REVIEW ARTICLE

Rising cases of hypertension among indigenous populations of Northeast India: an overview

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A sizable number of people with hypertension live in low- and middle-income countries that lack adequate health resources and where awareness of hypertension is limited, resulting in poor blood pressure control. This review paper aims to investigate the association between ethnicity and the prevalence of cardiovascular disease (CVD) risk factors, such as hypertension, among the indigenous populations of northeast India. Thirty-one articles were retrieved from PubMed, NCBI, and Google Scholar. These articles focus on hypertension cases across twenty-four different indigenous populations in all eight states of northeast India, including North Bengal. The participants included adults of both sexes. In some instances, systolic and diastolic blood pressure readings were reported for each population, along with nutritional status assessed through body mass index (BMI). Results indicate that the Mizo exhibit a high prevalence of systolic diastolic hypertension (SDH) in both males (57%) and females (43%), followed by the Ao Naga (45% Male and 41% Female). A notably high prevalence of isolated diastolic hypertension (IDH) is observed among the Angami Naga (67% Rural and 68% Urban). However, concerning BMI, a low percentage of Angami Naga (14% Rural and 20% Urban) are found to be obese. In most indigenous populations, males are more susceptible to developing vulnerabilities related to CVD risk factors than their female counterparts. To gain a comprehensive understanding, this prevalence must be viewed from an evolutionary perspective, taking into account physiological mechanisms and nutritional transitions among the indigenous populations of northeast India.

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INTRODUCTION

Hypertension is considered the leading cause of cardiovascular disease and premature death worldwide, including in low- and middle-income countries [1]. It ranks as the third most prevalent risk factor contributing to the disease burden in South Asia, including India. Studies suggest that a significant number of people with hypertension reside in low- and middle-income countries, with India being no exception. According to a WHO report, approximately 63% of total deaths in India result from some form of noncommunicable disease, with nearly 27% attributable to cardiovascular disease [2]. One of the key factors behind the high prevalence of hypertension in India is the lack of awareness regarding the condition and poor blood pressure management, particularly among indigenous populations. Moreover, limited health resources, especially in remote rural and tribal areas, have exacerbated the situation. Perhaps this is why only about 12% of individuals with hypertension in India have their blood pressure under control [2].

The report indicates that uncontrolled blood pressure is one of the most significant risk factors for cardiovascular diseases (CVDs) like heart attacks and strokes, which account for nearly one-third of total deaths in India [2]. Therefore, providing a continuum of care from early detection to managing hypertension and improving the quality of care is essential for maintaining a healthy life. This strategy can also lead to reduced morbidity and mortality resulting from CVDs [2].

Alarmingly, Indian indigenous populations, once considered vulnerable groups for all kinds of communicable diseases and generally free from noncommunicable diseases like CVDs, are now showing a significant prevalence of hypertension. A study suggests that nearly 16.1% of Indian tribes are hypertensive, with considerable heterogeneity [3].

Generally, rapid urbanization, rural-to-urban migration, and changes toward more sedentary lifestyles, along with the consumption of inexpensive, readily available, calorie-rich foods, contribute to a remarkable epidemiological transition marked by a rising prevalence of lifestyle diseases, including hypertension [4, 5]. Consequently, the aforementioned factors are often seen as essential causes of the nutritional transformation prevalent among many Indian tribal populations, which frequently results in hypertension (Fig. 1). Additionally, studies suggest that, similar to other low- and middle-income countries, large-scale developmental activities and urbanization in India have led to significant changes in the lifestyles, occupational patterns, and dietary habits of these tribal communities, previously regarded as outreach groups [4]. Furthermore, new "urban centers" are rapidly developing near rural and tribal areas [6].

Further, studies suggest that hypertension is closely related to environmental and lifestyle factors rather than genetically defined ethnic differences. To support this argument, empirical examples from various ethnic populations have been presented. For

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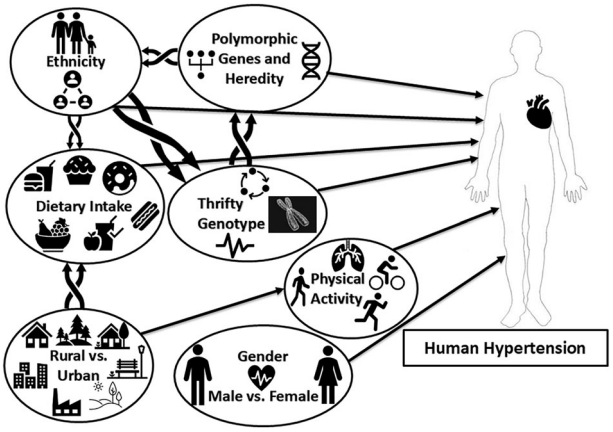

Fig. 1 Factors influencing hypertension in human.

instance, it is observed that hypertension is higher among people of African descent living in the UK or the USA than among white people [4]. Similarly, Vietnamese and other Southeast Asian individuals residing in the USA show greater blood pressure than their counterparts living in their native countries. These findings favor environmental factors or the interaction between genetic and ecological factors rather than genetic factors alone. In other words, genetic predisposition might be permissive rather than determinative [4]. Several tribal populations in India exhibit complexities in which environmental factors, such as the epidemiological transition and rural-to-urban migration, are not straightforward. For example, almost all the northeastern Indian states have been exclusively inhabited by tribal or indigenous populations for generations. Thus, indigenous populations from this region are not marginalized. Moreover, they have not experienced substantial urbanization. The process of urbanization is complicated in this part of the country. For example, a study suggests that urbanization in India's Northeast differs from the national pattern. The urbanization process in the region is asymmetric, mainly concentrated in state capital cities or district headquarters [7, 8]. The reasons for this isolated development include topography, the geopolitical environment, population density, and geographic isolation from the rest of the country. The study suggests that colonial rule in the nineteenth century significantly facilitated the growth of urban centers in the region. However, these urban centers are minuscule in number compared to the region as a whole. Later, post-independence development activities and political policies significantly influenced the growth of public administration, which, in turn, contributed to the development of cities and towns in the region. Nonetheless, the region's economy has suffered due to low manufacturing activities, as most of the population continues to depend on agriculture and its allied activities to date [7].

Thus, for the populations of northeast India, the interaction between environmental and genetic factors may be more significant than environmental factors alone. Additionally, genetic predisposition could be more critical in these northeast Indian communities than observed elsewhere. Recognizing the evolutionary perspective is essential to understanding the role of genetic predisposition in gene-environment interactions, particularly in explaining why hypertension occurs more frequently in some populations than others. From an evolutionary standpoint, many complex chronic diseases, including hypertension, seem to result from an imbalance and mismatch between our genetic makeup and contemporary living conditions in twenty-first-century nations amid epidemiological transition. More specifically, the modern human genome has been shaped over thousands of millennia, during which our ancestors transitioned from prehuman primates to modern humans, roughly between 100,000 and 50,000 years ago. These ancient modern humans became behaviorally advanced and lived lifestyles comparable to those of hunter-gatherers from previous centuries.

Our genetic makeup, particularly concerning our core metabolic and physiological traits, has changed very little from the emergence of agriculture roughly 10,000 years ago to the present day. In contrast, cultural change over these past 10,000 years has advanced at a super-accelerating rate [9]. The consequence of this dissonance between "Stone Age" genes and "Space Age" lives is perhaps fostering the development of multiple health disorders, including hypertension [9]. In this context, this review aims to examine the association between ethnicity and hypertension prevalence among indigenous populations of northeast India.

MATERIALS AND METHODS

Selection criteria

Initially, sixty-two articles were retrieved from PubMed, NCBI, Scopus, and Google Scholar. The key terms used in the search included hypertension, prevalence, blood pressure, tribal population, indigenous communities, ethnic groups, and Northeast India. Therefore, Boolean operators such as "Hypertension" AND "Tribal population" OR "Indigenous community" AND "North-east India" AND "Adult" NOT "Children" NOT "Non-tribal" were employed as search terms for selecting the appropriate database for the study. Later, the retrieved articles were filtered using several inclusion and exclusion criteria. For example, only peer-reviewed journal articles on the prevalence of hypertension among the tribal populations of Northeast India were included. Articles on the genetic pathways of blood pressure and the non-tribal populations were excluded. Research studies that included both adult males and females were also selected, while studies involving children and/or adolescents were excluded. Only peer-reviewed research published in the last twenty-five years and written in English was included in the analysis. Research articles with a robust sample size of at least 150-200 participants were considered for the present study. Filtration based on language, sample size, and publication year was implemented in the study.

Due to the limited number of research papers published in northeast India, only thirty-one articles were included and analyzed after applying the exclusion criteria to eliminate non-relevant articles on the prevalence of hypertension. Details are schematically depicted in Fig. 2, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) template [10]. The final articles were based on the rising cases of hypertension among twenty-four different indigenous populations located in all eight states of northeast India, including north Bengal (Fig. 2). Participants were all adults, both male and female. With an emphasis on fieldwork, this overview critically presents and illustrates major concepts from published cardiovascular studies in northeast India. Due to the limited number of studies on hypertension among ethnic communities, we included all studies published in north-east India over a decade. Nevertheless, almost all studies over the years used the same diagnostic cut-off point for hypertension, such as ≥140/90 mm Hg. Further, the heterogeneity score indicates low heterogeneity across years, suggesting negligible between-study variability in the diagnosis of hypertension.

Hypertension and obesity

In a natural human population, hypertension is diagnosed if systolic blood pressure is ≥140 mmHg and/or diastolic blood pressure is ≥90 mmHg. The articles have reported systolic and diastolic blood pressure for each population. This overview adhered to the aforementioned cut-off points and included articles that utilized this diagnostic criterion. In the present paper, the reporting of hypertension is elucidated at three different levels: isolated systolic hypertension (ISH), isolated diastolic

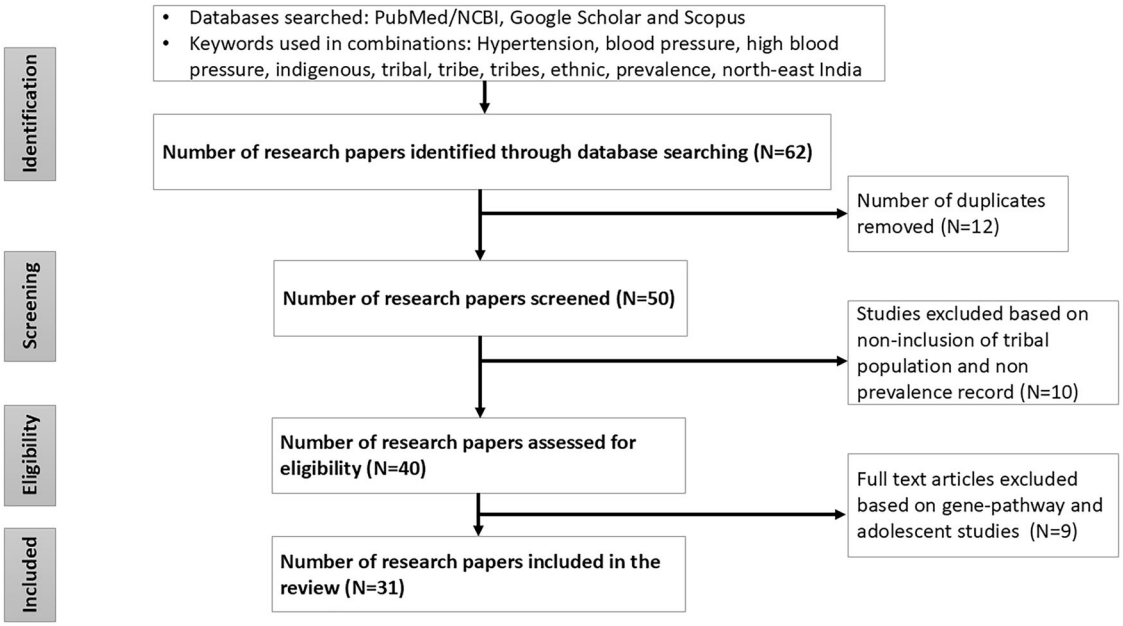

Fig. 2 Flow diagram depicting selection articles included in the review following PRISMA Template.

Table 1. Percentage distribution of hypertension and obesity among the north-east populations.

Variables	Percentage (%)			
	Males	Females	Combined (Male+Female)	Overall
Isolated Systolic Hypertension (ISH)	26.88	20.71	35.75	26.47
Isolated Diastolic Hypertension (IDH)	54.63	42.43	48.50	48.84
Systolic Diastolic Hypertension (SDH)	36.11	26.95	22.20	30.09
Obesity	24.60	24.73	17.00	24.00

hypertension (IDH), and systolic diastolic hypertension (SDH), following the 2018 European Society of Cardiology (ESC) and European Society of Hypertension (ESH) guidelines for the management of hypertension [11, 12]. According to these guidelines, ISH is defined as SBP ≥ 140 mmHg and DBP < 90 mmHg; IDH is defined as SBP < 140 mmHg and DBP ≥ 90 mmHg; and SDH is defined as SBP ≥ 140 mmHg and DBP ≥ 90 mmHg. The prevalence rate of hypertension is further categorized in the following manner for a clearer understanding of the prevalence situation in northeast India:

Low prevalence: <10%; Medium prevalence: 10%–30%; High prevalence: 31%–49% and very high prevalence: ≥50%. This threshold of "High prevalence" is chosen because it is the cut-off used in the World Health Organization's NCD Global Action Plan, which targets to decide who is eligible for drug therapy and counselling [13].

In addition, obesity, as measured by body mass index (BMI = weight/height2, kg/m2), was reported in several populations. Standard BMI classification was used in these studies following WHO [14] cut-off points for the Asian population [14] to diagnose obesity as follows: Obese ≥25.0 kg/m^2. In the statistical analysis, basic descriptive statistics and percentage distribution were calculated for gender, population, and state for the tabular and graphical presentation of the data from the literature.

RESULTS

Prevalence of hypertension

A total of 1,56,640 participants from indigenous tribal communities are identified in the selected 31 studies (Supplementary Table S1). These populations are Mizo [15–17], Liangmai [15], Bhutia [18–21], Toto [20, 21], Rai [18], Ao Naga [22–24], Angami Naga [25, 26], Chakma [27], Tripuri tribal [27], Wancho Naga [28], Chakesang Naga [29, 30], Hmar [31, 32], Lepcha [33, 34], Mishing [35], Zou [36], Adi/Padam [37], Tangkhul Naga [38], Khasi [31], and Garo [39]. In addition, NFHS data on the prevalence of hypertension across all of northeast India were included in the analysis [40]. Overall, the prevalence rate of hypertension among the indigenous populations of northeast India is found to be 30.1%, with high heterogeneity across populations. Nevertheless, an apparent sex difference is evident among these indigenous populations, where males (SDH: 36.11% Male vs. 26.95% Female) are more hypertensive than their female counterparts (Table 1). Furthermore, diastolic hypertension is found to be more prevalent than systolic hypertension in both males (26.88% ISH vs. 54.63% IDH) and females (20.71% ISH vs. 42.43% IDH).

Population-wise distribution of hypertension in Northeast India

Among 16 studies reporting mean systolic (SBP) and diastolic (DBP) blood pressure across various populations, Bhutia shows the highest prevalence of mean systolic hypertension, followed by Angami Naga, Lepcha, and Chakma (Supplementary Figure S1). In contrast, the mean DBP has been very high among the Bhutia, Angami Naga, and Lepcha.

Reporting of isolated systolic hypertension (ISH), isolated diastolic hypertension (IDH), and systolic diastolic hypertension (SDH) is found in 20 studies on indigenous populations from northeast India, namely Mizo, Bhutia, Toto, Rai, Ao Naga, Angami Naga, Chakma, Tripuri tribal, Wancho Naga, Chakesang Naga,

Table 2. State-wise prevalence of hypertension among the north-east populations of India.

	Name of the North-Eastern States
Low (≤ 10%)	Tripura
Intermediate (11%–30%)	Sikkim, Arunachal Pradesh, Manipur, Assam (rural), Meghalaya
High (31%–49%)	Nagaland, Assam (urban)
Very high (≥ 50%)	Mizoram

Hmar, Lepcha, Mishing, Zou, Adi/Padam, Tangkhul, Khasi, and Garo (Supplementary Table S2). The main findings can be summarized as follows: 1) Overall, a high prevalence of ISH and IDH, but not SDH, is evident among the tribal populations of northeast India; 2) Among ISH and IDH, the prevalence of IDH is more apparent than that of ISH, especially among the Bhutia, Lepcha, Angami Naga, and Mizo; 3) The Mizo are the only tribe that shows a high prevalence of ISH (45%), IDH (62%), and SDH (57%), particularly among men.

A high (31%–49%) prevalence of SDH is observed among the Ao Naga tribe. The majority of indigenous populations are found to fall into the medium (10%–30%) prevalence category for their SDH. These populations include Hmar and Lepcha, followed by Bhutia, Rai, Wancho Naga, Chakesang Naga, and Mishing. A negligible percentage of Khasis (15%) and Garos (17%) are found to fall into this category (Supplementary Figure S2). The Tripuri tribal population is the only group to report a low (<10%) prevalence of SDH (Supplementary Table S2).

A comparatively high percentage of Bhutia (61%) demonstrates a very high rate of isolated systolic hypertension (ISH), followed by Mizo (55%) and Angami Naga (50%). In contrast, Chakma (40%) presents a high prevalence of ISH (Supplementary Table S2). Conversely, Lepcha and Zou demonstrate a low prevalence of ISH (Supplementary Figure S3). Nevertheless, Lepcha is categorized as "very high" in isolated diastolic hypertension (IDH), followed by Angami Naga, Mizo, and Bhutia (Supplementary Figure S4). The Chakma of Tripura falls into the "high" (31%–49%) prevalence category, while Zou is classified as "low" (< 10%) in both ISH and IDH (Supplementary Table S2).

State-wise distribution of hypertension in Northeast India

The state-wise distribution of hypertension has identified Mizoram as one of the states with a very high (> 50%) prevalence of hypertension (Table 2). Other states with alarmingly high prevalence rates of SDH, ISH, and IDH include Nagaland, followed by Sikkim (Supplementary Figure S5). A few states, like Sikkim and Manipur, have shown low prevalence of ISH but very high (Sikkim) or high (Manipur) prevalence of IDH among populations residing in these northeastern states of India (Supplementary Table S2).

Population distribution of obesity in Northeast India

Interestingly, populations that have shown a high prevalence of hypertension do not reveal a comparable prevalence of obesity (BMI ≥ 25 kg/m^2). For example, the percentage distribution of obesity reported among the Mizo is negligible (6% Male vs. 8% Female) (Supplementary Table S2). Similarly, only 7% of males and 10% of females are found to be obese among the Ao Naga, whereas around 17% of Angami Naga falls under the obesity category of BMI. Furthermore, only 11% of Chakesang Naga females are obese based on their BMI (Supplementary Table S2).

DISCUSSION

The present paper is one of the first review papers reporting alarmingly high prevalence cases of hypertension among the indigenous populations of northeast India. Generally, it is believed that indigenous populations worldwide are undernourished with low blood pressure [41, 42]. However, recent studies suggest that the processes of economic development and urbanization, coupled with nutritional transition, have created a vulnerable situation for the so-called traditional populations to develop hypertension [4, 5, 42, 43].

In this review paper, a high prevalence of hypertension, but not obesity, is observed in several indigenous populations from northeast India. A significant number of risk factors for non-communicable diseases (NCDs), particularly hypertension, are reported among the Mizo, Angami Naga, Ao Naga, Lepcha, and Bhutia populations of Northeast India. The overall prevalence of hypertension among these indigenous populations (30.09%) is considerably higher than the overall prevalence rate among Indian tribes (18.4%), as indicated by a recent systematic review study [5]. Similarly, a high prevalence of hypertension is also reported among indigenous populations in other parts of the nation [5, 42, 43] and in low- and middle-income countries like those in Africa [4].

Urbanization and rural-to-urban migration

The important influential factors for hypertension in low- and middle-income countries like India are identified as urban residential status, male gender, and higher BMI [43, 44]. Urban male inhabitants are at greater risk of developing CVD-related risk factors than their rural and female counterparts. Other significant environmental causal factors of hypertension include smoking, alcohol intake, physical inactivity, excessive dietary sodium and fat intake, and deficiencies in potassium and fiber intake, along with psychosocial stress [45]. The causal effect behind this urban-rural dichotomy among indigenous populations is generally attributed to urbanization and the associated lifestyle changes. This leads to physical inactivity, psychosocial stress, and dietary changes following the migration from rural settlements to urban centers. Studies suggest that in low- and middle-income countries like Africa, urbanization is strongly correlated with an increase in hypertension prevalence [46]. Additionally, migration from rural to urban areas is linked with elevated blood pressure [47, 48]. In this context, it is noteworthy that the twenty-first century has witnessed rapid urbanization, economies of agglomeration, and a swift transition from rural to urban centers [49]. Nevertheless, the pace of urbanization is not uniform; it varies from country to country and region to region due to different policy measures and socioeconomic, geographical, and political factors [7]. As mentioned earlier, northeast India is no exception to this trend, where urbanization is primarily confined to state capital cities or district headquarters.

Moreover, no substantial migration from rural to urban areas is evident in Northeast India, possibly due to the scarcity of urban centers in this region. Additionally, almost all the states in this area are inhabited exclusively by indigenous peoples. Furthermore, census data have revealed that migration (>90%) is mainly restricted to the Northeast region, unlike in other parts of India [50]. In fact, according to the Census of India data (2011), migration within the same district is predominant in all the states, regardless of the presence of an urban center [51]. Therefore, unlike other parts of India where rural to urban migration, and associated sedentary lifestyle due to urbanization, is considered as the primary causal factor of hypertension among the indigenous populations, in the north-east region, the rising cases of hypertension among the indigenous communities may be impacted primarily by other causal factors. Moreover, recent studies also indicate that both urban and rural residents exhibit a strikingly comparable prevalence of hypertension, with low obesity rates [26]. In other words, the prevalence of hypertension among the indigenous populations of Northeast India is not confined to one type of residential area, whether rural or urban.

Genetic risk factors

An evolutionary approach is required to understand this region-specific rise in hypertension cases better. In this regard, it is now a well-established fact that significant risk factors for hypertension are both genetic and environmental. Many genes are responsible for hypertension [45]. Therefore, single-gene-related hypertension is rare [45]. Moreover, we need more genetic studies among Indian populations to understand the nature of the genetic contributions to hypertension in India. Studies in humans and animals suggest a polygenic, epidemiological model of hypertension, in which susceptibility conferred by any single gene is uncertain [52]. Consequently, such genetic variations may moderate responses to environmental exposure and may only achieve significance over the lifetime. Although this scenario dramatically complicates the task of genetic epidemiologists, several studies have identified a list of common genes contributing to hypertension, including thrifty genotypes.

Essential hypertension is believed to result from interactions between genes and the environment. The environmental effects are significant and account for most blood pressure differences among populations [53]. Therefore, a physiological mechanism involving genetic adaptation through a thrifty genotype, along with associated life-course plasticity and nutritional transitions, is proposed to explain the increasing prevalence of hypertension among the indigenous populations of Northeast India. According to this hypothesis, low birth weight babies adapt to their limited nutritional intake early in life through changes in growth and metabolism, which impact subsequent obesity and other cardiovascular disease (CVD) risk factors later in life [54]. In other words, inadequate growth during fetal life and infancy is closely linked to mortality from CVD and to adult levels of certain known risk factors, including hypertension [55].

Nutritional transitions

Furthermore, in the present century, global economic policies and strategies have influenced the nutritional status of various human populations worldwide and across generations [56]. Specifically, capitalism exposes populations to under- and over-nutrition, showcasing the contrasting effects of nutritional transition throughout their life course [56]. Such demographic and epidemiological transitions, along with the thrifty genotypes of the indigenous populations, may have contributed to the rise of hypertension in northeast India. Indigenous populations in this region live in diverse ecological conditions, speak different languages, and maintain various cultural beliefs. Additionally, they follow distinct traditional dietary habits [26], particularly excessive intake of animal protein, sodium, and fatty meats, while also experiencing deficiencies in potassium and fiber. The Mizo and Naga tribes are no exception to this trend [57]. Nearly all tribes in northeast India regularly consume excessive amounts of animal protein and fat [26]. According to the monographs on the tribes of northeast India, this dietary practice originated in ancient times when their ancestors were hunter-gatherers [57]. Consequently, these populations likely managed their resources through such dietary practices, storing energy during periods of food abundance for consumption during food shortages, reflecting their ancient hunting-gathering subsistence patterns.

Interestingly, this traditional dietary practice of excessive consumption of animal protein and fat has persisted into modern times, even though these populations no longer engage in hunting [26]. Furthermore, with the nutritional transition, these traditional populations are increasingly exposed to various factors such as excess fat, oil consumption, and high salt intake. This nutritional transition creates an obesogenic environment characterized by a calorie-rich food supply arising from global economic expansion [56]. Therefore, the discordance between the lifestyle to which the genomes of these populations were originally adapted and selected, and today's lifestyle, impacted by nutritional and demographic transitions, may have fostered vulnerabilities related to cardiovascular disease, including hypertension, among these tribal populations.

The major limitation of this review paper is that none of the cited studies have provided the genetic composition of these indigenous populations of northeast India. Potential biases in the investigator's measurement methods, sample selection, and other unknown factors may have influenced the prevalence data. Furthermore, it may be difficult to draw substantial conclusions without any cohort studies in the literature. Although a few studies did not address methodological aspects, the majority used the manual method with a sphygmomanometer and took multiple readings before calculating the average; such variations may have affected the comparability of the data.

It can be concluded that the advantageous adaptive mechanism of efficient energy use through frugality and careful resource management has enabled the indigenous populations of northeast India to survive successfully in the cold mountain regions of northwestern China (from which these populations originally migrated) for centuries while practicing a hunting-gathering subsistence pattern. Nonetheless, this historically advantageous adaptive mechanism has become mismatched in the current subsistence context. In other words, the adaptive mechanism involving the thrifty genotype may have benefited these populations during their hunter-gatherer periods. However, in the present context, such adaptive mechanisms have become disadvantageous due to the constant abundance of food supply. Additionally, the causal mechanism underlying the increasing cases of hypertension in northeast India requires more molecular-based population studies in this region.

Policy recommendations

Health policies for managing hypertension should prioritize the development of region- and indigenous population-specific strategies rather than a single nationwide health policy. For example, public awareness about the impact of hypertension could be raised. Healthy eating can be promoted by advising people to reduce their intake of excess sodium, animal protein, and animal fat. By routinely measuring blood pressure at health centers, the frequency of early detection could be increased. The development and adoption of treatment guidelines for Northeast India would greatly facilitate research into hypertension and its management, benefiting people. Moreover, addressing hypertension can only be achieved through a collaborative effort among the government, healthcare professionals, food and healthcare industries, and the indigenous populations.

DATA AVAILABILITY

The data supporting this study's findings are available from the corresponding author upon request. However, the data are not publicly available due to privacy or ethical restrictions.

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AUTHOR CONTRIBUTIONS

Sudipta Ghosh (SG) designed the study, extracted data, and wrote the manuscript.

COMPETING INTERESTS

The author declares no competing interests.

ETHICS APPROVAL

This is a review of published papers; hence, no ethical approval is required.

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