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PREVALENCE AND RISK FACTORS OF TYPE 2 DIABETES: A CROSS-SECTIONAL STUDY IN NORTHEAST INDIA

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ABSTRACT

The disease burden of type 2 diabetes among the Indian tribals is understudied, therefore, this study aims to estimate the prevalence of type 2 diabetes and its associated risk factors among the tribals of Northeast India. The present study is a cross-sectional study among two tribal communities-namely Kukis *and* Paites- *of Northeast India. A total of 1460 participants were recruited in the age range of 30-65. Data on sociodemographic, lifestyle variables, and anthropometric and physiological measurements were collected after pre-informed written consent was obtained. The prevalence of type 2 diabetes is 5.2% and 5.8%, statistically significant ($p<0.001$) between the studied tribal communities. It was found that the onset of diabetes was late when compared to non-diabetic participants, which is significant ($p<0.001$) in both the communities. Occupation, types of family, tobacco consumption status, central and abdominal obesity were found to contribute to diabetes. Type 2 diabetes is asymptomatic; hence, early diagnosis is vital for proper interventions to tackle the disease burden. Several interventions could be recommended, but there is always a gap in their implementation, which must be monitored. The health workers must join hands with the communities and spread awareness in a way that the communities want to participate in and remember to follow whatever they have learnt.*

Keywords*: Type 2 diabetes, prevalence, risk factors, Northeast India, tribals, public health*

INTRODUCTION

Type 2 diabetes occurs when the required amount of insulin is not produced or the cells do not respond to insulin. Insulin is produced by the beta cells of the islets of Langerhans in the pancreas and neurons of the central nervous system (Csajbok *et al*., 2016). Glucose, produced from a person's meal, stimulates insulin secretion (Kaufman *et al*., 2015). The role of insulin is to circulate glucose to

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various cells, including the hepatocytes, skeletal muscle cells, and adipocytes, to be stored in the form of glycogen for cellular metabolism (Vasiljevic *et al*., 2020). This storage can sometimes increase an individual's weight (Rahman *et al*., 2021). It is important to note that an insufficient supply of insulin causes a piling up of glucose in the bloodstream, restricting them from entering the cells for energy generation and thus leading to hyperglycemia (Vasiljevic *et al*., 2020). This condition may lead to diabetes mellitus, kidney failure, blurry eyes, and other health burdens. In some cases, the liver can start breaking down fats into ketone bodies for energy to compensate for the inadequate insulin supply required for circulating glucose. When the production of ketone bodies is high, the individual needs immediate medical attention as it can lead to ketoacidosis (acidic blood), whose common symptoms include frequent urge to urinate and feeling thirsty (Accili, 2017).

Type 2 diabetes is also a multifactorial disease involving several risk factors. Such risk factors are categorized into two types- modifiable and non-modifiable. The modifiable risk factors include lifestyle changes such as maintaining healthy diets and living active lifestyles, while the non-modifiable ones involve age and genetics (Tinajero and Malik, 2021). This type of diabetes is common and accounts for around 90% of diabetes cases worldwide. Previously, it was believed that diabetes occurred in the elder section of society, primarily individuals above 45 years, but recent reports claim that the prevalence is high in children and adolescents, too (Goyal and Jialal, 2022).

Cardiovascular diseases (CVDs) also play a significant role in the development of type 2 diabetes, and such association accounts for early death and disability of an individual due to ischemic heart disease, stroke, and various complexities (Einarson *et al*., 2018). It has been reported that type 2 diabetes-related CVDs incidence and mortality rates are reduced while its prevalence increases which could be intervened by lifestyle changes and clinical treatments (Ma *et al*., 2022).

Worldwide, there has been a public health burden caused by the alarming increase in the prevalence of type 2 diabetes over the past four decades (Tinajero and Malik, 2021). The International Diabetes Federation (IDF) predicted the global prevalence of diabetes to be 8.8% in 2015 and 10.4% in 2040 (Ogurtsova *et al*., 2017). An increase of approximately three-fold in health expenses was seen when compared between reports of 2007 and 2019 (Federation, 2019). The prevalence was also estimated to increase in the year 2045 by >50% (Perreault *et al*., 2021). The regions hit hardest by such burdens comprise low- and middle-income regions like Asia, followed by the Middle East and North Africa.

In India, the tribal population, also known as the indigenous population, constitutes 8.6% of the population (Census of India, 2011). It was reported that the burden of type 2 diabetes among the indigenous population was influenced by a multifaceted range of social factors (Yu and Zinman, 2007; Cunningham, 2009). The prevalence of diabetes, according to NFHS-5, in India as a whole, Manipur, and Churachandpur district of Manipur is 18.45%, 15.05%, and 14.35%, respectively (National Family Health Survey-5, 2019-20). Therefore, this study aims to estimate the prevalence of diabetes and its associated risk factors among the two tribal populations of Northeast India. The rationale behind choosing tribals is that they are known to be predisposed to numerous diseases as they are the marginalized section of society with minimal development and poor health-seeking behavior (Government of India 2018).

MATERIALS AND METHODS

Study design: The present study is a cross-sectional study conducted in Northeast India. The Institutional Ethics Committee, Department of Anthropology, University of Delhi, issued an ethical clearance as approval for the present study.

Study area and people: The universe of the study is Manipur, and sample collection was done in two blocks of Churachandpur district, Manipur (Figure-1). The two tribal communities, namely Kuki and Paite, were selected for the study for their higher numerical strength in accordance with the 2011 census of that area. The district of Churachandpur is divided into five blocks, and Churachandpur is the heart of these five blocks. The district is a dwelling place for various tribals categorized under Kuki-Chin-Mizo who, despite using their own languages, can

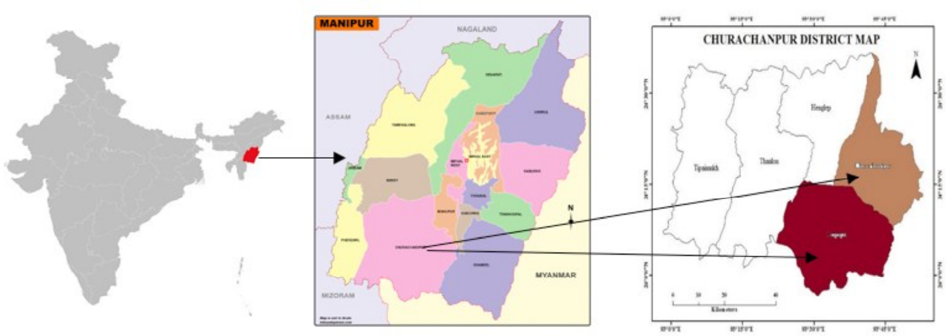

Figure-1: Map showing the study area (Churachandpur District, Manipur).

understand each other. The major religion followed is Christianity. The dietary habits of the people of this area include a non-vegetarian diet, and rice is the staple food. Generally, salt and sugar intake among tribals is known to be high. The prevalence of tobacco intake (68%) and alcohol consumption (19.65%) is high in the Churachandpur District (National Family Health Survey-5, 2019-20).

There is a high migration rate from village to urban areas for better living, resulting in a massive transition of lifestyle and dietary habits. There is also a common practice of eating 'Puri' (made of *maida*) along with tea in the morning, done mainly by men.

Recruitment of 1460 participants (Kuki-730 and Paite-730) was done irrespective of gender for the studied communities. Inclusion criteria included voluntary individuals aged 30 to 65 years belonging to the studied communities. The exclusion criteria included those individuals who recently had surgery (minor or major), blood donation, and pregnant or lactating women and those not falling within the age group.

Data collection and measurement: Information on sociodemographic factors and lifestyle was collected with the help of a pre-tested interview schedule. Anthropological measurements were taken based on standard procedures (Singh and Bhasin, 2004). Various measurements taken on each subject are given as under:

Height: Anthropometer was used to measure the standing height, measured from the vertex to the floor.

Weight: Digital weighing machine was used to measure the weight of the participants.

Waist circumference-Measurement was taken using flexible steel tape between iliac crest and lower rib.

Hip circumference: Measurement was taken using the flexible steel tape placed at the hip where the width is the greatest, which is between the iliac crest and hip's widest area.

Body Mass Index (BMI): It was calculated using weight and height. Waist-to-height ratio (WHtR) was calculated using waist circumference and height in centimeters. Waist-to-hip ratio (WHR) was calculated using waist circumference and hip circumference in centimeters.

Standard cut-offs: The cut-offs used were as follows:

Diabetes: Normal ($\leq$140 mg/dL), pre-diabetes (141-199 mg/dL) and diabetes ($\geq$200 mg/dL) (National Family Health Survey-5, 2019-20)

BMI: Underweight (<18.5 Kg/m^2), Normal (18.5-22.9 Kg/m^2), Overweight (23.0-24.9 Kg/m^2), and obese ($\geq$25.0 kg/m^2) (World Health Organization Expert Consultation, 2004). In the present study, overweight and obese were categorized as one during the analysis for a better outcome.

WC: For males- Normal (<90 cm) and high ($\geq$90 cm); For females- Normal (<80 cm) and high ($\geq$80 cm) (World Health Organization, 2011).

WHR: For males- Normal (<0.90) and high ($\geq$90); For females- Normal ((<0.80) and high ($\geq$0.80 cm) (World Health Organization, 2011).

WHtR: Normal (<0.5) and high ($\geq$0.5) (Ashwell and Gibson, 2016)

Statistical analysis: All analyses were done using SPSS version 22. Descriptive statistics were used to report the overall and sex-wise distribution of diabetes, sociodemographic, and lifestyle variables. A normality test was done, after which a median was used as the data were not normally distributed. The Mann-Whitney U test was used to check whether the difference in median values was significant. To evaluate the risk of the variable for the outcome, binary logistic regression with odds ratios and 95% confidence intervals were used, and p-values <0.05 were considered significant.

RESULTS

The present study recruited 730 participants each from the studied communities resulting in 1460 participants. The overall prevalence of diabetes was 5.2% and 5.8%, respectively, and the difference was statistically significant (p<0.001) between Kukis and Paites. Further, for male participants in both communities, Kuki community (5.7%) had a significantly (p=0.031) higher number of diabetic individuals than Paite community (4.8%). Again, for female participants, Paite community (6.6%) had significantly (p=0.003) higher numbers of diabetic individuals in comparison to Kuki community (4.8%) (Table-1).

Table-1: Prevalence of Type-2 diabetes among the two studied tribal communities of Manipur.

Variable	Parameter	Kuki Community				Paite Community				
		Total, N (%)	Males, N (%)	Females, N (%)	χ^2 p-value	Total, N (%)	Males, N (%)	Females, N (%)	χ^2 p-value	χ^2 p-value
Type 2 diabetes	**Normal**	609 (83.4)	277 (83.7)	332 (83.2)	0.714	550 (75.3)	259 (77.5)	291 (73.5)	0.389	<0.001*Ψ
	Pre-diabetes	83 (11.4)	35 (10.6)	48 (12.0)		138 (18.9)	59 (17.7)	79 (19.9)		0.031*¥
	Diabetes	38 (5.2)	19 (5.7)	19 (4.8)		42 (5.8)	16 (4.8)	26 (6.6)		0.003*€
Total		730 (100.0)	331 (100.0)	399 (100.0)		730 (100.0)	334 (100.0)	396 (100.0)		

*Significant at p<0.05; N: Count; p: Chi-square between overall participants of Kuki and Paite communities; ¥: Chi-square between males of both communities; €: Chi-square between females of both communities.

The Kuki communities showed earlier onset of diabetes than the Paites, which is statistically significant (p<0.001). The median age with Interquartile range (IQR) of diabetes for Kukis and Paites are 51.5 (40.0-63.0) years and 55.5 (45.0-64.25) years. Diabetic individuals were significantly (p<0.001) older than non-diabetic groups in the studied communities, which means late onset of diabetes. The joint family was found to be significantly (p=0.011) high among the diabetic individuals in the studied tribes. Families with members e”7 contribute the highest among the diabetic groups, although it is significant (p<0.001) for Paites only. Further, unemployed participants were significantly (p=0.033) high among the diabetic Kukis, while agriculturists were significantly (p<0.001) high for Paites. Individuals with monthly income d”Rs. 10,000 was high among the diabetic groups in both communities and significant (p=0.034) for Kukis only. This table 2 also shows that individuals who studied till high school contributed most in the case of diabetes, although statistically significant (p=0.027) for the Paites only. Non-alcohol consumers were high for the diabetes group and significant (p<0.001) for the Paites. Tobacco consumers contribute the highest among diabetic individuals for both communities, yet not significant. Although not significant, non-smokers contributed the highest for diabetes in both the studied tribes (Table-2).

Table-2: Distribution of sociodemographic and lifestyle variables with respect to type-2 diabetes among the two studied tribal communities.

Variables	Parameters	Kuki Community				Paite Community			
		Normal, N (%)	Pre-diabetes, N (%)	Type 2 diabetes, N (%)	χ^2 p-value	Normal, N (%)	Pre-diabetes, N (%)	Type 2 diabetes, N (%)	χ^2 p-value
Age (in years)	Median (IQR)	40.0 (30.0-51.0)	50.0 (39.0-59.0)	51.5 (40.0-63.0)	<0.001 *	45.0 (32.0-55.0)	52.0 (41.75-62.25)	55.5 (45.0-64.25)	<0.001 *
Family type	Nuclear	357 (58.6)	36 (43.4)	17 (44.7)	0.011*	323 (58.7)	66 (47.8)	15 (35.7)	0.002*
	Joint	252 (41.4)	47 (56.6)	21 (55.3)		227 (41.3)	72 (52.2)	27 (64.3)	
Number of family members	1-3	14 (2.3)	2 (2.4)	0 (0.0)	0.058	23 (4.2)	6 (4.3)	0 (0.0)	0.001*
	4-6	354 (58.1)	37 (45.1)	15 (39.5)		306 (55.6)	53 (38.4)	17 (40.5)	
	≥ 7	241 (39.6)	43 (52.4)	23 (60.5)		221 (40.2)	79 (57.2)	25 (59.5)	
Occupation	Unemployed	98 (16.1)	19 (22.9)	12 (31.6)	0.033*	81 (14.7)	39 (28.3)	15 (35.7)	<0.001 *
	Agriculturist	189 (31.0)	34 (41.0)	10 (26.3)		268 (48.7)	64 (46.4)	16 (38.1)	
	Self/government employed	172 (28.2)	15 (18.1)	9 (23.7)		132 (24)	21 (15.2)	8 (19.0)	
	Homemaker	150 (24.6)	15 (18.1)	7 (18.4)		69 (12.5)	14 (10.1)	3 (7.1)	
Monthly income (in Rs.)	≤ 10,000	388 (63.7)	55 (66.3)	21 (55.3)	0.034*	435 (79.1)	119 (86.2)	35 (83.3)	0.469
	10,001-20,000	191 (31.4)	25 (30.1)	10 (26.3)		99 (18)	18 (13.0)	6 (14.3)	
	≥ 20,001	30 (4.9)	3 (3.6)	7 (18.4)		16 (2.9)	1 (0.7)	1 (2.4)	
Education	Illiterate	30 (4.9)	5 (6.0)	3 (7.9)	0.285	63 (11.5)	23 (16.7)	6 (14.3)	0.027*
	High school	385 (63.2)	62 (74.7)	25 (65.8)		398 (72.4)	104 (75.4)	34 (81.0)	
	>High school	194 (31.9)	16 (19.3)	10 (26.3)		89 (16.2)	11 (8.0)	2 (4.8)	
Alcohol	Non-alcoholic	373 (61.2)	61 (73.5)	24 (63.2)	0.311	362 (65.8)	104 (75.4)	31 (73.8)	0.001*
	Current drinker	198 (32.5)	18 (21.7)	12 (31.6)		145 (26.4)	15 (10.9)	7 (16.7)	
	Ex drinker	38 (6.2)	4 (4.8)	2 (5.3)		43 (7.8)	19 (13.8)	4 (9.5)	
Tobacco consumers	Non-consumers	176 (28.9)	28 (33.7)	9 (23.7)	0.494	108 (19.6)	32 (23.2)	14 (33.3)	0.089
	Consumers	433 (71.1)	55 (66.3)	29 (76.3)		442 (80.4)	106 (76.8)	28 (66.7)	
Smoking status	No	419 (68.8)	55 (66.3)	29 (76.3)	0.799	216 (39.3)	52 (37.7)	18 (42.9)	0.475
	Yes	187 (30.7)	28 (33.7)	9 (23.7)		310 (56.4)	77 (55.8)	20 (47.6)	
	Ex-smoker	3 (0.5)	0 (0.0)	0 (0.0)		24 (4.4)	9 (6.5)	4 (9.5)	

*Significant at p<0.05; N: Count.

In both the studied communities, underweight individuals have a reduced risk of being pre-diabetic, yet not significant. In the case of overweight/obese individuals, although not significant, Kukis have 1.06- and 1.07-folds increased risk of having pre-diabetes (p=0.809) and diabetes (p=0.935), respectively. While among the Paites, overweight/obese individuals have a reduced risk for pre-diabetes (p=0.482) and a 1.86-fold increased risk of diabetes (p=0.088) which is not significant. For individuals with abnormal waist circumference (WC), there is slightly more than one-fold increased risk of having pre-diabetes and diabetes for both the studied communities, yet not significant. For abnormal waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) among the Kukis, there is more than a one-fold increased risk of having pre-diabetes and diabetes, respectively, which is not significant. In the case of Paites, individuals with abnormal WHtR and WHR have 1.31- and 1.28- folds increased risk of pre-diabetes (WHtR, p=0.209; WHR,p=0.322) which is not significant; while there are 3.48- and 7.70-folds significantly increased risk of having diabetes (WHtR, p=0.007; WHR,p=0.006), respectively (Table-3).

Table-3: Binary logistic regression of BMI with respect to type 2 diabetes after controlling for confounders.

Variables		Kuki Community				Paite Community			
		Pre-diabetes, N (%)		Type 2 diabetes, N (%)		Pre-diabetes, N (%)		Type 2 diabetes, N (%)	
		OR (95% CI)	χ^2 p-value	OR (95% CI)	χ^2 p-value	OR (95% CI)	χ^2 p-value	OR (95% CI)	χ^2 p-value
BMI	Underweight	0.28 (0.06-1.29)	0.102	1.66 (0.73-3.75)	0.224	0.79 (0.37-1.71)	0.551	0.44 (0.08-2.42)	0.436
	Overweight/Obese	1.06 (0.65-1.76)	0.809	1.07 (0.20-5.85)	0.935	0.86 (0.57-1.31)	0.482	1.86 (0.91-3.81)	0.088
WC	Abnormal	1.26 (0.77-2.07)	0.360	1.69 (0.83-3.47)	0.151	1.14 (0.76-1.73)	0.520	1.67 (0.86-3.23)	0.129
WHtR	Abnormal	1.53 (0.66-3.51)	0.321	1.27 (0.37-4.38)	0.707	1.31 (0.86-1.99)	0.209	3.48 (1.42-8.58)	0.007*
WHR	Abnormal	1.24 (0.56-2.74)	0.60	1.81 (0.41-7.95)	0.431	1.28 (0.78-2.10)	0.322	7.70 (1.78-33.33)	0.006*

*Significant at p<0.05; N: Count; Confounders for Kuki-age, family type, occupation, monthly income and for Paite- age, family type, number of family members, occupation, education, alcohol.

DISCUSSION

The present study found an overall (Kuki and Paite combined) prevalence of diabetes (5.5%), which is slightly higher than 4.94%, a pooled prevalence reported among the Indian tribes (Hazarika and Babu., 2022). In contrast, it is lower among the studied communities than the general population (7.3%) (Anjana *et al*., 2017). The sex-wise pooled prevalence of men and women in the present study was 5.3% and 5.7%, respectively. While Hazarika and Babu, 2022 reported it to be 6.04% and 6.48% among males and females among the Indian tribes. It can be observed that females have a comparatively higher prevalence than males in both the studies, which is similar to Ruhembe *et al*. (2014) and contrary to the findings of Amarasinghe *et al*. (2015), Chen *et al*. (2015). Such gender differences might be because women were found to be more hyperglycemic than males after meals resulting in increased oxidative stress leading to an increased risk of diabetes and various cardiovascular diseases (Tonolo, 2021). It has also been reported that women's bodies comprise more fat than muscles (Matsuda and DeFronzo, 1999), indicating that they are at higher risk for diabetes than men (Zhao *et al*., 2017). Moreover, most women with a history of gestational diabetes, which is common during pregnancy, have a high risk of diabetes as there are decreased beta cells (Buchanan and Xiang, 2005). In a study conducted by Chhungi *et al*. (2019) in Northeast India (Manipur), it was reported that the prevalence of type 2 diabetes was 4.9%, 26.6% and 32.8% among the Liangmai, Meitei, and Mizo, respectively. Their study could have a higher prevalence as fasting blood glucose was used, and the studied age range was 20-60 years.

It was also observed in the present study that the older age group was more diabetic than the younger ones. The findings are in agreement with Ruhembe *et al*. (2014) and Kumar *et al*. (2018). One reason might be that a sedentary lifestyle is commonly observed with advanced age, leading to adiposity, which is associated with high insulin resistance (Amati *et al*., 2009) and decreased pancreatic islet function (Chang and Halter, 2003; Reers *et al*., 2009). The present study found that joint families have a higher prevalence of diabetes which is the opposite of the study by Kumar *et al*., 2018. The common reason might be blood relation which is true, but besides this, it can also be that members of the joint family share a similar lifestyle (Centers for Disease Control and Prevention, 2022), leading to an increased risk of diabetes. This is possible because sharing similar habits in the same household is natural. It was observed in this study that tobacco consumers were more likely to be diabetic. The study was on par with Supriya *et al*. (2017) and Nagamma *et al*. (2019). They found that tobacco consumers significantly increased oxidative stress leading to diabetes. Tobacco consumption contains active ingredients known as nicotine which can elevate blood sugar levels. It also numbs the cells, causing them to be unresponsive to insulin (Centers for Disease Control and Prevention (2022).

The present study observed that being overweight/obese, along with abnormal-waist circumference, waist-to-height ratio, and waist-to-hip ratio, have higher risks of having diabetes. Studies done by Amarasinghe *et al*. (2015), Deeb (2017), Kumar *et al*. (2018) and Wang *et al*. (2018) support the findings. The reason behind such a mechanism is that cells restrict the entry of glucose escorted by insulin into them; besides this, the liver, an ideal place for storing glucose, is already filled with fats in the case of an obese individual. This increased glucose level in the bloodstream triggers the pancreas to overwork and produce more insulin, which exhausts the organ. It now produces less insulin leading to hyperglycemia. In contrast to the above findings, it was reported by Gujral *et al*. (2013) that South Asians are more prone to develop type 2 diabetes even in individuals with low body mass index (BMI). The reason for such high susceptibility is unknown, but the epidemiological transition and rapid lifestyle changes might be among the contributing reasons (Unnikrishnan and Mohan, 2018).

The study's strength is the large sample size of two tribal communities from remote areas which are not easily accessible parts of Manipur, Northeast India. The limitation of the present study is that no genetic markers were used.

CONCLUSIONS

Tribals who once were considered free from diseases are now reported to have a high burden of diseases, especially non-communicable diseases. These can be attributed to acculturation which greatly affects their lifestyles, dietary habits, and physical activity status. Tribals are also known for their minimal health-seeking behavior and poor knowledge of any disease, which needs to be improved. Regarding health-seeking behavior, social, cultural, and economic factors play a significant role in deciding whether to consult a doctor or ethnomedicine specialist. There are several existing health awareness programs and policies whose implementations need to be monitored. Programs should be made such that the participants are excited to participate and spread knowledge. Also, an intervention program can be started by monitoring diet and tobacco consumption and exercising, decreasing the risk of developing diabetes, diabetic retinopathy, and cardiovascular diseases. The interventions provided to individuals must be patient-centric instead of gluco-centric, which means the patients must be given tailored interventions based on their medical history, lifestyle, and so on (Yun and Ko, 2021). Therefore, various socio-cultural factors and poor policies deteriorate the health of the tribals and impose a health burden on them.

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