Arterial hypertension and its covariates among nomadic Raute hunter-gatherers of Western Nepal: a mixed-method study

Tapendra Koirala,1,2 Udaya Bahadur B C,3 Carmina Shrestha,4 Ujjawal Paudel,2,5 Rolina Dhital,4 Sunil Pokharel,6 Madhusudan Subedi7

ABSTRACT

Objectives To determine the prevalence of, and understand the factors associated with, hypertension among the nomadic Raute hunter-gatherers of Western Nepal.

Design A mixed-method study.

Setting The study was carried out at Raute temporary campsites in the Surkhet District of Karnali Province between May and September 2021.

Participants The questionnaire-based survey included all males and non-pregnant females of the nomadic Raute group aged 15 years and above. In-depth interviews were conducted among purposively selected 15 Raute participants and four non-Raute key informants to help explain and enrich the quantitative findings.

Outcome measures The prevalence of hypertension (defined as brachial artery blood pressure of systolic ≥140 mm Hg and/or diastolic ≥90 mm Hg) and its sociodemographic, anthropometric and behavioural covariates.

Results Of the 85 eligible participants, 81 (median age 35 years (IQR: 26–51), 46.9% female) were included in the final analysis. Hypertension was found in 10.5% of females, 48.8% of males and 30.9% of the total population. Current alcohol and tobacco use were high (91.4% and 70.4%, respectively), with concerning high rates among youths. Males, older people, current drinkers and current tobacco users were more likely to have hypertension. Our qualitative analysis suggests that the traditional forest-based Raute economy is gradually transitioning into a cash-based one that heavily relies on government incentives. Consumption of commercial foods, drinks and tobacco products is increasing as their market involvement grows.

Conclusion This study found a high burden of hypertension, alcohol and tobacco use among nomadic Raute hunter-gatherers facing socioeconomic and dietary transitions. Further research is needed to assess the long-term impact of these changes on their health. This study is expected to help appraise concerned policymakers of an emerging health concern and formulate context-specific and culturally sensitive interventions to limit hypertension-related morbidities and mortalities in this endangered population.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study to report the prevalence of hypertension and its covariates among the nomadic Raute hunter-gatherers of Nepal.
- The major strengths of this study are the use of a mixed-method design to have both quantitative and qualitative perspectives, near total population enrolment and robust methodology.
- The cross-sectional design of this study limits its ability to establish causal relationships between the variables.
- Several important factors, such as dietary fruits and vegetable consumption, salt intake and level of physical activities, as well as the presence of diabetes mellitus, dyslipidaemia or central obesity, were not assessed, preventing this study from determining the community’s actual cardiovascular disease risk.
- Interviews taken in language non-native (Nepali) to the Raute may be subject to language bias.

INTRODUCTION

Hunting-gathering is one of the oldest modes of subsistence, where most or all food is obtained through foraging edible plants and hunting wild animals.1 Hunter-gatherers (HG) were estimated to account for about 1% of the world’s population in the 1960s.2 As a result of rapid population growth, transformations of habitat, and globalisation, the population of traditional HG communities has rapidly declined.3 4 Currently, only a handful of communities are considered ‘pure HGs’, while many have transitioned either to agriculture, pastoralism or to a mixed economy where other adaptive strategies supplement foraging.5 6 HGs and other small-scale populations living traditionally are found to have a low prevalence of type 2 diabetes mellitus, hypertension and obesity.7 8 Their remarkable cardiovascular health is often linked to their high level of physical activity; low glycaemic

Correspondence to Tapendra Koirala; tapendrakoirala@gmail.com
Evidence has shown the emergence of obesity, diabetes, atherosclerosis and other lifestyle-related diseases among the former HGs as they transitioned from traditional to Western lifestyles. Health research in HGs has much to offer to modern medicine and public health. Knowledge of the interactions between health and lifestyle, diet and health behaviour among diverse traditional populations can aid in our understanding of several non-communicable diseases (NCDs) that plague modern societies. Inspired by HG research, several studies, including randomised controlled trials, have explored the role of HG or palaeolithic diets in various NCDs, from obesity, hypertension, diabetes and dyslipidaemia to multiple sclerosis among the general population.

However, HG’s health has not been extensively studied worldwide, and there is still a dearth of data on the impact of HG’s lifestyle choices on their health, particularly their cardiovascular and metabolic health. Studies from the mid-to-late 20th century constitute a sizeable portion of the existing research on HG’s health. Additionally, most studies focus disproportionately on HG societies in South America and sub-Saharan Africa. Asians, South Asian HG societies, in particular, are overtly underrepresented in research scrutiny. Only a handful of studies have explored the health and well-being of South Asian HGs. Data on the cardiovascular and metabolic health of contemporary HG populations in this entire region are almost non-existent, and Nepal is no exception.

Cardiovascular disease (CVD) is among the leading cause of preventable death globally. Raised blood pressure (BP) or hypertension is one of the strongest modifiable risk factors for CVDs. Approximately 34% of men and 32% of women aged 30–79 years worldwide, as well as 30% of men and 20% of women aged 15–69 years in Nepal, were estimated to have hypertension in 2019. Nevertheless, despite being the most representative of the available large-scale data, estimates from national-level public health surveys are often found to be significantly underrepresentative of ethnic minorities and difficult-to-reach mobile and migrant subpopulations. Furthermore, due to their unique lifestyle, diet and behaviour-related risks, the nationally representative data cannot be generalised to special subpopulations or groups.

Here, we present a distinctive group of Nepalese nomadic HGs with a unique set of lifestyle, tradition, language and sociocultural values who continue to live their traditional life, migrating from one place to another regularly gathering wild foods and bartering their carved woodenware for the grains and other necessities from the settled villagers. The Raute, a population apparently on the verge of extinction, is Nepal’s last remaining nomadic HGs. Since their existence was first documented in 1955, the Raute ethnography has been extensively studied by scholars worldwide. However, the Rautes’ health remains scientifically unexplored, especially their cardiovascular and metabolic health. Although anecdotal evidence suggests socioeconomic transition, changing health behaviours and deterioration in the general health of the Rautes, no scientific studies have explored the magnitude of such change and their impact on their health. Therefore, in an attempt to understand the state of their cardiovascular and metabolic health, this study aims to determine the prevalence of hypertension and understand the sociodemographic, anthropometric and behavioural factors associated with hypertension among nomadic Raute HGs of Western Nepal.

METHODS
Study design
This study adopted an explanatory sequential mixed-methods design. A quantitative study designed to determine the prevalence and factors associated with hypertension was followed by a qualitative study to understand, explain and enrich the quantitative findings.

Study population
The Raute is a small group of highly migratory, egalitarian HGs that exclusively hunts Rhesus and Langur monkeys, forages edible roots, fruits and herbs, carves woodenwares and trades them with the settled villagers for grains, clothes and other necessities. Rautes strongly opposes any idea of permanent settlement, agricultural practices and formal education. They are uninterested in new technologies and sophisticated gadgets and have little desire to save or store items. The Raute primarily inhabits forested areas and riverbanks of the mid-western part of the country. They alternate their habitat between higher altitudes (6000–10000 ft) in monsoon-months (April to September) and lower altitudes (2000–4500 ft) in winter (October to March). Their customary periodic migration is a complex function of their sociocultural belief system, environmental conditions, availability of forest resources, prospects for trade and relations with locals. ‘Khamchi’, a Tibeto-Burman language, is their mother tongue, although they are fluent in the local Nepali language. Their current economy is based on forest resources, trade and state incentives.

Study site and setting
Karnali province, the main home of the nomadic Rautes, is the largest but least populated of all the seven provinces of Nepal, with a population of about 1.5 million, a literacy rate of 62.77%, and a human development index score of 0.427. The province comprises 10 districts, Surkhet being the provincial capital. Districts such as Kalikot, Dailekh, Surkhet, Salyan and Jajarkot are among the most frequently, although not exclusively, inhabited places by the nomadic Rautes. At the time of the commencement of this study, they had been migrating through the District Surkhet. The study was completed in two phases between May and September 2021, following the Raute through their six successive campsites within the territories of Lekbashi and Gurbhakot Municipalities of the Surkhet District (figure 1).
Participants selection

For the quantitative study, all willing individuals aged 15 years and above belonging to the nomadic Raute population were considered eligible. Participants with suspected COVID-19 and pregnant females were excluded from the study (online supplemental figure 1). Since the entire eligible population was included, the sampling was deemed unnecessary.

Participants for the qualitative study were purposively selected: in-depth interviews (IDIs) were conducted among 15 (10 males and five females) Raute adults with and without hypertension. Four key informant interviews (KIIs) were conducted among a healthcare worker, two social workers and an expert in the field. The participants for the interviews were selected so that each would bring a unique perspective, thereby maximising demographic and experiential heterogeneity within the group. Interviews were conducted among Raute participants and outsiders to achieve a balanced perspective. We stopped taking further interviews when data obtained from respondents were repetitive or no new information was forthcoming.

Data collection

Quantitative data were collected through a structured questionnaire which included face-to-face interviews, anthropometric measurements and clinical examinations.

Four health workers (two health assistants and 2 public health nurses) were recruited and trained for data collection. They were supervised by the principal investigator (TK) and coinvestigators (CS and UP) during data collection. We used standard methods to obtain quantitative measurements.26 The data were collected at participants’ residences at their convenience by the data enumerators of their respective sexes.

Qualitative data collected through interviews (IDIs and KIIs) were taken face-to-face by two interviewers, UBB (MA) and TK (MBBS), using interview guides. UBB is a male public health expert with more than 10 years of experience. TK is a male medical graduate with over 5 years of clinical and research experience. Interviewers had interest in NCDs and their risk factors. They did not have any obvious bias or assumptions towards study population. A brief informal discussion was carried out with each participant to establish rapport and facilitate participation. Every participant was informed about the aims of the study, the researcher’s personal goal and the reason for conducting this study. All the participants approached for the study consented to participate, and there was no drop-out. Each of the IDIs lasted for approximately an hour and was audiorecorded. No repeat interviews were conducted with any participants. The interviewers made field notes during the data collection.

Figure 1  Study area map showing temporary Raute settlements (camps) and the data collection sites. Maps were created exclusively for the study using the QGIS V.3.28.0, and the GPS coordinates were taken from the study sites. (Data source: Shapefiles, Survey Department, Government of Nepal, http://nationalgeoportal.gov.np; Basemap, OpenStreetMaps contributors, https://www.openstreetmap.org).
All the interviews, measurements and clinical examinations were carried out, taking necessary precautions against COVID-19 transmission. The data enumerators and interviewers were tested for COVID-19 before and after carrying out data collection. During data collection, all researchers wore masks, face shields and gloves, while all the participants were given masks and kept at a distance of at least 1 m unless required to do otherwise.

Tools and instruments
Survey tool
To collect quantitative data, a structured questionnaire was adapted from validated tools for various national-level surveys and other relevant literature. The questionnaire was tailored according to the local context (online supplemental file 2). The questionnaire collected information on participant’s sociodemographic characteristics (age, sex, marital status, educational status and primary occupation), health-related behaviours (alcohol consumption and tobacco use), awareness and treatment of hypertension, physical measurements (height, weight, body mass index (BMI) and BP). Physical measurements were taken by trained enumerators according to established guidelines. Bodyweight in kilograms (kg) was measured to the nearest 0.2 kg using a well-calibrated standardised digital weighing scale (Seca, Hangzhou, China). Height was recorded to the nearest 0.1 cm using well-calibrated standardised portable stadiometers (Seca, Hangzhou, China). Weight and height measurements were performed without shoes, headgear or heavy clothing. BMI was calculated as weight in kilograms divided by height in metres squared (m²). BP measurements were performed using a well-calibrated digital automatic BP monitor (OMRON M6, Japan) with a universal cuff after the participants rested quietly for 15 min with their legs uncrossed. Each of the three BP readings was taken with participants requested to rest for 3 min in between. The mean of the second and third readings was taken for further analysis.

Interview guides
To collect qualitative data, we developed guides for IDIs and KIIs based on themes identified in the quantitative study. We also explored additional themes not captured in the quantitative study (online supplemental file 3).

Validation of tools
The survey questionnaire and interview guides were designed in English and translated into Nepali by the experts. The tools were then back-translated into English by a panel that speaks both languages for validation before administration. The structured survey questionnaire was pretested among eight Raute participants (10% of the total sample size) who were excluded from the final analysis. Similarly, the interview guides for IDI and KII were also pretested among three Raute participants and one key informant before their administration.

Operational definitions
Operational definitions were adopted for the key variables to maintain uniformity and consistency. Hypertension was defined and categorised based on the JNC seven recommendations. Details on operational definitions of the other study variables are given in the online supplemental file 4.

Data management and analysis
Quantitative data
We used descriptive statistics such as median and IQR for the continuous numerical variables and frequencies and proportions for the categorical variables to summarise our findings. All the data were analysed in SPSS (IBM) V.23 and visualised on R V.4.1.3. Maps were created by using QGIS V.3.28.0.

Qualitative data
For qualitative analysis, the audio recordings of IDIs and KIIs were transcribed verbatim in Nepali and then translated into English by the two investigators, TK and CS, independently. All the transcripts were imported to the Dedoose V.8.2.14 (SocioCultural Research Consultants, LLC, Los Angeles, CA). Two investigators, TK and RD, independently reviewed and coded the transcripts. Codes were compared, and the disagreements were resolved by consensus. All codes were merged into similar categories, which were further developed into major themes inductively. The data acquired through KIIs, IDIs and the quantitative study were triangulated during the final analysis. We did not return the transcripts to the participants due to logistical difficulties in finding highly migratory participants and their low literacy.

Data management
Participants’ personal health information (PHI) was protected on researchers’ fully encrypted devices with procedures for the deidentification of data during analysis, and no PHI was linked to geospatial data in the public domain. To ensure the credibility of the analysis, all procedures were supervised by research experts in the field.

PATIENT AND PUBLIC INVOLVEMENT
Raute participants were included during pretesting of quantitative and qualitative tools. Their feedback was incorporated accordingly. Raute chieftain coordinated with researchers to help them gather the necessary data. Social workers and relevant public health authorities will help disseminate the results to the participants.

RESULTS
Quantitative results
Population characteristics
Of the total 85 eligible participants, 81 participants between 15 and 69 years of age were included in the final quantitative analysis (online supplemental figure 1). The
The prevalence of alcohol consumption was alarmingly high with 90.7% of males and 92.1% of females reporting current consumption. In the age group 15–24 years, more than 68% drank alcohol in the past 30 days (data not shown). Overall, more than two-third of the participants currently uses tobacco products (81.4% males, 57.9% females). Approximately 42% of participants in the age group 15–24 years used some form of tobacco product in the preceding 30 days. The preference for tobacco products differed by gender; 87.5% of smokers were females, compared with 97.1% of smokeless tobacco users who were males.

For females, the median weight was 44 kg (IQR: 42–48), and the median height was 152.3 cm (IQR: 142.2–154.9). The median weight for males was 51 kg (IQR: 46–58), and the median height was 154.9 cm (IQR: 152.4–158.0). The median BMI for the population was 21.1 (IQR: 19.2–22.9) kg/m² with 17.3% of the participants being underweight (BMI<18.5 kg/m²), and 8.6% being overweight (BMI 25 to<30 kg/m²). None of the participants were found obese (BMI≥30 kg/m²).

For females, the medians for systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 122.5 mm Hg and 75.0 mm Hg, respectively. The mean arterial pressure (MAP) was 92.3 mm Hg.

### Table 1. Sociodemographic characteristics, behavioral risk factors, anthropometric profile and blood pressure of the nomadic Raute population by sex

<table>
<thead>
<tr>
<th>Variables</th>
<th>Female (n=38)</th>
<th>Male (n=43)</th>
<th>Total (n=81)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>35 (25–42)</td>
<td>35 (26–56)</td>
<td>35 (26–51)</td>
</tr>
<tr>
<td>15–34</td>
<td>19 (50.0)</td>
<td>21 (48.8)</td>
<td>40 (49.4)</td>
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<td>35–54</td>
<td>14 (36.8)</td>
<td>10 (23.3)</td>
<td>24 (29.6)</td>
</tr>
<tr>
<td>≥55</td>
<td>5 (13.2)</td>
<td>12 (27.9)</td>
<td>17 (21.0)</td>
</tr>
<tr>
<td><strong>Marital status</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Unmarried</td>
<td>15 (39.5)</td>
<td>14 (32.6)</td>
<td>29 (35.8)</td>
</tr>
<tr>
<td>Married</td>
<td>23 (60.5)</td>
<td>29 (67.4)</td>
<td>52 (64.2)</td>
</tr>
<tr>
<td><strong>Alcohol use</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current user</td>
<td>35 (92.1)</td>
<td>39 (90.7)</td>
<td>74 (91.4)</td>
</tr>
<tr>
<td>No. of days drank in the previous month, median (IQR)</td>
<td>10 (5–10)</td>
<td>15 (15–20)</td>
<td>15 (15–20)</td>
</tr>
<tr>
<td>No. of drinks drank per day in the previous month, median (IQR)</td>
<td>1 (1–1)</td>
<td>2 (1–2)</td>
<td>1 (1–2)</td>
</tr>
<tr>
<td><strong>Tobacco use</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current user</td>
<td>22 (57.9)</td>
<td>35 (81.4)</td>
<td>57 (70.4)</td>
</tr>
<tr>
<td>No. of days any tobacco products used in the previous month, median (IQR)</td>
<td>7.5 (3–15)</td>
<td>25 (25–25)</td>
<td>10 (10–25)</td>
</tr>
<tr>
<td><strong>Anthropometric profile</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm), median (IQR)</td>
<td>152.3 (142.2–154.9)</td>
<td>154.9 (152.4–158)</td>
<td>154.9 (144.8–157.5)</td>
</tr>
<tr>
<td>Weight (kg), median (IQR)</td>
<td>44 (42–48)</td>
<td>51 (46–58)</td>
<td>47 (44–53)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>20.4 (18.3–22.2)</td>
<td>21.8 (20–23.3)</td>
<td>21.1 (19.2–22.9)</td>
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<tr>
<td>Under/overweight (&lt;18.5 or ≥25)</td>
<td>15 (39.5)</td>
<td>6 (14.0)</td>
<td>21 (25.9)</td>
</tr>
<tr>
<td>Normal (18.5–24.9)</td>
<td>23 (60.5)</td>
<td>37 (86.0)</td>
<td>60 (74.1)</td>
</tr>
<tr>
<td><strong>Blood pressure (mm of Hg)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP, median (IQR)</td>
<td>122.5 (118.0–132.0)</td>
<td>135.0 (128.0–153.0)</td>
<td>130.0 (121.0–137.0)</td>
</tr>
<tr>
<td>DBP, median (IQR)</td>
<td>75.0 (70.0–83.0)</td>
<td>86.0 (79.0–90.0)</td>
<td>83.0 (74.0–87.0)</td>
</tr>
<tr>
<td>MAP, median (IQR)</td>
<td>92.3 (87.0–97.0)</td>
<td>103.0 (97.0–107.7)</td>
<td>97.0 (90.3–103.7)</td>
</tr>
</tbody>
</table>

DBP, diastolic blood pressure; MAP, mean arterial pressure; No., number; SBP, systolic blood pressure.

Non-response rate was 2.4%. Table 1 summarises the key population characteristics of this study. The median age of the participants was 35 years (IQR: 26–51), with a slight male predominance (53.1%, n=43). The majority of the participants were currently married (64.2%). Most males (90.7%) reported ‘carving and trading woodenware’ as their main occupation, while the majority (94.7%) of females reported being homemakers. None of the participants had received any formal education.

The prevalence of alcohol consumption was alarmingly high with 90.7% of males and 92.1% of females reporting current consumption. In the age group 15–24 years, more than 68% drank alcohol in the past 30 days (data not shown). Overall, more than two-third of the participants currently uses tobacco products (81.4% males, 57.9% females). Approximately 42% of participants in the age group 15–24 years used some form of tobacco product in the preceding 30 days. The preference for tobacco products differed by gender; 87.5% of smokers were females, compared with 97.1% of smokeless tobacco users who were males.

For females, the median weight was 44 kg (IQR: 42–48), and the median height was 152.3 cm (IQR: 142.2–154.9). The median weight for males was 51 kg (IQR: 46–58), and the median height was 154.9 cm (IQR: 152.4–158.0). The median BMI for the population was 21.1 (IQR: 19.2–22.9) kg/m² with 17.3% of the participants being underweight (BMI<18.5 kg/m²), and 8.6% being overweight (BMI 25 to<30 kg/m²). None of the participants were found obese (BMI≥30 kg/m²).

For females, the medians for systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 122.5 mm Hg and 75.0 mm Hg, respectively. The mean arterial pressure (MAP) was 92.3 mm Hg.
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The same for males were 135 (IQR: 128–153) and 86 (IQR: 79–90) mm of Hg, respectively. Medians for SBP, DBP and MAP were all higher among males than females across all age groups (table 1). We found notably high recordings for SBPs and DBPs among a small subset of participants aged 20–30 (figure 2, A and B). However, apart from this, in both sexes, the SBP increased steadily with age (figure 2, A). In males, DBP and MAP both increased significantly with age until the age of 60, when the former began to decline (figure 2, B and C). In females, DBP and MAP both decreased in early adulthood, followed by a moderate increase until the age of 60, after which the former started to decline.

Prevalence, associated factors, awareness and treatment of hypertension

The prevalence of hypertension was 10.5% among females, 48.8% among males and 30.9% overall. Males (48.8%) had a 4.6-fold higher prevalence of hypertension than females (10.5%). Nonetheless, a significant proportion (73.7%) of females were in the pre-hypertensive group (figure 2, D).

The prevalence of hypertension (D) by age groups and sex. Bars represent the percentage for each category of normotensive, prehypertensive and hypertensive participants. The cutoffs for normotension, prehypertension and hypertension were mean SBPs of <120, 120–139 and ≥140 mm of Hg, respectively, and/or mean DBPs of <80, 80–89, and ≥90 mm of Hg, respectively. SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure.

Table 2 summarises the participants’ sociodemographic characteristics, behavioural risks and anthropometric profiles by hypertension status. When compared across age groups, the prevalence of hypertension was 2.6 times higher among those 55 and older (52.9%) than among those under 35 (20%). Hypertension was twice more common among those who currently drink (32.4%) than those who do not (14.3%, data not shown). The median days the participants drank alcohol in the previous month were higher among hypertensive than non-hypertensive participants (15 vs 10 days). Likewise, hypertension was 1.5 times more common among the current tobacco user than the current non-user (30.5 vs 20.8%). Similarly, the median days of tobacco products used in the previous month among the hypertensive and the non-hypertensive participants were also different (25 vs 15 days). The median BMIs were almost similar among participants with or without hypertension (21.5 vs 20.5 kg/m²).

Figure 2 Age-related changes in systolic (A), diastolic (B) and mean arterial (C) blood pressure in nomadic Raute adults. Males are green dots; females are red dots. Displayed curves are third-order polynomial fits. The shaded area represents the 95% CI. The prevalence of hypertension (D) by age groups and sex. Bars represent the percentage for each category of normotensive, prehypertensive and hypertensive participants. The cutoffs for normotension, prehypertension and hypertension were mean SBPs of <120, 120–139 and ≥140 mm of Hg, respectively, and/or mean DBPs of <80, 80–89, and ≥90 mm of Hg, respectively. SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure.
Among the respondents who had hypertension, only 8% were aware of it. None of the hypertensive participants ever received any treatment.

**Qualitative results**

A total of 15 Raute participants (10 males, five females and 33.3% hypertensives) participated in IDIs, with their ages ranging from 15 to 72 years. Four non-Raute key informants (one social scientist, two social workers and one health worker) of diverse backgrounds working closely with the Raute community participated in the KIIs (online supplemental table 5). None of the participants approached refused to participate. Four major themes developed from the thematic analysis are presented below, with some representative narratives from the participants with their age group, sex, hypertension status and participant number in the parenthesis.

**Theme 1: socioeconomic transition**

The majority of the key informants observed significant socioeconomic changes in the Raute community over the last decade. According to them, the traditional, foraging-based and barter-based economy of Raute is now transitioning towards a predominantly cash-based economy. Most Raute participants, regardless of their hypertension status, agreed that their generation-old belief and view towards money is now changing.

People of the previous generation did not accept paper money. They exchanged their wooden wares for grains, flour, and other essentials. They thought accepting paper money was a sin and brought bad luck during their hunting. These days, even our chieftains prefer paper money so that they can purchase goods whenever needed and do not have to carry heavy loads of goods while migrating. (Raute male, age range 40–45 years, non-hypertensive, IDI#11)

Currently, from the federal and provincial governments combined, each individual, including children from the Raute community, receives a sum of 5000 Nepali Rupees (approx. 42 USD) per month.30 The allowance provided by the government was noted by most participants as the main driver of the socioeconomic transition of the community.

In the past, we used to earn our living with the use of our muscles. These days we get an allowance. These days we have ease. (Raute male, age range 40–45 years, non-hypertensive, IDI#11)

Previously, my parents must have had so much hardship raising me. We did not have an allowance. They used to make wooden bowls and boxes, go to the village, and exchange them for grains. They ate a

<table>
<thead>
<tr>
<th>Variables</th>
<th>Non-hypertensive (n=56)</th>
<th>Hypertensive (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (n%)</td>
<td>N (n%)</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>33 (23–42)</td>
<td>48 (31–61)</td>
</tr>
<tr>
<td>15–34</td>
<td>32 (80.0)</td>
<td>8 (20.0)</td>
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<td>35–54</td>
<td>16 (66.7)</td>
<td>8 (33.3)</td>
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<tr>
<td>≥55</td>
<td>8 (47.1)</td>
<td>9 (52.9)</td>
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<tr>
<td><strong>Marital status</strong></td>
<td></td>
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</tr>
<tr>
<td>Unmarried</td>
<td>20 (69.0)</td>
<td>9 (31.0)</td>
</tr>
<tr>
<td>Married</td>
<td>36 (69.2)</td>
<td>16 (30.8)</td>
</tr>
<tr>
<td><strong>Alcohol consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current drinker</td>
<td>50 (67.6)</td>
<td>24 (32.4)</td>
</tr>
<tr>
<td>No. of days drank in the previous month, median (IQR)</td>
<td>10 (7–15)</td>
<td>15 (15–20)</td>
</tr>
<tr>
<td>No. of drinks drank per day in the previous month, median (IQR)</td>
<td>1 (1–1)</td>
<td>2 (1–3)</td>
</tr>
<tr>
<td><strong>Tobacco use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current user</td>
<td>37 (64.9)</td>
<td>20 (35.1)</td>
</tr>
<tr>
<td>Median days (IQR) any tobacco products used in the previous month</td>
<td>15 (5.0–25.0)</td>
<td>25 (22.5–25.0)</td>
</tr>
<tr>
<td><strong>Body mass index (kg/m2)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>20.5 (18.5–23.0)</td>
<td>21.5 (19.6–22.9)</td>
</tr>
<tr>
<td>Under/overweight (&lt;18.5 or ≥25)</td>
<td>16 (76.2)</td>
<td>5 (23.8)</td>
</tr>
<tr>
<td>Normal (18.5–24.9)</td>
<td>40 (66.7)</td>
<td>20 (33.3)</td>
</tr>
</tbody>
</table>

No., number.
little and gave it to me. That’s how they raised me. Nowadays, it is much better. (Raute male, age range 30–35 years, non-hypertensive, IDI#8)

One of our KII participants indicated that the Rautes’ proximity to settled communities has increased. They now prefer to camp close to market areas where commodities may be easily obtained. Even the Rautes have perceived less of a need to work as the allowance money they receive can be used to purchase food and other essentials.

We don’t work as much as before. We can purchase our grains and essentials with an allowance. We go to the forest only for firewood and wood for making our hut. We don’t carry big logs to make wooden wares as much as before. (Raute male, age range 55–60 years, hypertensive, IDI#14)

Most of the participants of IDI had witnessed a significant decline in the demand and, therefore, the production of traditional wooden wares. Even though most males identified ‘crafting and trading’ as their primary occupation in our quantitative study, many stated that they now craft wooden wares just to keep the tradition alive. A few participants noted that the change in the livelihood of the Raute was inevitable as modern industrial wares became popular.

People don’t like using traditional wooden wares anymore. They prefer to use steel and other metalware these days. (Raute female, age range 50–55 years, non-hypertensive, IDI#12)

Theme 2: change in patterns of alcohol and tobacco use

Alcohol consumption

Although drinking homemade alcohol has long been a Raute tradition, most participants have noted a shift in alcohol consumption in recent years. Raute, who used to drink traditionally made alcohol occasionally, has lately begun purchasing commercial alcohol from surrounding communities and marketplaces. Many participants of IDI and KII speculated that their increasing interaction with outsiders could be one of the factors contributing to the Raute community’s rising alcohol usage.

We have been drinking homemade alcohol made in wooden vessels since the time of our forefathers. However, the local liquor made and sold by the settled communities and bottled alcohol is getting increasingly popular in recent years. Rautes learned it from the outsiders. (Raute male, age range 55–60 years, hypertensive, current drinker, IDI#14)

All the participants of KII reported widespread use of alcohol among Rautes, including youths and children. As evident in our quantitative study, an alarmingly high proportion of Raute youth currently consumes alcohol and tobacco products. One adolescent participant stated that drinking alcohol is common among young Rautes, including children, and they learn it from their elders.

These days, big people, even our chieftains, everyone drinks alcohol. So, we, too, drink alcohol. Even small children, smaller than me, consume alcohol. Rautes are like this. (Raute male, age range 15–20 years, non-hypertensive, current drinker, IDI#1)

One of our KII participants speculated that the provisions of allowance by the government could have an important influence on the recent change in alcohol consumption among the Raute community.

Ever since the government started providing them with an allowance, they seem confused about investing this money. They started spending money on alcohol and tobacco. (Social Scientist, male, age range 50–55 years, KII#3)

However, some Rautes claimed that only a negligible portion of the allowance is spent on buying alcohol.

We don’t spend too much money on alcohol. We first buy rice, salt, and flour. We buy alcohol from what remains. (Raute male, age range 30–35 years, hypertensive, current drinker, IDI#9)

Most of the IDI participants could not clearly outline the adverse health effects of alcohol regardless of their hypertension status. Some participants had certain ideas about the influence of alcohol on their socioeconomic life, general health and injuries, for example, falls and burns.

We don’t go hunting these days as much as we used to. People nowadays drink alcohol from the allowance they receive. They can’t go hunting when they are drunk. Alcohol makes them feel weak. (Raute male, age range 15–20 years, non-hypertensive, current drinker, IDI#1)

I have heard that alcohol affects our chest and intestine. (Raute male, age range 15–20 years, hypertensive, current drinker, IDI#3)

Both I and my wife drink alcohol. Once, we drank and slept near the fireplace. I woke up with a burnt face the next morning. I was so drunk that I did not realize it. (Raute male, age range 30–35 years, hypertensive, current drinker, IDI#9)

According to a health worker (KII) who works closely with the Raute community, the usage of commercial alcohol has adversely affected the health of Raute youths.

Commercial, low-quality alcohol has adversely affected the health of the youth of this community. I saw some young people with jaundice. It must have been caused by alcohol; don’t you think so? (Health worker, male, age range 25–30 years, KII#1)

Tobacco use

Most of the Rautes reported using tobacco—the preference for the type of tobacco varied between men and women. We did not find significant differences in patterns,
preferences and perceptions regarding tobacco use among hypertensive and non-hypertensive participants.

We, men, prefer chewing tobacco while women prefer cigarettes, hookah, and other smoking tobacco. (Raute male, age range 55–60 years, hypertensive, current tobacco user, IDI#14)

A recent shift in the pattern with increased use of commercially available tobacco products has been reported by the Rautes.

Women used to take hookah in the past. They used to make their own tobacco from tobacco leaves. Nowadays, they can easily buy cigarettes from the marketplace and smoke. (Raute male, age range 25–30 years, non-hypertensive, IDI#7)

During our IDI, a few Raute asked us for chewing-tobacco. Some participants demanded tobacco products as incentives for participating in our interviews.

Raute cannot speak without tobacco. We will talk to you only if you give us tobacco. (Raute male, 25–30 years, non-hypertensive, current tobacco user, IDI#6)

Most of the respondents were not aware of the adverse health effects of tobacco. Only a few participants were able to state that smoking negatively affects health, but they were unable to outline the direct health effects of smoking.

Smoking blackens our lungs. (Raute male, age range 15–20 years, hypertensive, current tobacco user, IDI#3)

Theme 3: changing diet and food security

Most Raute participants had witnessed a significant change in their dietary patterns in recent years. The majority also noted a substantial improvement in food security in recent years compared with the past.

In the past, if we could sell our woodenware, we got to eat food; else, we had to either sleep on an empty stomach or borrow food from relatives. These days, we don’t need to sleep hungry. (Raute male, age range 55–60 years, non-hypertensive, IDI#14)

Historically, the Raute diet consisted of grains obtained through barter and roots, tubers and herbs collected from the forest, supplemented with bushmeat, according to most participants. The current Raute diet consists chiefly of rice grain and a few vegetables obtained directly from the market or donated by various governmental and non-governmental organisations. Participants reported that hunted game, wild roots and tubers are less common in their current diet than in the past. The participants did not differ in their perception of changing dietary patterns regardless of their hypertension status.

We previously used to bring air potato, yam, and five-leaf yam from the jungle and eat them. These days, we eat rice all the time. (Raute male, age range 30–35 years, hypertensive, IDI#9)

Many Raute participants reported that they used to self-process and prepare their food from raw grains. Packaged and processed modern foods have been reported to find their way into the Raute diet in recent years.

Back then, we used to go to a watermill or grind it in a large mortar to make flour out of millet and maize to make flatbread. We used to eat roasted maize. Nowadays, we can easily buy Rice and processed wheat flour from the marketplace. (Raute female, age range 30–35 years, non-hypertensive, IDI#10)

In our times, we used to eat bayberries, barberries, guava, and various other wild fruits. Young people these days have learned to eat noodles and biscuits. (Raute male, age range 55–60 years, hypertensive, IDI#14)

Theme 4: traditional healthcare practices

In their ill health, the majority of participants of IDIs reported using various kinds of medicinal herbs based on their indigenous knowledge and seeking traditional healers within their community who practice spiritual healing and herbal medicine. A few participants also stated that they should visit healthcare workers if the illness does not improve with traditional healing, indicating growing awareness of modern healthcare.

If we get sick, we try home remedies such as medicinal herbs from the jungle. We also go to the traditional healer who blows charms and assesses our pulse. If we don’t get better, nowadays they (Outsiders) say we should go to the doctor. (Raute male, age range 55–60 years, hypertensive, IDI#14)

DISCUSSION

To the best of our knowledge, this is the first study to assess the status of cardiometabolic health and investigate hypertension as an emerging health concern among endangered Raute HGs of Nepal. Overall, 30.9% of the population (10.5% of females and 48.8% of males) were found to have hypertension. A significant majority currently consumes alcohol (91.4%) and tobacco (70.4%), with an alarmingly high prevalence among youths (68% and 42%, respectively). Our qualitative analysis showed that the traditional forage-based and barter-based Raute economy had been gradually transitioning into a cash-based economy that is heavily reliant on state incentives, leading to a decline in forest-based activities and an increase in the consumption of purchased foods, beverages and tobacco products with the increased market involvement.

Although there is still a great paucity of research on HG health, extant data show that HGs and other small-scale
subsistence-based populations have a significantly lower prevalence of lifestyle-related diseases, including hypertension. 7,31 HGs with relatively traditional living, such as the Pygmies of Southern Cameroon and the Hadza of Northern Tanzania, for example, were found to have remarkably lower rates of hypertension (3.3% and 13%, respectively).31–33 Similarly, the Tsimane forager-horticulturists of the Bolivian Amazon also showed a low prevalence of hypertension (2.9%) and no significant increase in BP with age.34 In contrast to these studies, we found a much higher (30.9%) prevalence of hypertension among nomadic Raute HGs exceeding that of general Nepalese populations (rural: 19.1%–23.8%, urban: 22.4%–25.2%) based on data from the most recent composite national surveys.18,35 Metanalyses have reported slightly higher national pooled prevalence ranging from 27.3% to up to 32%.36,37 A recent survey that included samples from former nomadic HGs, including sedentary Rautes from the far west, reported a relatively lower prevalence (23.8%) of hypertension among the indigenous Nepalese population.36 Among Negritos, Batek and Jehai HGs from Peninsular Malaysia who receive significant government support and have stable livelihoods demonstrated a much higher (>40%) prevalence of hypertension than our study population.39,40 The differences in hypertension prevalence observed across these populations might be due to various variables. Aside from genetic, ethnic and environmental variations, lifestyle, diet, level of physical activity, behavioural risks and degree of acculturation, all should be considered.

The effect of gender and age on BP is well established.41,42 In the general population, both SBP and DBP rise steadily in early adulthood up to age 50 years, following which SBP steeply rises while DBP markedly declines.42 In our study, SBP increased steadily with age, whereas DBP did not demonstrate a significant rise. In contrast, Tsimane and Hadza HGs exhibited a less sustained change in BP with the age categories in our study, males had considerably higher SBP and DBP than females, although the difference in BP narrowed slightly after the age of 60 years. This is in agreement with the findings among the general population.41,44 The BP amplification from central to peripheral arteries increases with body height and is thus more pronounced in males.45 This may partly explain why brachial artery BP is lower among premenopausal females than among age-matched males. Nonetheless, the origin of sexual dimorphism in BP might be multifaceted, encompassing the combined influence of hormonal, chromosomal, genetic and morphological variations in body size and socioeconomic and environmental covariates.46–48 Surprisingly, recent sex-specific analyses indicated that females, compared with males, exhibit a steeper rise in BP with age starting early in life.46 Among subsistent populations, Tsimane and Pygmie females demonstrated similar gender-related variations in BP.31–33 Hadza, on the other hand, exhibited only age-related, not gender-related, changes in BP.35 In our study, the proportion of males with hypertension was significantly higher than that of females. Findings from Tsimane and Pygmies resonate with this.31,32 In contrast, Hadza females had a higher prevalence of hypertension compared with males.33

A significant majority of the participants in our study were current drinkers (91.4%) and some forms of current tobacco users (70.4%). This exceeds the rate of current alcohol (20.8%) and tobacco (28.9%) use among the general Nepalese population.18 High rates of alcohol (68%) and tobacco (42%) use among the young Raute population under 25 were particularly concerning. Raute youths claim to have learnt it from their elders. However, Raute elders believe that their increased interaction with the Duniya (the outside world) has influenced the new generation’s heavy use of commercial alcohol and tobacco products. Among Rautes, hypertension was more than twice as common among individuals who currently drink or use tobacco products than those who do not. Interestingly, conventional risk factors, such as alcohol and tobacco use, were not found to be strongly associated with hypertension in many traditional populations, despite their high prevalence.31,32,38–49,50 This might imply that these populations could have other important hypertension risk factors not caught by existing survey instruments or that they have several protective factors that negate the risk associated with these conventional risk factors, emphasising the importance of a context-specific approach.

Globally, HGs communities are renowned for their remarkably low obesity.7 Only a small minority (8.6%) of our study population was overweight (BMI 25–29.9 kg/m²), and we found no obesity (BMI≥30 kg/m²). Among the well-studied HG populations, the prevalence of overweight ranged from 2% among the Hadza to 15%–21% among the Tsimane.7,51 BMI positively correlates with BP among Tsimane and Pygmies.31,32,52 However, we did not find a correlation between BMI and BP among our study population.

In meta-analyses of several RCTs, the palaeolithic diets based on lean meat, fish, fruits, vegetables, root vegetables, eggs and nuts were shown to have more significant improvements in cardiometabolic parameters such as BP, BMI, lipid profile and blood sugar level than the guideline-based control diets. However, the benefits were transient, and the strength of the evidence was low.13,53,54 A transition from the traditional HG diet to a grain-based western diet has been reported to result in a deterioration in general health and an increase in obesity, diabetes and other metabolic diseases among Australian HGs.14,55 Interestingly, temporary reversal to the traditional diet among Australian aborigines was further shown to result in marked improvement in carbohydrate and lipid metabolism.56 Although we did not collect exclusive quantitative data on the Raute diet and nutrition, our qualitative data showed a transition from a traditional forest-based nomadic diet to a grain-based diet with an increasing proportion of market-bought, packaged/processed foods and beverages gradually getting their way into the
Raute food culture in recent years. The factors we found, which are also supported by the previous studies, such as depleting forest resources, shrinking traditional barter system, stable cash flow in the form of state incentives, and increasing market involvement, may all be implicated in such dietary transition.\textsuperscript{57,58} There is evidence that monetary income and access to the market contributed to a greater intake of energy-dense foods like sugar and oil, as well as a higher rate of obesity and increased drinking and smoking among HGs.\textsuperscript{59} Nonetheless, the interaction between market, diet and HG’s health is complex and warrants more research.

Socioeconomic transition, acculturation and exposure to Western lifestyles have been equated to an increase in the prevalence of so-called diseases of civilization including hypertension, among many traditional communities worldwide.\textsuperscript{11-12,60-63} Socioeconomic transition, a major theme of our qualitative analysis, was frequently linked to rising commercial alcohol and tobacco use and changing dietary patterns among Raute. A high rate of alcohol consumption, particularly hazardous consumption and declining foraging behaviour with the socioeconomic transition has been well documented among the Congolese BaYaka and Tanzanian Hadza HGs, respectively, which resonate with our findings.\textsuperscript{64,65}

The Rautes have rich indigenous knowledge of medicinal herbs. Although traditional healing is still practiced, the Raute is increasingly becoming more aware of modern healthcare. The awareness of the diagnosis among hypertensive participants was 8%, which should not be surprising given the low awareness (~22%) even among the general population, reflecting overall poor access to and under-utilisation of healthcare services in Nepal.

Our study identifies a high burden of hypertension among nomadic Raute HGs in the background of changing socioeconomic status, dietary patterns and health behaviours. The long-term impact of these changes on Rautes’ health is yet to be explored. From the studies conducted in Australia and South America, it is evident that incidences of cardiovascular and metabolic diseases increase when the population moves away from their traditional lifestyles and gets exposed to modernisation.\textsuperscript{11,12} The association of various socioeconomic, dietary, and lifestyle factors in populations as simple as HGs emphasises their potential contribution to the occurrence of cardiovascular disorders like hypertension in other indigenous and general populations in Nepal and elsewhere.

**STUDY LIMITATION**

The several limitations of this study should be noted. The cross-sectional nature of the study limits its ability to establish or refute causal relationships between the variables studied and hypertension. The prevalence of hypertension estimated in this study should be interpreted with caution. The prevalence of hypertension tends to be overestimated in cross-sectional analyses, highlighting the significance of longitudinal monitoring for accurate estimation.\textsuperscript{31} We did not collect data on several important factors such as dietary fruits and vegetable consumption, salt intake, level of physical activities and presence of diabetes mellitus, hyperlipidemia or central adiposity among our study participants, which would have given deeper insight into the actual CVD risk of this population. Our study was primarily deficit-focused; however, a strengths-based approach highlighting the community’s resilience and strengths alongside its deficiencies would have been more insightful and empowering. We recommend that future research take this critical aspect into account.

Despite these limitations, this study has several strengths. This study is the first to report the prevalence of hypertension and some of its important sociodemographic, behavioural and metabolic covariates in this unique, difficult-to-reach, endangered population. Enrolment of the entire population, rigorous data collection protocol and utilisation of a mixed-method study to get both quantitative and qualitative perspectives were the strengths of this study.

**CONCLUSION**

We found a high burden of hypertension among nomadic Raute HGs exceeding that of the general Nepalese population. Alcohol and tobacco use was widespread, with alarmingly high rates among youths. The traditional forest-based Raute economy is gradually transitioning to a cash-based economy heavily reliant on government incentives. Consumption of purchased foods, beverages and tobacco products is increasing in tandem with market involvement. Nonetheless, further research is needed to assess the long-term health impact of these socioeconomic, dietary and behavioural changes. This study is expected to help appraise concerned policymakers of an emerging health concern and formulate effective context-specific and culturally sensitive community-based interventions to limit the morbidity and mortality associated with hypertension in the endangered nomadic Raute population.

**Author affiliations**

1Dasharathpur Primary Health Care Center, Surkhet, Karnali Province, Nepal
2Department of Health Services, Ministry of Health and Population, Kathmandu, Bagmati Province, Nepal
3Public Health Service Office Surkhet, Ministry of Social Development, Surkhet, Karnali Province, Nepal
4Health Action and Research Pvt. Ltd, Kathmandu, Bagmati Province, Nepal
5Jibjibe Primary Health Care Center, Rasuwa, Bagmati Province, Nepal
6Centre for Tropical Medicine and Global Health, Nuffield Department of Clinical Medicine, University of Oxford, Oxford, UK
7Department of Community Health Sciences, Patan Academy of Health Sciences, Lalitpur, Bagmati Province, Nepal

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ORCID iD Tapendra Koirala http://orcid.org/0000-0002-2664-3566

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sex chromosomes cause sex differences in the development trajectories over the life course.


