REVIEW ARTICLE

Metabolic Syndrome and Tribal Population in India: A Review Article

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Abstract

Background: Metabolic syndrome (MetS), a cluster of risk factors including central obesity, hypertension, dyslipidemia, and insulin resistance, has emerged as a significant public health concern in India. While tribal populations have traditionally been perceived as protected from noncommunicable diseases, emerging evidence suggests a rising burden of MetS in these communities due to rapid lifestyle and nutritional transitions.

Objective: To synthesize current evidence on the prevalence, risk factors, diagnostic challenges, and health system gaps related to MetS among tribal populations in India, and to identify research and policy directions for inclusive healthcare planning.

Methods: A narrative review was conducted using peer-reviewed literature sourced from national and international databases, including Google Scholar, PubMed, and Scopus. A total of 42 studies were reviewed, including cross-sectional surveys, meta-analyses, and regional health assessments among various Scheduled Tribes and Particularly Vulnerable Tribal Groups (PVTGs) across India.

Results: The prevalence of MetS among tribal populations ranges from 3.8% in adolescents to over 39% in adults, with higher rates in females and increasing with age. Common risk factors include a shift from traditional to processed diets, physical inactivity, high alcohol and tobacco use, and socioeconomic deprivation. Genetic predispositions such as hemoglobinopathies also contribute to metabolic risk. Diagnostic inconsistency, small sample sizes, and underrepresentation in national surveys hinder effective disease surveillance. Health system barriers include poor access to diagnostics, low health literacy, and limited outreach of national NCD control programs.

Conclusion: Tribal populations in India are increasingly vulnerable to MetS, reflecting a double burden of undernutrition and metabolic risk. There is an urgent need for culturally adapted screening programs, tribe-specific diagnostic thresholds, community-based interventions, and longitudinal research to address this emerging public health challenge.

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Introduction

Metabolic syndrome (MetS)—a cluster of interrelated metabolic abnormalities including central obesity, insulin resistance, hypertension, dyslipidemia, and hyperglycemia—has emerged as a major global public health challenge. It substantially increases the risk for cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), and overall mortality.[1] The worldwide prevalence of MetS has risen sharply over the past two decades, particularly in low- and middle-income countries undergoing rapid urbanization.

In India, recent pooled data indicate that approximately 30% of adults are affected by MetS, with higher rates among urban dwellers (32%) compared to rural (22%) and tribal (28%) populations.[2] These estimates, however, may obscure the complex epidemiology of MetS in indigenous populations who are often underrepresented in national surveys.

Several organizations, including the National Cholesterol Education Program (NCEP ATP III), International Diabetes Federation (IDF), and World Health Organization (WHO), have developed diagnostic criteria for MetS. These differ primarily in their cut-offs for waist circumference and the centrality of obesity in diagnosis. The IDF, for instance, mandates central obesity as a prerequisite, while NCEP ATP III permits diagnosis based on any three of five factors.[3–5] Such variation can lead to inconsistencies, particularly in tribal populations where body habitus may not align with standard thresholds.

Pathophysiologically, insulin resistance is considered the common denominator in MetS. Visceral adiposity, systemic inflammation, and dysregulated lipid metabolism form the foundation for metabolic dysfunction.[6] However, the concept of "lean MetS"—observed in undernourished populations with normal body mass but abnormal metabolic markers—challenges the conventional obesity-centric model.[7]

Among tribal communities in India, studies have identified both undernutrition and metabolic dysfunction, indicating a double burden of disease. For example, research in rural West Bengal and Chhattisgarh has reported significant rates of MetS and its components, even in individuals without obesity.[7,8] These findings highlight the limitations of current diagnostic frameworks and suggest the need for region- or tribe-specific anthropometric cut-offs.[9]

Tribal communities, which comprise 8.6% of India's population across 705 recognized groups, are disproportionately affected by structural health inequities, limited access to healthcare, and nutrition transition.[10] With increasing exposure to packaged foods, sedentary lifestyles, and substance use, these communities are becoming increasingly vulnerable to MetS and its sequelae.

This review aims to synthesize current evidence on the epidemiology, risk factors, diagnostic challenges, and health policy implications of MetS among India's tribal populations. By critically examining both national datasets and tribe-specific studies, we seek to illuminate a neglected dimension of India's noncommunicable disease burden.

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Overview of Tribal Populations in India

India is home to one of the world's largest and most diverse tribal populations, officially categorized as "Scheduled Tribes" (STs). According to the 2011 Census, approximately 104 million individuals, or 8.6% of the Indian population, belong to tribal communities, spread across 705 recognized tribes in 30 states and union territories.[11] These communities differ widely in language, culture, ecology, and socioeconomic conditions, from the Bhils and Gonds of Central India to the Santhals in the East and the Todas in the South.

Most tribal populations reside in remote, ecologically sensitive regions—forests, hills, and plateaus—where health and social services remain scarce. Historically dependent on hunting, shifting cultivation, and subsistence agriculture, many tribal groups are undergoing rapid socioeconomic and lifestyle transitions due to deforestation, displacement, urban migration, and market integration.[12]

A subcategory within STs—the Particularly Vulnerable Tribal Groups (PVTGs)—represents communities with the lowest literacy rates, poorest health outcomes, and least integration into state health infrastructure. Evidence from Odisha suggests extremely poor health indicators among PVTGs, including rising prevalence of hypertension, diabetes, and undernutrition, with minimal access to diagnosis or treatment.[13]

Multiple studies indicate that tribal communities are experiencing an epidemiological transition, marked by the coexistence of infectious and noncommunicable diseases. Drivers of this shift include nutritional transition (from millet- and tuber-based diets to polished rice and processed foods), increased alcohol and tobacco use, physical inactivity, and low health literacy.[8] Despite this, many tribes still rely heavily on traditional healers, spiritual beliefs, and ethnomedicine—often delaying modern medical intervention.[14]

There are also inter-tribal disparities in metabolic and cardiovascular health. For example, the Katkaris of Maharashtra show high rates of underweight and stunting, while the Bhils and Kokanas show higher prevalence of hypertension and overweight.[15] In Chhattisgarh, the Bhatra, Gond, Kondh, and Paraja tribes have high frequencies of genetic disorders such as sickle cell anemia and thalassemia, complicating both diagnosis and management of metabolic risk factors.[14]

Given this heterogeneity, tribe-specific epidemiological baselines are essential. Generalized health data and policies often fail to capture the nuanced needs of tribal subpopulations. Any assessment of MetS in these communities must therefore account for regional, cultural, and biological variability.

Prevalence of Metabolic Syndrome in Tribal Groups

Metabolic syndrome, once considered rare among indigenous populations, is now increasingly prevalent among Indian tribal groups. Epidemiological studies conducted over the last two decades reveal wide variation in MetS prevalence, ranging from 3.8% in adolescents to over 39% in adults, depending on region, age, tribe, and diagnostic criteria used.[7,15–18]

A study by Mahajan and Kshatriya among tribal adolescents in Gujarat estimated the prevalence at 3.8%, highlighting a disturbing early onset of metabolic risk factors.[16] In contrast, studies from Kerala, West Bengal, Chhattisgarh, and Maharashtra report much higher rates in adult populations—ranging from 21% to 39%.[16–18] For instance, in a tribal region of Kerala, the prevalence was 28.3% using NCEP-ATP III criteria, and notably higher in women (32.5%) than in men (21%).[17]

The burden also varies based on tribe-specific factors and ecological zones. In Maharashtra, the Bhils, Katkaris, and Thakars showed metabolic abnormalities despite being underweight, illustrating that MetS can coexist with chronic undernutrition.[16] Among Rang Bhotias, 39.2% had MetS, 43.4% had hypertension, and 33.7% had abdominal obesity, underscoring the transition from traditional to modern risk profiles.[18]

Gender disparities have been reported consistently, with most studies finding higher prevalence in women, potentially due to compounded effects of obesity, lower physical activity, and hormonal profiles.[7,17] Additionally, the age-wise trend shows a sharp increase in MetS prevalence beyond the age of 30, suggesting that early adulthood is a critical window for intervention.[7,16]

Importantly, when tribal populations are compared with their rural and urban nontribal counterparts, MetS prevalence is only marginally lower or similar, despite socioeconomic disadvantages. In fact, Krishnamoorthy et al. showed that tribal adults have a pooled prevalence of 28%, nearly closing the gap with urban adults (32%).[2]

These findings not only dismantle the assumption of tribal protection against metabolic disorders but also emphasize the need for targeted screening programs using culturally sensitive, tribe-specific diagnostic approaches (Table 1).

Comparison of MetS prevalence across different population groups in India. Urban adults show the highest prevalence (~32%), followed by tribal (~28%) and rural adults (~22%). Data synthesized from national and regional studies (Fig. 1).[2]

Risk Factors among Tribal Populations

The etiology of MetS among tribal populations in India reflects a complex interplay of lifestyle transitions, environmental changes, cultural practices, and genetic predispositions.

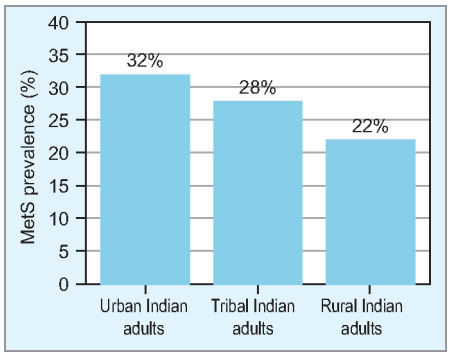

Fig. 1: Metabolic syndrome prevalence across the Indian population

Table 1: Summary of studies on MetS prevalence in Indian tribes

Study	*Year*	*Tribe/region*	*Sample size*	*Prevalence (%)*	*Criteria used*
Mahajan and Kshatriya[16]	2020	Kukana tribe, Gujarat	296 adolescents	3.8	ATP III (Cook's criteria)
Ismail et al.[17]	2016	Kannavam tribal, Kerala	120 adults	28.3	NCEP-ATP III
Mukhopadhyay et al.[7]	2018	Tribals in West Bengal	200 STs	21.4	IDF/ATP III
Kandpal et al.[18]	2016	Rang Bhotia, Uttarakhand	288 adults	39.2	NCEP-ATP III
Deo et al.[15]	2018	Bhils, Katkaris, Kokana, Thakars	1,864 adults	11.7–28.0	Field protocol
Krishnamoorthy et al.[2]	2020	National (meta-analysis)	133,926	28.0 (tribal subgroup)	Pooled

Unlike the traditionally active and minimally processed diets of the past, tribal populations are now experiencing a rapid nutrition transition, marked by reduced dietary diversity and increased consumption of high-calorie, low-nutrient foods.[17]

Staples such as millets, forest tubers, and wild greens are being replaced with polished rice, maize, and packaged foods, contributing to a higher glycemic load and micronutrient deficiencies.[7] This transition is also tied to declining physical activity, as mechanization of agriculture, deforestation, and migration to urban settlements reduce manual labor and daily energy expenditure.[19]

In parallel, alcohol and tobacco consumption are widespread and culturally ingrained in many tribal groups. Studies show that daily or binge alcohol use is common among both men and women, significantly contributing to hypertension, liver dysfunction, and lipid abnormalities.[12]

Sedentarism, particularly among tribal youth and women, is an emerging concern. Increased screen time, joblessness due to migration, and reduced agricultural engagement all contribute to a more sedentary lifestyle, a core risk factor for insulin resistance and central obesity.[19]

Socioeconomic deprivation is another powerful determinant. Limited access to healthcare, low health literacy, poor sanitation, and food insecurity increase vulnerability to both undernutrition and overnutrition.[13] Simultaneously, a number of studies highlight genetic susceptibility, especially in tribal groups with high prevalence of hemoglobinopathies such as sickle cell disease and thalassemia, which are associated with chronic inflammation and metabolic disruption.[15]

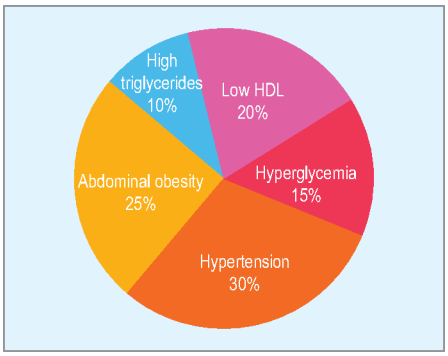

Fig. 2: Distribution of MetS components among tribal groups

This confluence of environmental and biological factors underscores the importance of context-specific, tribe-sensitive interventions in both research and policy (Table 2).

The estimated distribution of key components of MetS among tribal populations in India. Hypertension (30%) and abdominal obesity (25%) are the most prevalent features, followed by low HDL (20%), hyperglycemia (15%), and elevated triglycerides (10%) (Fig. 2).

Health System and Policy Gaps

Despite the rising burden of MetS and associated noncommunicable diseases (NCDs) among India's tribal populations, structural health system limitations continue to hinder early diagnosis, management, and prevention efforts. A core challenge is the lack of routine screening and surveillance in tribal belts, where even basic anthropometric measurements, blood pressure checks, and glucose monitoring are inconsistently conducted.[12]

Health infrastructure in many tribal areas remains inadequate, with primary health centers (PHCs) often understaffed, underequipped, and geographically inaccessible. In remote regions, diagnostic tools such as lipid profiling kits, autoanalyzers, and trained technicians are often unavailable, resulting in underdiagnosis and misclassification of metabolic risk factors.[13] Studies have also documented delays in transporting blood samples, improper sample handling, and cultural reluctance to provide blood specimens due to traditional beliefs.[15]

Compounding these gaps is the low health literacy among tribal populations. Many individuals are unaware of the asymptomatic nature of hypertension, dyslipidemia, and glucose intolerance, contributing to poor care-seeking behavior. Additionally, the dominance of magico-religious beliefs and reliance on traditional healers means that symptoms are often attributed to supernatural causes rather than biological ones.[16]

India's national NCD control programs—such as the NPCDCS (National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke)—have limited reach in tribal areas. Although screening has been scaled up under the Ayushman Bharat scheme, tribal districts remain underrepresented in data reporting, and culturally adapted outreach strategies are lacking.[19]

There is also an evident gap in tribal health research funding, with relatively few large-scale studies focused specifically on tribal populations. Methodological limitations such as small sample sizes, cross-sectional designs, and nonstandardized criteria further restrict generalizability and policy relevance.[20]

To bridge these gaps, health policies must adopt a tribe-centric approach. This includes mobile health units, community-based screening drives, training of local health workers in MetS diagnostics, and inclusion of tribal-specific health indicators in national surveys. Additionally, strengthening IEC (Information, Education, Communication) tailored to tribal languages and beliefs is vital to promote preventive care.

Research Gaps and Methodological Concerns

Despite growing awareness of the rising burden of MetS among India's tribal populations, research on this topic remains methodologically fragmented and underpowered. Key gaps limit the utility of current evidence for large-scale policy formulation.

A fundamental issue is the variation in diagnostic criteria across studies. Some investigations apply NCEP ATP III, others use IDF, and a few rely on modified thresholds adapted for adolescents or South Asians.[17] This inconsistency creates difficulties in comparing prevalence estimates or aggregating data for meta-analyses. Moreover, many studies do not justify their choice of criteria relative to the tribal population's anthropometric characteristics.[7]

Another challenge is the lack of longitudinal and large-sample studies. Most research is cross-sectional, with small, nonrepresentative

Table 2: Risk factors identified across reviewed studies

Study	*Tribe*	*Risk factors*	*Notes on lifestyle/occupation*
Mahajan and Kshatriya[16]	Kukana (Gujarat)	Low HDL, high BP	Adolescents; high-starchy diet
Ismail et al.[17]	Tribals of Kerala	High BMI, high WHR	Alcohol use, reduced physical work
Kandpal et al.[18]	Rang Bhotia	Abdominal obesity, smoking	Age + inactivity linked with high MetS
Shrivastava et al.[12]	Multiple tribes	Hypertension, high glucose	Shift from millet to rice; alcohol use
Balgir[14]	Gond, Bhatra, Paraja	SCD, thalassemia	Genetic load + undernutrition

Table 3: Methodological variability in reviewed studies

Study	*Sample size*	*Diagnostic criteria*	*Limitation*	*Suggestion*
Mahajan and Kshatriya[16]	296	Modified ATP III (adolescents)	Narrow age band, not generalizable	Include adult and adolescent strata
Ismail et al.[17]	120	NCEP ATP III	Small, convenience sample	Use probability sampling
Mukhopadhyay et al.[7]	200 STs	IDF + ATP III	Mixed criteria, no follow-up	Use a consistent diagnostic model
Kandpal et al.[18]	288	ATP III	No adjustment for behavior confounders	Apply multivariate regression
Tripathi et al.[20]	Meta-analysis	Mixed (21 studies)	High heterogeneity	Tribe-specific subgroup analyzes

samples limited to one or two villages, thus precluding causal inference or generalizability.[18] Very few studies employ multivariate modeling to account for confounding variables such as income, access to healthcare, or dietary diversity.[19]

Underreporting is also a systemic issue. Tribal populations are poorly represented in national health surveys such as the NFHS and DLHS. This leads to data invisibility, especially for Particularly Vulnerable Tribal Groups (PVTGs), who are excluded even from stratified reporting frameworks.[20]

Additionally, biomedical and cultural barriers to participation—such as mistrust of blood sampling, logistical delays, or poor translation of informed consent—further restrict data accuracy.[17]

For future research to be policy-informative, studies must emphasize:

- Standardized and context-sensitive diagnostic criteria.
- Larger sample sizes and geographic diversity.
- Inclusion of both biological and sociocultural risk dimensions (Table 3).

Conclusion and Recommendations

The burden of MetS among India's tribal populations has been historically underrecognized but is now increasingly evident across both adolescents and adults. The synthesis of current research shows that tribal communities are no longer insulated from the metabolic shifts associated with urbanization and globalization. Prevalence estimates ranging from 3.8% in adolescents to over 39% in adults challenge the outdated perception of tribal populations as purely undernourished or immune to noncommunicable diseases (NCDs).[17]

A confluence of dietary shifts, reduced physical activity, socioeconomic deprivation, substance use, and genetic vulnerability is accelerating the rise of MetS in these communities. Yet, tribal-specific screening, diagnostic benchmarks, and preventive interventions are nearly absent from India's national health strategy.[12]

The heterogeneity among tribes—in ecology, culture, health beliefs, and disease burden—demands context-sensitive approaches to screening and care delivery. Standard national policies must be tailored to reflect the lived realities of tribal people, particularly those in remote or forested regions with high barriers to care.[13]

Based on the evidence reviewed, we propose the following recommendations:

- *Diagnostic reform*: Adopt tribe- and region-specific criteria for obesity and waist circumference to improve detection of MetS in lean or undernourished individuals.
- *Community-based screening*: Integrate MetS screening into existing tribal health and nutrition outreach programs, such as PHCs, Mobile Medical Units, and Anganwadi centers.
- *Health literacy initiatives*: Develop culturally appropriate IEC materials in tribal languages, involving local leaders and traditional healers to improve acceptability.
- *Longitudinal studies*: Fund multicentric, longitudinal studies with standardized criteria to better understand trends and design evidence-based interventions.
- *Policy integration*: Ensure tribal districts are fully included in the implementation and reporting frameworks of the NPCDCS and Ayushman Bharat programs.
- Ultimately, achieving equitable health outcomes for India's tribal populations requires a decisive shift toward inclusion, customization, and continuity of care in both research and policy.

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