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Millet consumption in type 2 diabetics in urban slums of India: a pilot study

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ABSTRACT

Diabetes is a leading cause of death and disability worldwide, affecting people regardless of their country, age group, or sex. Considering the growing prevalence of diabetes among low socioeconomic groups in developing countries like India, the present study aims to determine the prevalence of millet consumption in urban slums in Pune, India. A pilot cross-sectional study was conducted at a private medical college's field practice area in Pune from January to March 2024. The study focused on individuals with type 2 diabetes mellitus. A pre-designed, pretested semi-structured paperless questionnaire in the Kobo tool app was used to collect information on socio-demographic information, consumption of millet, and diabetes-related information. A total of 30 type 2 diabetics were interviewed as a pilot study. Of these, 53.57% were females, and 46.43% were males. The prevalence of millet consumption was 93% in type 2 diabetics. Sorghum was the most consumed millet amongst all other millet. Age >50 years, education >10th pass, and non-alcoholics were significantly associated with satisfactory consumption of millet. Diversifying diets with nutritious foods like millet can help reduce health-related burdens, including type 2 diabetes. This is important for policy-making and prioritizing diabetes self-care interventions.

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1. INTRODUCTION

Diabetes, a metabolic disorder, leads to high blood glucose levels. Type 2 diabetes is more common with high morbidity and is often associated with lifestyle factors such as obesity, lack of physical activity, and poor diet [1]. In recent decades, there has been a significant increase in diabetes prevalence worldwide, with 415 million people currently living with the condition [2]. Diabetes mellitus is among the top 10 causes of death, alongside cancer, respiratory diseases, and cardiovascular diseases, making it one of the most crucial health issues of the 21st century [3]. According to the World Health Organization, noncommunicable diseases were responsible for 74% of global deaths in 2019, specifically, diabetes led to 1.6 million fatalities, establishing itself as the ninth principal cause of death on a global scale [4]. By the year 2035, it is predicted that nearly 592 million people will die from diabetes [5]. Type 2 diabetes, which accounts for 90% of all diabetes cases, was previously thought to be a disease prevalent in affluent "Western" countries [6]. In 2021, 38.4 million Americans, or 11.6% of the population, had diabetes, out of which 29.7 million were diagnosed, and 8.7 million were undiagnosed [7].

In recent years, India has emerged as a significant hub for a variety of non-communicable diseases, encompassing diabetes mellitus (DM), hypertension, obesity, atherosclerosis, ischemic heart disease, angina,

cardiac arrest, and stroke. Significantly, these conditions are increasingly affecting individuals in younger age brackets, even in their mid-thirties and forties [8]. India has been identified as the global capital for diabetes, as per a study conducted by ICMR-INDIAB [9]. With an age group of 20-79 years, India had 74.9 million diabetics in 2021 projected to increase to 124.9 million by 2045. According to the International Diabetes Federation, 1 out of every 7 diabetic adults worldwide resides in India [10]. The burden of type 2 DM in India is influenced by ethnic factors, a carbohydrate-rich diet, and urbanization. Asian Indian type 2 DM patients often have truncal obesity with a relatively low body mass index, leading to a younger age of onset [11].

A recent publication from The Lancet Commissions emphasizes the imperative nature of identifying sustainable and nutritious diets and promoting the utilization of underutilized plant species such as quinoa, millet, and sorghum [12]. The dietary recommendations aim to benefit most people with diabetes and serve as a starting point for nutrition therapy. However, the best results for each patient depend on the health professional's skills. Since it's hard for most people to make sudden or radical lifestyle changes, health professionals must work with their patients to apply these recommendations in a way that will produce the greatest benefit for each person with diabetes [13]. The common term “Millet” has been used for approximately 10,000 years and encompasses some of the grains that have served as plant-based human foods [14]. The term “Millet” refers to a group of crops commonly found in India as well as in other Asian and African countries [15]. These crops include sorghum, pearl millet, and a variety of small millet. India is the leading producer and consumer of different types of millet, such as finger millet, pearl millet, kodo millet, foxtail millet, barnyard millet, proso millet, and little millet [16]. India is also the sixth-largest producer of sorghum globally [17]. Traditionally, these grains have been used to make various foods and beverages in different regions, playing an important role as a staple food in the local food culture [18].

Millets are a great choice for ecological agriculture and a sustainable source of food. They are drought-resistant, small-seeded grass that can be grown in arid conditions with less water and farming intensity. This makes them ideal for combating hunger in the face of the rapidly changing global climate and for constructing climate-resistant agri-food systems [19]. Millet is often referred to as "smart food" as they are nutritious and healthy for individuals, environmentally sustainable for the planet, and resilient for farmers [17]. Millet, a diverse group of grains, is a healthy food option that can help manage lifestyle diseases, particularly diabetes. The key lies in low glycemic index (GI) of millet which is crucial for stabilizing blood sugar levels. On average, millet has a GI of 52.7, which is lower than that of white rice, corn flour, and refined wheat flour. Millets are rich in dietary fibers, proteins, essential vitamins, and minerals [20]. Addressing diabetes necessitates multifaceted strategies, with diet playing a pivotal role. Over the past 15 years, clinical studies have intensified their exploration of various dietary approaches in diabetes management. Research indicates that diabetics face a higher risk of respiratory and multiple organ failure [21]. In India, 8-10% of the diabetic population is aged 20-70, posing a challenge for country with a predominantly young population. Hence managing diet is key and most cost-effective way to effectively handle diabetes mellitus and its associated complications. Millets are unequivocally top choice for diabetes prevention according to leading associations [8].

A recent systematic review and meta-analysis of low GI millet (including sorghum) showed that it has a beneficial effect on managing and reducing the risk of developing type 2 diabetes. The review found that millet positively impacts various outcomes, such as fasting and post-prandial blood glucose levels, insulin index, and glycated hemoglobin (HbA1c) marker levels [22]–[24]. Researchers, nutritional volunteers, and food manufacturers need to understand the prevalence and consumption of millet in order to plan interventions for the diabetic population. Although several separate studies on millet consumption and production exist, but their information is available for a heterogeneous population. Therefore, it is important to document the evidence of the prevalence of millet consumption patterns in type 2 diabetics in the urban slums of Pune City, India. The objectives of the study were: i) To assess the prevalence of millet consumption in type 2 diabetics in urban slums of Pune, India, ii) To determine the prevalence of diabetes-related information amongst type 2 diabetics, iii) To find the association between socio-demographic variables and consumption of Millet in type 2 diabetics.

2. METHOD

2.1. Study design, study setting, and participants

It was a cross-sectional community-based pilot study that was conducted on 30 type 2 diabetics from January to March 2024. The present study was carried out under the field practice area of the urban health training center (UHTC) of a private medical college in Pune, Maharashtra, India. Diagnosed type 2 diabetics over 30 years old and living in the urban slums for at least six months were included in the study. We excluded those who had not given consent, pregnant females, those who were on steroids, and those with mental disabilities and bedridden.

2.2. Sample size and sampling method

It was a pilot study that was part of the main research protocol. It was carried out for planning and modification of the main research protocol. Therefore, 30 type 2 diabetics, which accounted for 10% of the sample size of the main research, were taken as study participants. There are 15 administrative wards under

Pune Municipal Corporation, India [25]. Out of 15 wards, Urban Health Training Centre of a private medical college provides health-related services to three administrative wards covering approximately 60,000 population. Under these 3 administrative wards, there are 8 slums covering 36 Anganwadis. The list of type 2 diabetes patients was obtained from the child development project officer, which contained the demographic details and addresses of type-2 diabetics in different wards of urban field practice areas. This list was compiled to form the required sampling frame for the selection of type 2 diabetics. To achieve randomization in the selection of subjects at each slum, simple random sampling was used. For the random sampling, RAND Corporation released a random number table was used. 30 selected participants aged 30 years and above diagnosed cases of type 2 diabetes were included in the study.

2.3. Data collection tool

A predesigned, pretested, semi-structured validated questionnaire was used for the data collection. The questionnaire was prepared after a thorough review of the literature. It consisted of a socio-demographic profile, diabetes-related information, addiction history, and millet consumption information in type 2 diabetics. The questionnaire was written in English, translated into the local language (Marathi), and back-translated to English to assess the accuracy of translation. Data was collected using the interview method. The data collection tool was prepared using the Kobo tool, which is a survey administration software. If the type 2 diabetic of a selected household was not available a maximum of the second visit was done.

2.4. Ethical consideration and quality control

Before the start of the study, permission was obtained from the institutional ethics committee (BVDUMC/IEC/67). Study participants were informed about the study objectives and questionnaire. Any concerns were addressed by providing information about the study data. No personal identifiers were used in the datasets. All the forms were reviewed by investigators to ensure they were complete and error-free.

2.5. Operational definitions

Millet consumption was defined as the consumption of any type of millet in any form for more than or equal to six months. Satisfactory millet consumption was defined as the consumption of Millet at least 3 times a week of any type and in any form for more than or equal to three months. Different types of millet include sorghum, pearl millet, finger millet, amaranth, foxtail millet, barnyard millet, proso millet, and little millet.

2.6. Statistical analysis

Data was downloaded and analyzed using SPSS software using version 29. Frequency and percentages (descriptive statistics) were calculated. The Chi-square test was used as a test of significance of the proportion of satisfactory and unsatisfactory consumption of millet with various socio-demographic characteristics; $p<0.05$ was considered statistically significant. The odds ratio, along with confidence intervals, was used to find the strength of association of various factors associated between satisfactory and unsatisfactory consumption of millet.

3. RESULTS AND DISCUSSION

3.1. The details of the consumption of millet by type 2 diabetics

Table 1 revealed a survey of 30 type 2 diabetics, 93% consumed millet. Out of 93%, 46% consumed millet daily, followed by 14% consumed it 3 times a week. Only 11% of type 2 diabetics consumed millet once in 3 months. The most consumed millet was found to be sorghum (jowar) (100%), followed by pearl millet (bajra) (53.5%), finger millet (ragi) (25%), and amaranth millet (rajgira) (14.2%). The majority (86%) liked to consume sorghum in the form of Indian bread (bhakri). It was found that only 3% were consuming millet in the form of sweet cookies made up of amaranth millet. The majority, 46% of type 2 diabetics consumed one quantity of Indian bread per day, while 11% like to consume one cup of millet porridge. About 54% of type 2 diabetics fulfilled the criteria of satisfactory consumption of millet, whereas only 46% were under the criteria of unsatisfactory consumption.

3.2. Information of type 2 diabetics

Table 2 displays diabetes-related information of type 2 diabetics. As shown in Table 2, it was observed that 34% were suffering from type 2 diabetes for 5 to 9 years, followed by 30% for four years. Only 3% of the study participants were suffering from Diabetes for more than 20 years. Around 30% of the participants had a family history of diabetes, and it was surprising to see that 33% were unaware of their family's diabetes status. The majority (90%) were on oral hypoglycemic drugs, followed by 3% who were injecting insulin daily by themselves or by their family members.

3.3. Association between socio-demographic characteristics and consumption of millet of type 2 diabetics

Table 3 shows Type 2 diabetics over 50 years old exhibited higher millet consumption compared to those under 50 years old with type 2 diabetes, and this difference is statistically significant (93.33% versus 6.67%, p-value=0.006). Those with education more than 10th grade showed significantly higher satisfactory consumption of millet than those with less than or equal to a 10th grade education (66% versus 33% p-value=0.032). The non-alcoholics consumption had a significant satisfactory consumption of millet as compared to alcoholics (73.3% versus 26.6%, p-value=0.02).

Table 1. Distribution of type 2 diabetic as per millet consumption

Variables		Frequency (%)
Consumption of millet (n=30)	Yes	28 (93)
	No	2 (7)
Frequency of millet consumption (n=28)	Daily	13 (46)
	Three times a week	4 (14)
	Once a week	3 (11)
	Once in 15 days	4 (14)
	Once in 3 months	3 (11)
	Less often	1 (4)
*Type of millet consumption (n=28)	Sorghum	28 (100)
	Sorghum/Pearl millet	15 (53.5)
	Sorghum/Pearl millet/Finger millet	7 (25)
	Sorghum/Pearl millet/Finger millet/Amaranth	4 (14.2)
Form of millet consumption (n=28)	Millet flour (Sorghum)	24 (86)
	Millet sweet cookies	1 (3)
	Millet porridge	3 (11)
Quantity of millet consumed per day (n=28)	One sorghum Indian bread	13 (46)
	One and half sorghum Indian bread	11 (39)
	One bowl of millet porridge	3 (11)
	Two millet sweet cookies	1 (4)
Consumption of millet (n=28)	Satisfactory consumption	15 (54)
	Unsatisfactory consumption	13 (46)

Table 2. Diabetes-related information of type 2 diabetics (n=30)

Variables		Frequency (%)	Variables		Frequency (%)
Duration of diabetes status (in years)	0-4 years	9 (30)	Family history of diabetes	Don't know	10 (33)
	5-9 years	10 (34)		No	11 (37)
	10-14 years	9 (30)		Yes	9 (30)
	15-19 years	1 (3)	Types of medication	Only OHA	27 (90)
	>20 years	1 (3)		Only Insulin	1 (3)
				Both	2 (7)

Table 3. Association between socio-demographic characteristics and consumption of millet

Sociodemographic characteristics		Consumption of millet		Total (%)	χ^2	p-value
		Unsatisfactory	Satisfactory			
Age category (in years)	≤50	7(53.85)	1(6.67)	8(28.57)	7.59	0.006*
	>50	6(46.15)	14(93.33)	20(71.43)		
Sex	Female	7(53.85)	8(53.33)	15(53.57)	0.007	0.98
	Male	6(46.15)	7(46.67)	13(46.43)		
Marital status	Married	10(76.92)	10(66.67)	20(71.43)	0.36	0.55
	Other	3(23.08)	5(33.33)	8(28.57)		
Caste	Open	10(76.92)	9(60.00)	19(67.86)	0.91	0.34
	SC	3(23.08)	6(40.00)	9(32.14)		
Type of family	Nuclear	5(38.46)	6(40.00)	11(39.29)	0.006	0.93
	Joint	8(61.54)	9(60.00)	17(60.71)		
Income category (in INR)	<10,000	3(23.08)	4(26.67)	7(25.00)	1.58	0.45
	10,000-20,000	8(61.54)	6(40.00)	14(50.00)		
	>20,000	2(15.38)	5(33.33)	7(25.00)		
Education category	≤10thgrade	10(76.92)	5(33.33)	15(53.57)	5.32	0.032*
	>10thgrade	3(23.08)	10(66.67)	13(46.43)		
Occupation category	Employed	6(46.15)	4(26.67)	10(35.71)	1.15	0.28
	Other	7(53.85)	11(73.33)	18(64.29)		
Occupation of the head of the household	Employed	4(30.77)	6(40)	10(35.71)	0.26	0.61
	Other	9(69.23)	9(60)	18(64.29)		
Education of the head of the household	≤10th grade	7(53.85)	5(33.33)	12(42.86)	1.20	0.27
	>10th grade	6(46.15)	10(66.67)	16(57.14)		
Alcohol consumption	Yes	9(69.23)	4(26.67)	13(46.43)	5.07	0.02*
	No	4(30.77)	11(73.33)	15(53.57)		

χ^2 Chi-square value; *p<0.05 considered statistically significant

3.4. Manifests univariate logistic regression analysis for different risk factors and consumption of millet

In Table 4, univariate logistic regression was used to assess socio-demographic characteristics (independent variables) associated with categorical dependent variables. Type 2 diabetics of more than 50 years of age were significantly associated with higher odds of having satisfactory consumption of millet (OR 16.33). Type 2 diabetics having education more than 10^{th} grade were 6.67 times more satisfactory consumption of millet than those who were less than equal to 10^{th} grade. The odds of satisfactory consumption of millet were 6.19 times higher in non-alcoholics as compared to alcoholics.

Table 4. Univariate logistic regression analysis for different risk factors and consumption of millet

Variables		Consumption of millet		Total	OR (95%CI)	p-value
		Unsatisfactory	Satisfactory			
Age category	≤50	7	1	8	16.33(1.63-163.45)	0.02*
	>50	6	14	20	1	
Sex	Female	7	8	15	1.02(0.23-4.53)	0.98
	Male	6	7	13	1	
Marital status	Married	10	10	20	1.67(0.31-8.93)	0.55
	Other	3	5	8	1	
Caste	Open	10	9	19	2.22(0.43-11.60)	0.34
	SC	3	6	9	1	
Type of family	Nuclear	5	6	11	0.93(0.20-4.29)	0.93
	Joint	8	9	17	1	
Income category (in INR)	<10,000	3	4	7	1.88(0.20-11.27)	0.58
	10,000-20,000	8	6	14	3.33(0.47-23.47)	0.23
	>20000	2	5	7	1	
Education category	≤10^{th} grade	10	5	15	6.67(1.24-35.71)	0.03*
	>10^{th} grade	3	10	13	1	
Occupation category	Employed	6	4	10	2.36(0.49-11.45)	0.29
	Other	7	11	18	1	
Occupation of head of the household	Employed	4	6	10	0.67(0.14-3.19)	0.61
	Other	9	9	18	1	
Education of the head of the household	≤10^{th}grade	7	5	12	2.33(0.51-10.78)	0.28
	>10^{th} grade	6	10	16	1	
Alcohol consumption	Yes	9	4	13	6.19(1.20-31.97)	0.03*
	No	4	11	15	1	

*p<0.05 considered statistically significant; OR-Odds Ratio

4. DISCUSSION

The current study focused on the prevalence of millet consumption among type 2 diabetics in the urban slums of Pune. It was a pilot study with 30 participants. The Indian Government has implemented a multi-stakeholder approach toward the celebration of the International Year of Millet 2023 [26]. During the G20 meetings held in 2023, millet is being promoted on a large scale through millet meals, and the distribution of millet gift hampers amongst the Indian population. Recognizing the enormous benefits, the Government of India has introduced various policies to boost the production and consumption of millet. This was highlighted in the budget speech by Union Finance Minister, Ms. Nirmala Sitharaman in February 2022 [27]. To promote Millet, the Department of Agriculture and Farmers Welfare has implemented a sub-mission on nutritional cereals under the National Food Security Mission (NFSM) in 212 Districts of 14 states since 2018-19 [28].

India is the world's largest producer of millet. Millet is grown over an area of 13.8 million hectares in India, yielding 17.3 million tones at 1,247 kg per hectare [29]. Rajasthan has the highest area under millet cultivation (29.05%), followed by Maharashtra (20.67%), Karnataka (13.46%), Uttar Pradesh (8.06%), Madhya Pradesh (6.11%), Gujrat (3.94%), and Tamil Nadu (3.74%) [30]. To our knowledge, no study has been conducted on the prevalence of millet consumption in urban slums, particularly among individuals with type 2 diabetes. Our study revealed that 93% of type 2 Diabetics in the urban slum population in Pune, Maharashtra, consumed millet. It's important to note that this data was obtained from a pilot study with a relatively small sample size of 30 participants who were type 2 Diabetics only, which means that the reported prevalence is inflated towards the higher end.

A large-scale survey of 15,522 individuals was done in Urban India in 2021, which reported 49.6% consumption of millet once or more times per week [31], which is consistent with our study findings. A study done in Udaipur City on the consumption of millet by 120 adults documented that 51.67% [32] often consume millet which was slightly higher than in our study. Another study done by Verma *et al*. [33] on millet consumption in children aged 2-14 years with type 1 diabetes from a pediatric endocrinology clinic, recorded that only 11.6% of the type 1 diabetic children consumed millet daily followed by 15.1% consumed 3-4 times a week, 39.3% did once weekly and 33.7% rarely, this shows that in type 1 diabetes, it is recommended to include a millet-rich diet. Pathak *et al*. conducted a study on the consumption pattern of

millet and millet-based products in Raipur City, Chhattisgarh, and of the 150 respondents, only 31% reported frequent consumption of millet (once or more times a week) [34] which is in line with our study results.

Lakshmy Priya *et al*. study, conducted among South Indian adults, aimed to determine the consumption pattern of millet through a structured interviewer-administered questionnaire. The results revealed that 41% consumed millet 1-3 times a week [35], which is much higher as compared to our study. On the other hand, Padmalini *et al*. conducted a cross-sectional descriptive study on 400 south Indian women from Chennai, Bengaluru, and Hyderabad through convenience sampling technique by using a structured questionnaire method and found that 38% of south Indian women were consuming Millet of which 27% consumed it regularly (at least once a day) and 53% of them consumed it twice a week [36], which was much higher than our study results.

Consistent with the results of Alam Prashanthi *et al*. on the consumption of Millet among 320 school children of 8th and 9th grade from Zilla Parishad high schools in rural and urban areas of Telangana, India, established that 25% of school children from rural areas consumed millet once a week followed by 21.88% once in a month, 18.12% daily and 5% once in three months and similarly, 21.87% of school children from urban areas consumed millet once in a month, followed by 21.25% once a week and 19.37% once in three months [37]. In our study, satisfactory consumption of Millet was found to be higher in Type 2 Diabetics whose age is more than 50, which is in line with the study conducted in the Coimbatore district of Tamil Nadu by Vahini *et al*. [38]. A study by Shah *et al*. also revealed that demographic factors such as age significantly impact millet consumption [39]. In contrast to our findings, George *et al*. [40], found that there is no significant difference between the demographic factors such as age, sex, and consumption of millet. The present study also reflected that type 2 Diabetics with more education (10th pass) had more satisfactory millet consumption, and this was statistically significant. This is similar to the study done by Sangeetha *et al*. at Tirupati, India [41], education can significantly increase awareness about nutrition, including the consumption of millet. The study found that there was an increase in satisfactory consumption of millet among non-alcoholics, which was a significant finding. Alcohol consumption, a modifiable factor, is usually associated with the failure of type 2 diabetics to achieve good glycemic control.

Several limitations may impact the results. For example, the number of participants with type 2 diabetes was inadequate, which can be attributed to the study being in its pilot phase and being designed as a cross-sectional study. Further research is needed on the association between millet consumption and glycemic control. This information will be useful for policy-making and prioritizing diabetes self-care interventions to enhance glycemic control.

5. CONCLUSION

Despite the increasing awareness of health-related issues among the urban population and the rising incidence of non-communicable diseases in India, there is a lack of research on the consumption and nutritional importance of millet, particularly for individuals with type 2 diabetes. A preliminary investigation with 30 type 2 diabetes participants found that 93% consume millet in their diet. Out of this group, 46% consume millet daily. Among these individuals, sorghum was the most consumed millet. The study findings reflect the participant's preference for millet flour and millet sweet cookies. Factors such as age, education, and alcohol consumption seem to influence the consumption of millet. These findings indicate the need to actively promote the benefits of millet and raise awareness about various cooking methods and millet-based products that cater to different tastes. Millets can contribute to sustainable development. There is potential for growth in both the cultivation and sale of millets, which could help change people’s perceptions of millets and ultimately increase their consumption, especially among individuals with type 2 diabetes.

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