Abdelaal F, Bawazeer A, Keti V, Ferns G. (2011). The relationship between glycosylated haemoglobin (HbA1c) and measures of insulin resistance across a range of glucose tolerance. *Scandinavian Journal of Clinical and Laboratory Investigation*. 2011; **71**(2): 168-72. DOI: https://doi.org/ 10.3109/00365513.2010.547947.

18. Zaman FA, Borang A. Prevalence of diabetes mellitus amongst rural hilly population of North Eastern India and its relationship with associated risk factors and related co-morbidities. *Journal of Natural Science, Biology, and Medicine.* 2014; **5**(2): 383-388. DOI: 10.4103/0976-9668.136195.

19. Yumuk VD, Hatemi H, Tarakci T, Uyar N, Turan N, Bagriacik N, Ipbuker A. High prevalence of obesity and diabetes mellitus in Konya, a central Anatolian city in Turkey. *Diabetes Research Clinical Practice.* 2005; **70**(2): 151-158. DOI: 10.1016/j.diabres.2005.03.030.

20. Shahid A, Saeed S, Rana S, Mahmood S. Family history of diabetes and parental consanguinity: important risk for impaired fasting glucose in South East Asians. *West Indian Medical Journal.* 2012; **61**(3): 219-223. DOI: 10.7727/wimj.2011.072.

21. Ramachandran A, Snehalatha C. Type 2 Diabetes Mellitus - The Epidemic Of The 21st Century: The Indian Scenario. *International Journal of Diabetes in Developing Countries.* 1999; **19**: 158-164.

22. Hu EA, Pan A, Malik V, Sun Q. White Rice consumption and risk of type 2 diabetes: meta-analysis and systematic review. *British Medical Journal.* 2012; **344**: e1454. DOI: https://doi.org/10.1136/bmj.3.1454.

23. Sun Q, Spiegelman D, van Dam RM, Holmes MD, Malik VS, Willett WC, Hu FB. White rice, brown rice, and risk of type 2 diabetes in US men and women. *Archives of Internal Medicine.* 2010; **170**(11): 961-969. DOI: https://doi.org/10.1001/archinternmed.2010.109.

24. Malik VS, Sudha V, Wedick NM, RamyaBai M, Vijayalakshmi P, Lakshmipriya N, Gayathri R, Kokila A, Jones C, Hong B, *et al.* (2019). Substituting brown rice for white rice on diabetes risk factors in India: a randomised controlled trial. *The British Journal of Nutrition* 2019; **121**(12): 1389-1397. DOI: https://doi.org/10.1017/S000711451900076X.

25. Slavin JL, Martini MC, Jacobs DR, Marquart L. Plausible mechanisms for the protectiveness of whole grains. *American Journal of Clinical Nutrition.* 1999; **70**(3 Suppl): 459S-463S. DOI: https://doi.org/ 10.1093/ajcn/70.3.459s.

26. Inter Act Consortium. Dietary fibre and incidence of type 2 diabetes in eight European countries: The EPIC-InterAct Study and a meta-analysis of prospective studies. *Diabetologia.* 2015; **58**(7): 1394-408. DOI: https://doi.org/10.1007/s00125-015-3585-9.