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Research Article

Prevalence Of Metabolic Syndrome Among Adult Population Of South India: A Multistage Systematic Random Sampling Approach

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ABSTRACT

Background: Metabolic syndrome is a major public health concern that contributes to life-threatening cardiovascular and diabetic complications. The rising prevalence of non-communicable diseases in Malappuram, the most densely populated district in Kerala, South India highlights the need to assess metabolic syndrome and its risk factors

Aim: To estimate the prevalence of metabolic syndrome among adults in Puzhakattiri Panchayath and to identify its association with socio-demographic, lifestyle, and behavioural factors.

Methods: A cross-sectional study was conducted from April 25th 2024- September 30th 2024 , among adults aged ≥18 years of rural area of Malappuram district ,Kerala ,India. Using multistage systematic random sampling, 380 participants were selected. Data were collected using a validated semi-structured questionnaire. Data were processed using SPSS v23.0.

Statistical analysis used: Descriptive statistics along with Chi square test for associations were used.

Results: The prevalence of metabolic syndrome was 44.5%, higher in females (45.2%) than males (42.9%), though not statistically significant. Significant associations were observed with age >50 years and family history of hypertension.

Conclusion High prevalence demands urgent lifestyle-based public health interventions.

Keywords*: Metabolic syndrome, Cardiovascular comorbidities, Type2 diabetes mellitus.*

INTRODUCTION

Metabolic Syndrome (MS) refers to a cluster of interrelated metabolic, physiological, biochemical, and clinical abnormalities that significantly elevate the risk for cardiovascular diseases (CVD), type 2 diabetes mellitus (T2DM), and all-cause mortality. It is characterized by a clustering of conditions, including central obesity, insulin resistance, dyslipidaemia (elevated triglycerides, low HDL cholesterol), and hypertension. The presence of MS identifies individuals at high risk for the development of atherosclerotic cardiovascular diseases and type 2 diabetes. Epidemiological studies indicate that individuals with MS have a two-fold increased risk of CVD and a five-fold increased risk of developing T2DM.[1]

The etiopathogenesis of MS is primarily driven by excess adiposity and sedentary lifestyles, both of which promote insulin resistance and systemic inflammation.[2] MS is often associated with a range of other clinical conditions, including non-alcoholic fatty liver disease (NAFLD), cholelithiasis (cholesterol gallstones), obstructive sleep apnoea, hyperuricemia, gout, polycystic ovarian syndrome (PCOS), and certain psychiatric disorders like depression.[3] The prevalence of MS increases with advancing age, with a particularly sharp rise after 50 years, placing individuals at a significantly higher risk of adverse cardiovascular and metabolic outcomes, a trend observed in both rural and urban populations across southern India, including Kerala[4].

Review of previous literature on prevalence of metabolic syndrome revealed that most of the researches were hospital based studies that assessed occurrence of diseases in high risk people who visit the hospital , exempting a significant proportion of unreported cases at community level. Our aim was to employ a multi stage systematic random sampling technique to study the prevalence of metabolic syndrome and its association with various sociodemographic, lifestyle, and behavioural factors among the adult population (aged above 18 years) of rural area of South India.

METHOD

STUDY DESIGN- Cross-sectional study

STUDY PERIOD-April 25th 2024- September 30th 2024

STUDY SETTING – India is a federal parliamentary democratic republic, governed by the Central Government. It comprises of 28 states and 8 Union Territories, each having own State Government. Each state is further divided into districts. Each district is further divided into administrative divisions known as blocks.The Panchayati Raj is the oldest system of local government followed in rural areas. Each village or group of villages has a Gram Panchayat, which is the basic unit of local self-government .A Panchayat is further divided into wards, each represented by an elected member. These institutions ensure that governance and development reach the grassroots level. Kerala ,is one of states , located in the southwestern part of India. It has 14 districts, in which the most populated district located at the northern region is Malappuram . Setting of the study is Puzhakattiri panchayath located at Mankada block of Malappuram district which is also the field practice area of Medical college in Malappuram. Puzhakattiri Panchayath has total of 17 wards with total population of 40,512. Each ward has almost equal distribution of houses approximately 600.

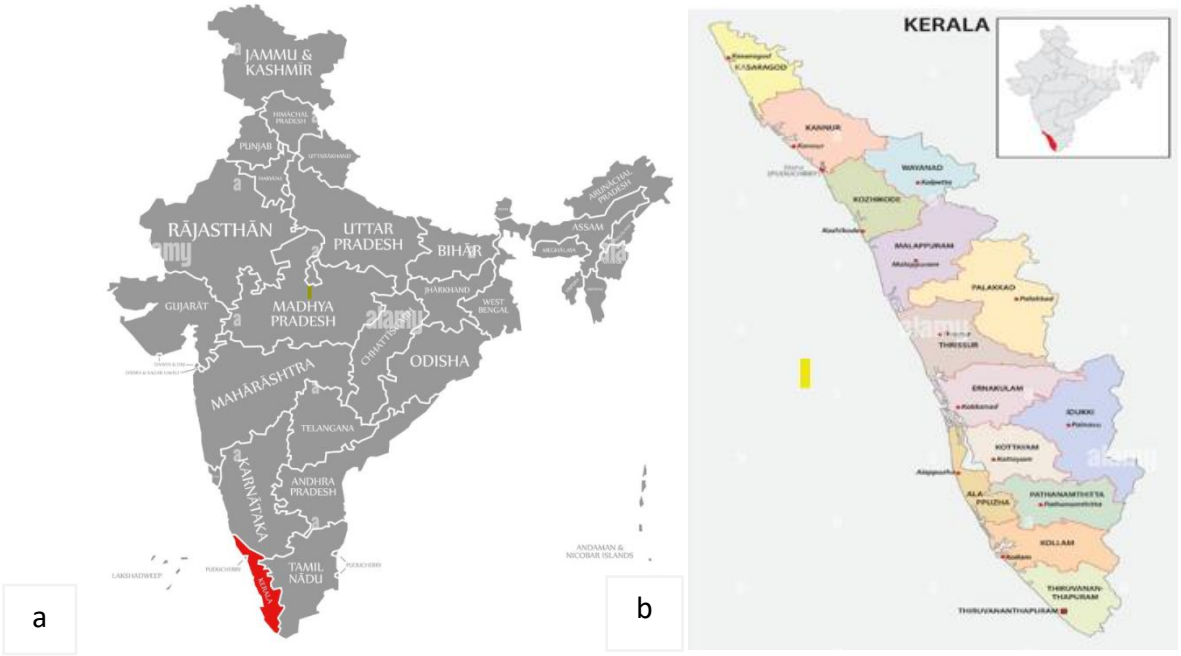

Fig 1 .a).Map of India ,b)Map of Kerala

INCLUSION CRITERIA

- Participants aged 18 years and above.
- Residents of Puzhakattiri panchayath for at least 6 months.
- Individuals willing to provide informed consent and participate in the study.

EXCLUSION CRITERIA

- Individuals diagnosed with PCOS, taking long-term steroids , psychiatric medications & on hormone replacement therapy.
- Individuals with cognitive impairments that would hinder their ability to provide accurate data or participate in the study procedures.

SAMPLE SIZE

Sample size was calculated from the formulae $n = Z^2\alpha*p*q/d^2$

Prevalence of metabolic syndrome in Kerala was reported to be 61% in a study by Srinivasa et al.[28] (p = prevalence = 61; q = (100-p) = 39; d = absolute precision of 5%).

Zα = Z-value corresponding to the desired confidence level (e.g., 1.96 for 95% confidence)

Plugging the values into formulae, we got as 380.41 as the sample size.

Institutional ethics committee approval was obtained for the study and written informed consent was obtained by the participants.

Sampling Technique:
A Multistage systematic random sampling was done. Study setting was Puzhakattiri panchayath which is the FAP field area of the Medical college. A line list of all the houses were available from the FAP register and was used as the sampling frame. Stage1 was selection of 4 wards out of total 17 wards of Puzhakattiri Panchayath using simple random sampling through lottery method. Stage 2 was selection of Participants from each of the four selected wards equally, ie 380/4 =95. Stage 3 was selecting Houses within Each Ward. Each ward has around 600 houses approximately. So Systematic random sampling (600/95≈6) by taking 6 as sampling interval was done. The first house was chosen randomly by lottery method. After selecting the first house, every 6th house was selected until 95 eligible participants were obtained from that ward.

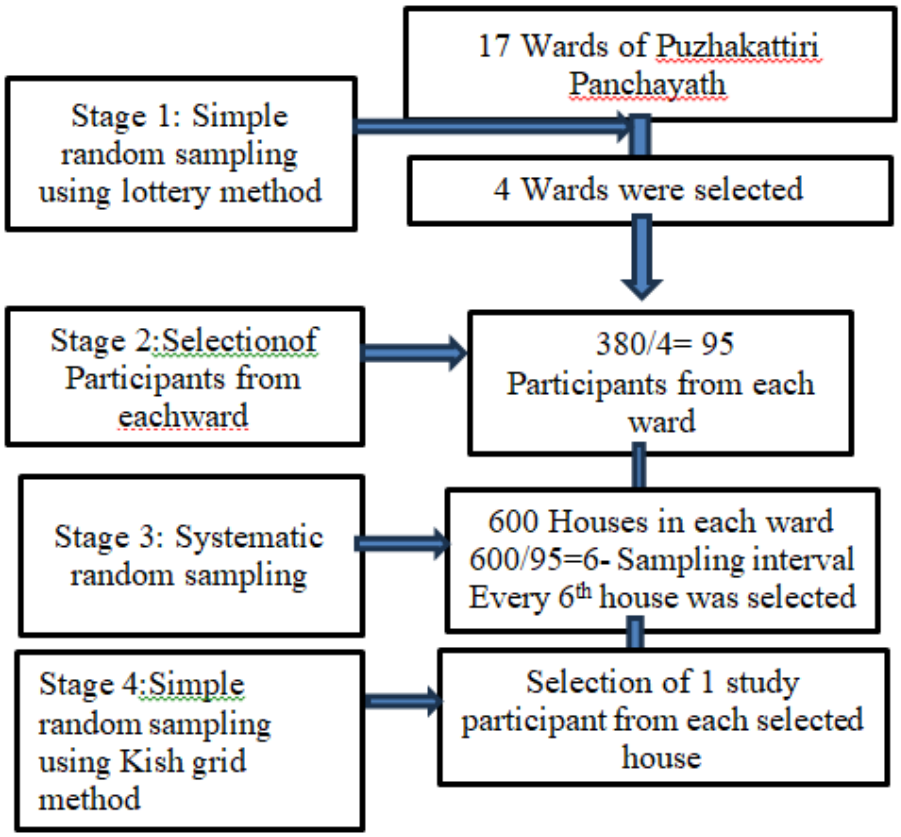

Fig 2.Multi stage systematic random sampling

From each selected house, one of the available members who met the inclusion criteria (age 18 and above, residing in Puzhakattiri for at least 6 months) was chosen using Kish grid method. By following this method, we ensured that 380 participants were systematically selected from 4 wards, ensuring random representation from each area. The selected participants were asked to report at the medical camp set up at the Puzhakattiri Community health centre, where the data collection and results of the blood investigations were collected.

DATA COLLECTION
A pre-designed, pre-tested, semi-structured, and validated questionnaire was utilized to gather information on socio-demographic characteristics, lifestyle factors, personal habits, and existing co-morbidities. The questionnaire underwent content validation by three subject matter experts. Information regarding alcohol and tobacco use was collected.

Anthropometric measurements, including height, waist circumference, and hip circumference, were recorded using a non-stretchable fibre measuring tape. Body weight was measured in kilograms using a digital weighing scale (Health o Meter) with minimal clothing. Blood pressure was measured using a mercury sphygmomanometer (Elko meter Deluxe model), with the average of two readings taken at least one minute apart being considered. Blood investigations such as fasting blood sugar, fasting lipid profile including HDL and triglyceride levels were also carried out in the diagnostic laboratory Puzhakattiri Community health centre as part of their routine investigations.

The National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) criteria were used in this study to diagnose METS. According to these criteria, the presence of any three or more of the following five conditions indicates a diagnosis of metabolic syndrome[20]:

Sl No	Parameter	Cut off Values
1	Abdominal obesity Waist circumference	Males >40 inches (102 cm)
		Female >35 inches (88 cm)
2	Fasting plasma glucose	≥100mg/dl / being on treatment for elevated glucose levels.
3	Serum triglycerides	≥150 mg/dl / being on treatment for elevated triglycerides.
4	Low high-density lipoprotein (HDL) cholesterol:	Males-<40 mg/dl Female-<50mg/dl /on treatment for low HDL.
5	Elevated blood pressure	Systolic BP>130 mmHg, Diastolic BP>85mmHg,/ being on antihypertensive treatment.

ANALYSIS

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM, New York, USA). Normality of data distribution was assessed using the Kolmogorov-Smirnov test (P value >0.05). Descriptive statistics were reported as mean ± standard deviation (SD) for normally distributed continuous variables. Chi square test was used to find the association between Metabolic syndrome and sociodemographic, lifestyle factors. Statistical significance was set at a P value < 0.05.

RESULTS

The study included 380 participants having mean age 49.2±13 years. Majority were female 68%, n=258), while males comprised 32% (n=121). The prevalence of metabolic syndrome was found to be 44.5%(Fig 3). Lifestyle factors and family history were assessed. Smoking prevalence was low at 2.1% (n=8), and alcohol consumption was reported by 9.5% (n=36). Family history of diabetes was present in 30.0% (n=114), and hypertension in 31.1% (n=118). Education up to high school level was reported by 46.3% (n=176), suggesting a diverse educational background (Table1).

Table 1: Lifestyle and Family History Distribution (n = 380)

Si No	Category	Frequency	Percent
1	Smoking	8	2.1%
2	Alcohol consumption	36	9.5%
3	Family history of diabetes	114	30.0%
4	Family history of hypertension	118	31.1%
5	Education level up to Highschool	176	46.3%

On assessing the parameters of metabolic syndrome, Waist-to-hip ratio (WHR) indicates 51.3% to be normal and 48.7% with abdominal obesity. Raised blood pressure was seen in 52.9%. Low HDL was observed in 45.8%, whereas 54.2% normal. High triglycerides are present in 49.7%. Raised fasting plasma glucose affects 45.5%, with 54.5% normal(Table2).

Table 2: Health Indicators Distribution (n = 380)

Category	Indicator	Frequency	Percent
WHR	Normal	195	51.3%
	Abdominal Obesity	185	48.7%
Raised Blood Pressure	Normal	179	47.1%
	High	201	52.9%
Low HDL	Normal	206	54.2%
	Low HDL	174	45.8%
High Triglycerides	Normal	191	50.3%
	High	189	49.7%
Raised Fasting Plasma Glucose	Normal	207	54.5%
	High	173	45.5%
Total		380	100.0%

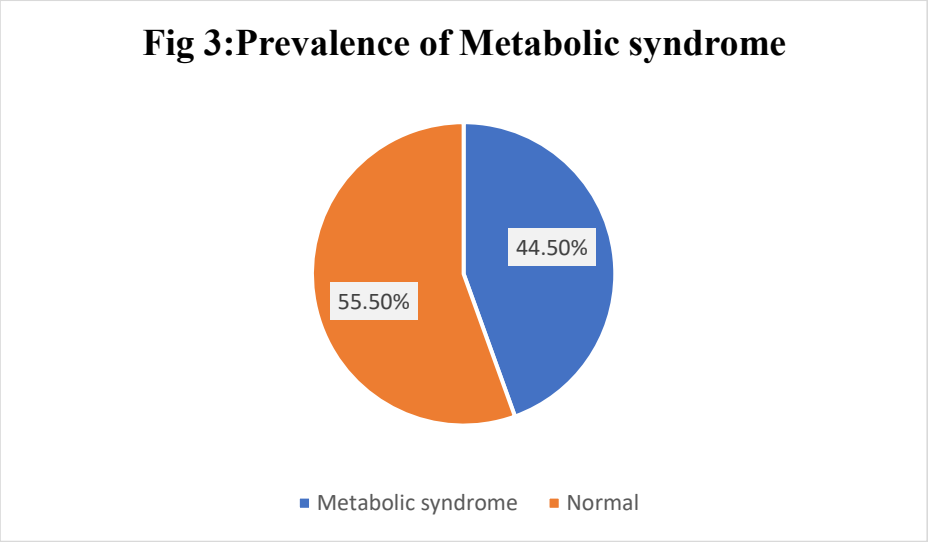

Fig 3: Prevalence of Metabolic syndrome

Metabolic syndrome prevalence was found to be 44.5% (n = 169) versus 55.5% normal (n = 211)Fig1 .

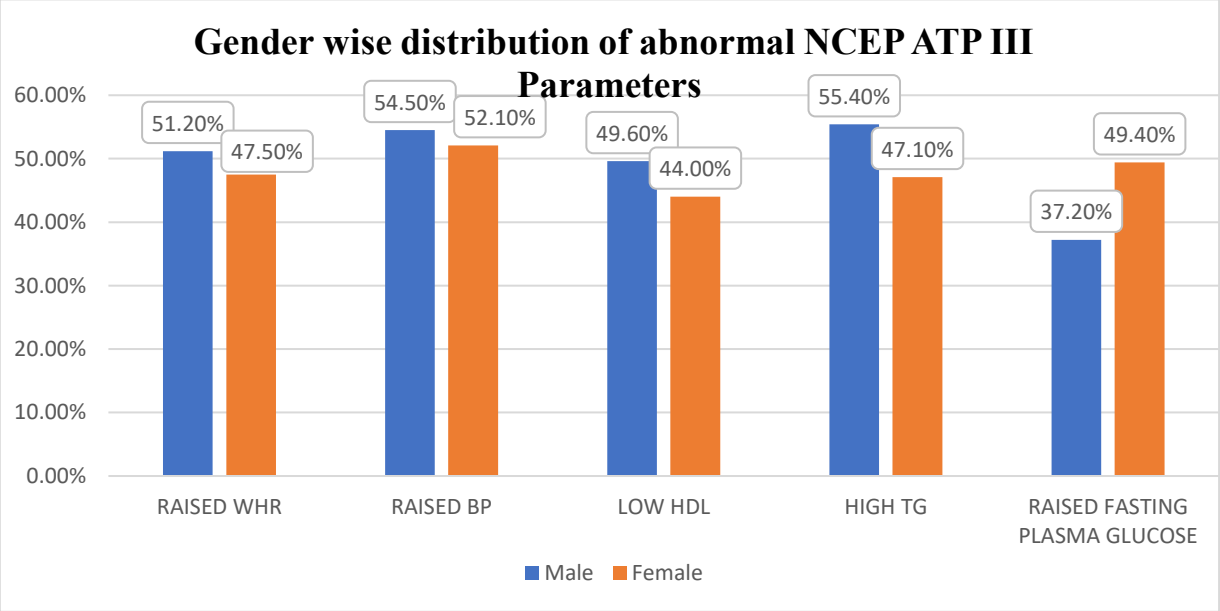

Fig 4: Comparison of Parameters of NCEP ATP III between Gender

The figure 4 compares NCEP ATP parameters between gender.It shows that male gender has slightly higher prevalence of abnormal parameters except fasting plasma glucose

ASSOCIATION OF SOCIO-DEMOGRAPHIC VARIABLES WITH MS

Gender shows no significant association (p = 0.688), with 43.0% of males and 45.2% of females affected. Family history of diabetes (p = 0.457) and education level (p = 0.440) also lack significant associations.

Table 3:

Variable	Category	Normal (n)	Metabolic Syndrome (n)	Total	Chi-Square Value	P-Value
Gender	Male	69 (57.0%)	52 (43.0%)	121	0.161	0.688
	Female	142 (54.8%)	117 (45.2%)	259		
Family History of DM	No	151 (56.8%)	115 (43.2%)	266	0.553	0.457
	Yes	60 (52.6%)	54 (47.4%)	114		
Family History of HTN	No	154 (58.8%)	108 (41.2%)	262	3.614	0.047

	Yes	57 (48.3%)	61 (51.7%)	118		
Education Level	Up to High School	94 (53.4%)	82 (46.6%)	176	0.595	0.440
	Above High School	117 (57.4%)	87 (42.6%)	204		
Total		211 (55.5%)	169 (44.5%)	380		

Table 4 shows group Statistics for Age. Individuals with metabolic syndrome (n = 169) have a significantly higher mean age (59.43 ± 9.15 years) compared to those without (n = 211, 41.01 ± 9.2 years; p = 0.001), indicating age as the key factor in metabolic syndrome prevalence

Table 4: Group Statistics for Age

Metabolic syndrome status	Frequency	Mean Age	Standard deviation	P value
Normal	211	41.01	9.2	0.001
Metabolic syndrome	169	59.43	9.15	

DISCUSSION

From our study ,the prevalence of Metabolic Syndrome (MS) was found to be 44.5%, which is higher than most global estimates. Giles et al. and Misra et al. reported global MS prevalence ranging from 7.1% to 41.6%[11,12], while Galassi et al.'s meta-analysis reported a range of 23%–46% using NCEP criteria, consistent with our findings[13]. Ford ES et al. noted a 35% prevalence in the USA , Marquez et al[14]. reported 24.9% in Latin America[15], and Aryal et al. found 29.8% (IDF) and 26.1% (ATP III) in Southeast Asia[16]. Gulf countries showed prevalence rates between 20.7% and 37.2%[17]. These variability in prevalence may be due to sociodemographic factors, geographic differences, and differing diagnostic criteria.

India has seen a rapid shift in disease burden, with non-communicable diseases accounting for 60% of deaths[18]. A meta-analysis by Krishnamoorthy et al. reported a national prevalence of metabolic syndrome of 30%[19], with state-wise rates highest in Madhya Pradesh[42], followed by Odisha[42], Delhi[43], and Telangana[43]. Similar to our findings, Bansal et al. reported 48% in Delhi[20], Bhattacharya et al. found 42% in Telangana[21], and Majumdal et al. noted 54% in Andhra Pradesh[22]. Das et al. found 48% in West Bengal[23], Tharkar et al. 57% in Tamil Nadu[24], Kanjilal et al. 58% in Karnataka[25], Kaur et al. 41% in Tamil Nadu [26], and Madan et al. 40–43% in Maharashtra[27]. These results reflect comparable sociodemographic profiles and shared diagnostic standards.

In Kerala, MS prevalence has varied widely. Srinivasa et al. reported 61% with a higher prevalence in females and older adults .[28]Harikrishnan et al. found a lower prevalence of 24%[29], while Rosemary et al. reported a much higher rate of 76%, with males at 80.4% and females at 67.8%.[30]Ismail et al. found a 28.3% prevalence in Kannur, with 32.5% among females and greater prevalence in those over 45 years[31]. While these studies noted higher prevalence in females, our study did not show a statistically significant gender association. However, the mean age of individuals with MS in our study was significantly higher (59.43 years) than those without MS (41.01 years), consistent with existing literature emphasizing age as a major risk factor.

Our study also. found a significant association between MS and family history of hypertension. Similar findings were observed by Chakraborty et al. and Bhagat et al.[33,34] Ranasinghe et al. reported a 1.19 times increased risk of MS with a family history of hypertension [35], while Liu et al. in Japan found maternal hypertension linked to obesity and MS [36]. Kanchan et al. also identified familial hypertension as a key predictor of modifiable risk factors for MS[37]. These findings support a genetic predisposition toward MS, especially through hypertensive pathways.

Regarding individual components of MS, 48.7% of participants in our study had abdominal obesity—more common among females. Elevated fasting glucose was found in 45.5%, elevated triglycerides in 49.7%, low HDL cholesterol in 45.8%, and elevated blood pressure in 52.9%, with hypertension more common in males. These patterns are well-documented. Hourfil et al., in a French cohort, emphasized abdominal obesity as a core MS component, linked with triglycerides, HDL, and blood pressure .[38]Our finding of greater abdominal obesity in females is consistent with the CURES study from Chennai by Mohan et al., which reported central obesity in 54% of females[39]. Similarly, Thankappan et al., in the Kerala Diabetes Prevention Program, and Azizi et al. from Iran, highlighted abdominal obesity as more prevalent among women and central to MS development. [40]

The prevalence of elevated blood pressure (52.9%) in our study, especially in males, also mirrors Harikrishnan et al.'s results in Kerala[29].In summary, our findings reflect the high burden of metabolic syndrome and its components in the adult population, consistent with national and some international data. Age and family history of hypertension were key factors, while gender showed mixed associations across different studies . As the limitation of the study we understand that cross-sectional design only captures a glimpse of the prevalence of MS at one specific moment, which limits the

ability to infer causality between associated factors and MS. Hence we look forward to more longitudinal studies on the pattern over time about metabolic syndrome in future. Also, reliance on self-reported data may introduce bias, as participants might underreport unhealthy behaviours or overreport healthy ones.

CONCLUSION

High prevalence of Metabolic syndrome driven by modifiable risks and genetic predisposition in Puzhakattiri panchayath, Malappuram, Kerala , highlights the urgent need for community health initiatives focused on lifestyle modifications and early detection . Routine Screening Program for NCDs especially for those in high risk group i.e. genetic predisposition has to be implemented systematically . Promotion of balanced diet with low refined sugars and fats, physical activity through village-based fitness initiatives has to be strengthened at primary level.

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