

Socio-Demographic and behavioural predictors of Metabolic Syndrome: An inter-generational study among the Toto community

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ABSTRACT

Background and Objectives: Metabolic syndrome (MetS) is a major global public health concern due to its increasing prevalence and association with cardiovascular diseases (CVD). The present study aimed to identify the key socio-demographic and behavioural predictors of MetS and to examine inter-generational differences in the Toto community of West Bengal. **Materials and Methods:** A cross-sectional study was conducted among the Toto population. Anthropometric measurement, blood pressure, blood glucose, and lipid profile were assessed using standardized techniques, while socio-demographic and behavioural information was recorded using a pre-structured schedule. Data were analysed using SPSS version 26.0 (IBM), and $p < 0.05$ was considered statistically significant. **Results:** In the parental generation, junk food intake emerged as the best predictor of waist circumference, fasting blood glucose, triglycerides, and high-density lipoprotein cholesterol, while extra salt intake was the best predictor of systolic and diastolic blood pressure. Among the younger generation, educational status and alcohol consumption additionally emerged as the best predictors. **Conclusion:** The study indicates that lifestyle transitions and changing behavioural patterns may increase susceptibility to MetS among the younger generation of the Toto community.

Keywords: Toto, Metabolic syndrome, Cardiometabolic risk, Intergenerational study, Socio-demographic factors, Behavioural factors

INTRODUCTION

Metabolic syndrome (MetS) is a cluster of several cardio-metabolic risk factors, including abdominal obesity, hypertension, dyslipidemia, and elevated fasting blood glucose. Over the last few decades, MetS has emerged as a major global public health problem among non-communicable diseases (NCDs) [1–4]. Numerous socio-demographic and behavioural risk factors have been identified as contributing to its development, such as advancing age, genetic predisposition, physical inactivity, socio-economic conditions, high-fat diets, excessive intake of sugar and salt, consumption of processed foods, and substance use [5–7].

For instance, higher alcohol consumption has been associated with a 1.84-fold increased risk of MetS compared to non-drinkers [8], while chronic alcohol consumers show a higher incidence rate compared to their non-drinker counterparts [9]. Furthermore, studies report that the combined use of alcohol and tobacco has increased the level of triglyceride (TG), which is a key component of MetS [10]. Several studies reveal that not only the consumption of alcohol and tobacco products, but also junk food, has become a common part of the diet

among young adults because it is an easily accessible, quick, and low-cost alternative to homemade meals. According to the National Institutes of Health, Junk foods tend to be high in sugar, salt, saturated fatty acids, and calories [11-12]. Therefore, its higher intake is associated with the development of diabetes, MetS, and cardiovascular diseases [13]. Chopra et al. mentioned in their study that the taste of junk food has influenced Indian adolescents to consume it, despite their knowledge of its negative effects [14].

There is no single universally accepted guideline for diagnosing MetS. Various professional bodies, such as the World Health Organization (WHO), American Association of Clinical Endocrinologists (AACE), European Group for the Study of Insulin Resistance (EGIR), National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP-III), and International Diabetes Federation (IDF), propose different diagnostic criteria. While the AACE, WHO, and EGIR guidelines primarily focus on insulin resistance, the NCEP ATP-III guideline is more clinician-oriented, relying on readily available clinical and laboratory measurements. Despite these variations, all these guidelines highlight that MetS is a valuable tool for early detection and prevention of cardio-metabolic disorders [15-16].

Globally, the prevalence of MetS has increased rapidly. In the United States of America (USA), more than 25.0% of the adult population is affected, while in a few European countries, the prevalence is nearly 23.0%. In South Asia, studies reported that around 20.0% to 25.0% of the population is affected by MetS [17-18]. Existing studies indicate that rapid changes in dietary patterns and physical activity have contributed to its increasing prevalence, especially among younger populations. In India, increasing trends have been reported not only in urban and rural settings but also among traditional communities, such as the Toto [19-20]. A recent study among the Toto population reports 44.7% of males and 57.2% of females in the younger generation were affected by MetS [19].

However, despite the increasing burden of this syndrome, there is very limited evidence on the relative importance of socio-demographic and behavioural risk factors, particularly in small and isolated populations like the Toto. Existing studies have mainly focused on major populations, often overlooking community-specific dynamics and inter-generational differences in risk. Understanding these patterns is essential, especially in populations undergoing rapid lifestyle changes, where behavioural and social changes may play a significant role in developing the risk of MetS. Toto is a numerically small, genetically homogeneous, and geographically isolated tribal population that provides a unique context for examining the relationships between socio-demographic and behavioural risk factors and MetS, because any changes in their health status are likely to be due to shifts in lifestyle and behavioural patterns rather than genetic and environmental factors. Therefore, the present study aims to identify the key socio-demographic and behavioural predictors of MetS among

the Toto community and to examine inter-generational differences between the parental and younger generations in relation to these determinants.

MATERIALS AND METHODS

Study Design and Participants: The present study was a cross-sectional study. In this research, complete enumeration was targeted, and those who voluntarily participated were included. This study comprises 676 participants, including the parental generation ($n = 317$) and the younger generation ($n = 359$), all of whom were biological children of the parental group.

Study Area: The present cross-sectional study was carried out among the Toto tribal community of West Bengal, India. This community lives in a village named 'Totopara', in the district of Alipurduar (*erstwhile*, Jalpaiguri) in West Bengal near the Indo-Bhutan border.

Data collection: Age, marital status (MS), and educational status (Edu. Status), junk food intake (JF), extra salt intake (ES), and substance consumption (alcohol, smoking, and tobacco chewing habits) were recorded using a structured schedule. Waist circumference (WC) was measured using the standard technique [23]. Blood pressure (BP) measurements were taken using a sphygmomanometer and a stethoscope. Blood samples from each participant were collected after overnight fasting (~12 hours) using a Standard SD Biosensor (Korea) analyser to assess fasting blood glucose (FBG), triglycerides (TG), and high-density lipoprotein cholesterol (HDLc). MetS was diagnosed according to the definition proposed by the NCEP ATP-III in 2005 [24].

Statistical analyses: The data were analysed using IBM SPSS (version 25). Categorical variables were presented as frequencies (n) and percentages (%). To understand the relationship between MetS and selected risk variables, partial correlation analysis was performed after controlling for age and sex. Only those variables that showed statistically significant associations in the partial correlation analysis were considered for multiple regression (stepwise), which was carried out to identify the best predictors among the socio-demographic and behavioural factors for MetS. A p -value of less than 0.05 was considered statistically significant.

RESULTS

Table 1 shows the socio-demographic and behavioural characteristics of the study participants, which include age, educational status (Edu. Status), marital status (MS), junk food intake (JF), extra salt intake (ES), and substance consumption. The mean age of male participants in the parental generation was 51.21 years ($SD = 10.46$; range: 38–84), compared to 29.53 years ($SD = 7.03$; range: 20–44) in the younger generation. Among females, the mean age was 48.58 years ($SD = 10.40$; range: 36–80) in the parental generation and 28.61 years ($SD = 6.92$; range: 20–43) in the younger generation.

Edu. Status showed a clear generational difference between the two groups. In the parental generation, the majority of participants, both males (56.4%) and females (80.4%), were non-literate. On the other hand, the younger generation showed higher educational attainment, with most participants in the secondary category (males: 39.7%; females: 25.6%). It has been observed that the majority of participants in both generations were married. However, a higher percentage of unmarried individuals was observed in the younger generation compared to the parental generation. Similarly, a higher frequency of JF and ES intake was observed among the younger generation compared to their parental counterparts. Interestingly, the frequency of substance consumption was higher among the parental

generation, but the frequencies also indicate some participants of the younger generation (both males and females) regularly or occasionally consume substances, which is quite concerning in the context of the Toto population.

Table 1: Socio-demographic and behavioural characteristics of the study participants

Variables	Male (n = 328)		Female (n = 348)	
	Parental generation	Younger generation	Parental generation	Younger generation
Number of participants n (%)	149 (45.4)	179 (54.6)	168 (48.3)	180 (51.7)
Age (in years)				
Min - Max	38 – 84	20 – 44	36 – 80	20 – 43
Mean ± SD	51.21±10.46	29.53±7.03	48.58±10.40	28.61±6.92
Educational status n (%)				
Non-literate	84 (56.4)	10 (5.6)	135 (80.4)	58 (32.2)
Can Sign.	27 (18.1)	29 (16.2)	23 (13.7)	23 (12.8)
Primary	20 (13.4)	15 (8.4)	10 (6.0)	28 (15.6)
Secondary	18 (12.1)	71 (39.7)	-	46 (25.6)
Higher Secondary	-	32 (17.9)	-	16 (8.9)
Graduate and above	-	22 (12.3)	-	9 (5.0)
Marital Status n (%)				
Unmarried	-	42 (23.5)	-	29 (16.1)
Married	135 (90.6)	133 (74.3)	154 (91.7)	144 (80.0)
Widow/Widower	12 (8.1)	4 (2.2)	14 (8.3)	6 (3.3)
Divorcee/Separated	2 (1.3)	-	-	1 (0.6)

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Variables	Male (n = 328)		Female (n = 348)	
	Parental generation	Younger generation	Parental generation	Younger generation
Junk Food Intake n (%)				
No	72 (48.3)	56 (31.3)	92 (54.8)	42 (23.3)
Occasional	45 (30.2)	66 (36.9)	41 (24.4)	76 (42.2)
Regular	32 (21.5)	57 (31.8)	35 (20.8)	62 (34.5)
Extra Salt Intake n (%)				
No	74 (49.6)	57 (31.8)	77 (45.8)	31 (17.2)
Occasional	39 (26.2)	70 (39.1)	48 (28.6)	82 (45.6)
Regular	36 (24.2)	52 (29.1)	43 (25.6)	67 (37.2)
Alcohol Consumption n (%)				
No	51 (34.2)	70 (39.1)	93 (55.4)	134 (74.4)
Occasional	80 (53.7)	96 (53.6)	64 (38.1)	39 (21.7)
Regular	18 (12.1)	13 (7.3)	11 (6.5)	7 (3.9)
Smoking Habit n (%)				
No	102 (68.5)	121 (67.6)	159 (94.6)	177 (98.3)
Occasional	22 (14.8)	21 (11.7)	3 (1.8)	2 (1.1)
Regular	25 (16.8)	37 (20.7)	6 (3.6)	1 (0.6)
Tobacco (Chewing) n (%)				
No	63 (42.3)	95 (53.1)	85 (50.6)	153 (85.0)
Occasional	6 (4.0)	5 (2.8)	2 (1.2)	1 (0.6)
Regular	80 (53.7)	79 (44.1)	81 (48.2)	26 (14.4)

To identify the key socio-demographic and behavioural predictors of MetS components and distinguish between the two generations, partial correlation analyses were first performed, controlling for age and sex. Tables 2a and 2b present the results for the parental and younger generations, respectively. Many variables showed significant correlations ($p < 0.05$) with one or more MetS components in both generations. Significantly correlated variables were then included in stepwise multiple regression analyses, with each MetS component as the dependent variable and the relevant risk variables as independent variables.

For the parental generation, stepwise regression revealed that JF was the strongest predictor for waist circumference (WC), fasting blood glucose (FBG), triglycerides (TG), and high-

density lipoprotein cholesterol (HDLc). In contrast, ES was the best predictor for systolic and diastolic blood pressure (Table 3a).

Among the younger generation, JF was the strongest predictor for WC, while ES predicted both systolic and diastolic blood pressure. Edu. Status emerged as a significant predictor for TG, and alcohol consumption was the best predictor for HDLc. No significant predictor was identified for FBG in the younger generation (Table 3b).

These findings indicate that the impact of socio-demographic and behavioural predictors on MetS components varies between generations, with dietary behaviours such as junk food and salt intake being consistently important, while other factors such as education and alcohol use show generation-specific effects.

Table 2a: Partial correlation analysis between the socio-demographic and behavioural risk variables and MetS components among the parental generation (controlling for age and sex)

MetS Components		Edu. Status	MS	JF	ES	Alcohol	Smoking	Tobacco (Chewing)
WC	R	0.100	0.142	0.732	0.183	0.053	0.025	0.007
	P	0.077	0.012	<0.001	0.001	0.353	0.659	0.898
SBP	R	0.106	0.057	0.223	0.865	0.027	0.009	0.046
	P	0.059	0.316	<0.001	<0.001	0.627	0.874	0.412
DBP	R	0.114	0.101	0.161	0.675	0.090	0.056	0.066
	P	0.042	0.075	0.004	<0.001	0.112	0.322	0.242
FBG	R	0.063	0.045	0.179	0.053	0.045	0.046	0.053
	P	0.267	0.430	0.001	0.350	0.425	0.418	0.352
TG	R	0.046	0.075	0.229	0.095	0.138	0.044	0.088
	P	0.413	0.185	<0.001	0.094	0.014	0.441	0.118
HDL ^c	R	-0.012	-0.126	-0.264	-0.003	-0.126	-0.108	-0.087
	P	0.830	0.025	<0.001	0.954	0.026	0.055	0.123

r = partial correlation coefficient; p = probability value

Table 2b: Partial correlation analysis between the socio-demographic and behavioural risk variables and MetS components among the younger generation (controlling for age and sex)

MetS Components		Edu. Status	MS	JF	ES	Alcohol	Smoking	Tobacco (Chewing)
WC	r	0.169	0.043	0.707	0.227	0.692	0.268	0.005
	p	0.001	0.420	<0.001	<0.001	<0.001	<0.001	0.919
SBP	r	0.068	0.027	0.223	0.835	0.174	0.388	0.008
	p	0.198	0.615	<0.001	<0.001	0.001	<0.001	0.876
DBP	r	0.010	0.051	0.335	0.635	0.270	0.569	0.017
	p	0.857	0.337	<0.001	<0.001	<0.001	<0.001	0.751
FBG	r	0.029	0.137	0.008	0.099	0.015	0.057	0.022
	p	0.586	0.010	0.877	0.061	0.772	0.285	0.679
TG	r	0.134	0.007	0.185	0.084	0.150	0.198	0.013
	p	0.011	0.897	<0.001	0.113	0.005	<0.001	0.811
HDLc	r	-0.153	-0.078	-0.218	-0.143	-0.192	-0.035	-0.101
	p	0.004	0.142	<0.001	0.007	<0.001	0.507	0.056

r = partial correlation coefficient; p = probability value

Table 3a: Multiple regression (stepwise) analyses between the socio-demographic and behavioural risk variables and MetS components among the parental generation

Dependent variables	Best predictors	β	Significant β	R	R ²	Adjusted R ²
WC	JF	0.708	<0.001	0.708	0.501	0.499
SBP	ES	0.869	<0.001	0.869	0.755	0.754
DBP	ES	0.688	<0.001	0.688	0.474	0.472
FBG	JF	0.175	0.002	0.175	0.030	0.027
TG	JF	0.223	<0.001	0.223	0.050	0.047
HDLc	JF	-0.264	<0.001	0.264	0.070	0.067

 β = standardized regression coefficient; R = correlation coefficient; R² = coefficient of determination; Adjusted R² = adjusted coefficient of determination

Table 3b: Multiple regression (stepwise) analyses between the socio-demographic and behavioural risk variables and MetS components among the younger generation

Dependent variables	Best predictors	β	Significant β	R	R^2	Adjusted R^2
WC	JF	0.719	<0.001	0.719	0.517	0.515
SBP	ES	0.771	<0.001	0.771	0.595	0.594
DBP	ES	0.635	<0.001	0.635	0.404	0.402
FBG	-	-	-	-	-	-
TG	Edu. Status	0.277	<0.001	0.277	0.077	0.074
HDLc	Alcohol	-0.230	<0.001	0.230	0.053	0.050

β = standardized regression coefficient; R = correlation coefficient; R^2 = coefficient of determination; Adjusted R^2 = adjusted coefficient of determination

DISCUSSION

Numerous studies indicate that MetS comprises several cardio-metabolic abnormalities [25]. But the definite aetiology of MetS is still unknown to us. Most of the studies report that it is a mixture of genetic, metabolic, socio-demographic, and behavioural risk factors [26]. Socio-demographic factors such as Edu. Status and MS are significantly associated with MetS. A study shows that the odds of MetS were higher among divorced or separated women than those of ever-married and recently married women [27]. On the other hand, a contrasting result has been observed for Edu. Status. Some studies have found that education is negatively associated with the risk of MetS, as it increases awareness among individuals [28-29]. Whereas some other studies have shown that education is positively associated with the risk of MetS, as most individuals with higher education are employed in sedentary occupations [30-31]. These findings support our study, where it was observed that the prevalence of higher education was higher among the younger generation, and Edu. Status also emerged as a predictor of MetS in the younger generation (Tables 1 and 3b). Existing studies reveal that individuals who follow a healthy dietary pattern have better cardio-metabolic health [32]. Studies show that JF, ES, and substance consumption increase the risk of MetS [26, 33-34] because JF is positively associated with BMI, WC [35], plasma glucose level, and the level of blood pressure [36], whereas ES is positively associated with hypertension [37].

Overall, the evidence suggests that Edu. Status, MS, JF, ES, and substance consumption (alcohol, tobacco chewing, and smoking) are some of the socio-demographic and behavioural predictors which led to the development of MetS. But in both the parental and younger generations, the effect of these predictors may differ. Thus, the present study has identified which predictors are most significantly associated with MetS in the parental generation and which predictors are most significantly associated with MetS in the younger generation. It was observed that, among the predictors of MetS in the parental generation, JF and ES were

the best predictors. On the other hand, among the younger generation, Edu. Status and alcohol consumption, along with JF and ES, were found to be the best significant predictors (Tables 3a and 3b). These results further demonstrate that the younger generation is more affected by socio-demographic and behavioural risk factors than their parental generation.

The observed patterns can be effectively interpreted through the health belief model (HBM). According to HBM, health behaviours are influenced by individuals' perceptions of risk, severity, and benefits of action [38-39]. In the present study, the persistence of unhealthy dietary practices, despite a higher prevalence of MetS, may indicate limited awareness of the long-term consequences of such behaviours, particularly among the younger generation. Notably, perceived barriers, such as accessibility, affordability, and cultural preferences for certain foods, may further contribute to the continuation of these risk behaviours. Existing literature highlights that the taste of JF has influenced Indian adolescents to consume it, despite their knowledge of its negative health effects [14]. A study conducted among the Toda community of Tamil Nadu highlights that market accessibility has contributed to the inclusion of non-traditional foods (which include packaged foods, processed foods, and instant meals) into the everyday diets of this tribal population [40].

An important finding of the present study is that while dietary factors were associated with MetS components in both generations, other predictors such Edu. Status and alcohol consumption showed generation-specific effects. For example, education was a significant predictor of triglyceride levels only in the younger generation, suggesting that its influence may vary depending on the socio-cultural context and stage of transition. This highlights the need to consider generational differences when designing public health interventions.

The present study indicates that the younger generation has been more affected by these socio-demographic and behavioural factors, suggesting that they have moved away from their traditional lifestyle. It was observed that social factors have had less impact on the parental generation who follow a traditional lifestyle. In a cross-sectional study, it was found that traditional communities in India are not adhering to their traditional lifestyles. They are constantly acquiring lifestyles that were not originally theirs, leaving behind their own traditional lifestyle. These lifestyle changes are leading to the development of MetS and its associated risks [41].

CONCLUSION

The present study revealed that socio-demographic and behavioural risk predictors were more prevalent among the younger generation compared to their parental generation. In the parental generation, junk food and extra salt intake emerged as the best predictors of MetS, whereas in the younger generation, educational status and alcohol consumption, along with junk food and extra salt intake, were identified as the best predictors. These findings clearly indicate that, due to lifestyle changes, the younger generation is more susceptible to MetS and its associated cardio-metabolic risks. Therefore, targeted intervention strategies and awareness programmes are essential to mitigate the growing burden of MetS within the Toto community.

ABBREVIATIONS: **AACE:** American Association of Clinical Endocrinologists, **BMI:** Body Mass Index, **BP:** Blood Pressure, **DBP:** Diastolic Blood Pressure, **Edu. Status:** Educational Status, **EGIR:** European Group for the Study of Insulin Resistance, **ES:** Extra Salt, **FBG:** Fasting Blood Glucose, **HDLc:** High-Density Lipoprotein Cholesterol, **HBM:** Health Belief Model, **IDF:** International Diabetes Federation, **IR:** Incidence Rate, **JF:** Junk Food, **MetS:** Metabolic Syndrome, **MS:** Marital Status, **NCDs:** Non-Communicable Diseases, **NCEP ATP-III:** National Cholesterol Education Program Adult Treatment Panel III, **SBP:** Systolic Blood Pressure, **SD:** Standard Deviation, **TG:** Triglycerides, **USA:** United States of America, **WC:** Waist Circumference, **WHO:** World Health Organization

ACKNOWLEDGEMENTS: The authors sincerely thank all Toto participants for their active cooperation during data collection. The authors also express their gratitude to the authorities of Sidho-Kanho-Birsha University for providing the necessary infrastructural and academic support for conducting this study. Appreciation is further extended to the Indian Council of Social Science Research for awarding the Centrally-Administered Full-Term Doctoral Fellowship, which supported the present research.

FUNDING: This research was financially supported by the Indian Council of Social Science Research through the Centrally-Administered Full-Term Doctoral Fellowship awarded to Subhrajyoti Das (File No. RFD/2022-23/GEN/HLTH/233; dated 15 December 2022).

ETHICAL CLEARANCE: Ethical approval for the study was obtained from the Institutional Ethical Committee (IEC) of Sidho-Kanho-Birsha University (Memo No. R/IEC/1584/SKBU/24; dated 03 October 2024).

CONFLICT OF INTEREST: The authors declare no conflicts of interest

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