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Prevalence of hypertension at high altitude: cross sectional survey in Ladakh, Northern India 2007-2011

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Epidemiology of hypertension in Ladakh; socio-economic, cultural, and dietary factors play bigger role than altitude.

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Abstract

Objective: This population-based epidemiological study was aimed to determine the prevalence of hypertension and its relation to altitude, occupation, and ethnicity in a widely dispersed (45110 square kilometre) representative group of Ladakhi in Northern India (Altitude 2600-4900m).

Methods: 2800 subjects (age 20-94 years) were enrolled. Systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure of ≥90 mm Hg was defined as hypertension. Measurements included height and weight for body mass index and SpO_2. The rural population comprised of six subdivisions with distinct altitude, dietary and occupational pattern. Subjects in the urban area of Leh consist of four groups, i.e. Tibetan or Ladakhi migrants settled in Leh from Changthang area, Tibetan born in Leh, and native Ladakhi. Their prevalence of hypertension were compared with those in Tibetan or Ladakhi nomads in Changthang and native Ladakhi in other rural areas. The effect of altitude, occupation and rural-to-urban migration to hypertension were analysed by multiple logistic regression adjusted with age, sex and overweight.

Results: The prevalence of hypertension was highest in Tibetan migrants settled in Leh (48.5 %) followed by Ladakhi migrants (47.2%), Tibetans born in Leh (42.4%) and native ladakhi in Leh (40.7%) compared with rural Ladakhi (33.9-34.5%). The lowest prevalence of hypertension was shown in Tibetan natives (19.7 %) living at higher altitude (4000-4900m). The associated factors with hypertension were aging, overweight, dwelling at higher altitude, engagement in modernized sedentary occupation, and rural-to-urban migration. The effect of modernized occupation and rural-to urban migration to hypertension were stronger than that of altitude by multivariate analysis adjusted with confounding factors.

Conclusions: Socio-economic and cultural factors play bigger role than altitude for the causation of hypertension in high-altitude people in Ladakh.

Strengths and limitations of this study

▪This study examined most of the socio-economic environmental factors known to influence hypertension in population of different distinct geographical subdivisions of high altitude region.

▪This study showed the influence of aging, overweight, modernized sedentary occupation, and rural-to-urban migration to hypertension with the confounding factor of altitude by multivariate analysis.

▪ This study did not look into the genetic factors, as both environmental and genetic factors may contribute to regional and racial variation of blood pressure and prevalence of hypertension.

Introduction

Systemic arterial hypertension at high Altitude has evoked great interest amongst high altitude researchers as well as in sojourners and natives. There have been conflicting reports with investigators in the Himalayas generally reporting slight increase in the blood pressure level soon after arrival at high altitude and investigators in Andes reporting no such change[1]. Similar contradictory views also exist between the investigators of the two high altitude continents regarding the blood pressure status of the high altitude natives. Studies done in Spiti India (4000m) shows lower prevalence of hypertension.[2] Andean residents are reported to have low prevalence of hypertension,[1,3] while prevalence of hypertension in Tibet Lhasa was found to be higher than Han migrants residing in Tibet.[4] The risk of developing hypertension may depend on socio-economic factors, geographic and racial differences. It is in the backdrop of this difference in opinion that we planned this study in Ladakh, one of the highest inhabited regions in northernmost part of India. The population of the two districts of Ladakh (Leh and Kargil) was about 270,000 (Leh: 130,000, Kargil: 140,000) in 2011 by Census.[5] 77% of the population in Leh are Buddhist and 80% of the Kargil population are Muslim. Spread over 45110 sq km, sandwiched between Karakorum in the North and Trans-Himalaya in the south and 80% comprising of rural population with many villages high up in the mountains remaining inaccessible during winter, logistics for conducting a comprehensive epidemiological study representative of the whole population is formidable. The purpose of the study is twofold. One, to determine the prevalence of hypertension in different geographical subdivisions of this widely dispersed high altitude district and second which factors among the altitude, diet, occupation, socio-economic, and lifestyle plays predominant role in causation of hypertension.

Methods

This cross sectional epidemiological study was carried out from 2007 to 2011. A total of 2800 subjects aged between 20 to 94 years were examined. Figure 1 shows the map of Ladakh region showing all the subdivisions where the study was conducted. Two-stage stratified sampling method was used to select a representative sample of the adult population over 20 years of age. The population was first stratified as urban versus rural and then in the rural sector into six geographical areas (Sub-divisions). Each geographical sub-division has different characteristics in altitude, occupation, dietary habits and socio-economic conditions and is separate administrative blocks (Table 1). Migrants from rural population now settled in Leh town subdivision since 1970s were included in the urban population as they have adopted a life style similar to the city dwellers. A house to house survey list prepared in 2007 by Tata institute of social sciences was used to draw samples of urban population. A random table was used to draw sample for study amongst age group of 20-90 years of both gender. There were no criteria for exclusion except absentees and critical and terminal illness patients who cannot report to the study centre to complete the study. Subjects in **Leh town subdivision** was classified into four groups, i.e. Tibetan migrants settled in Leh from Changthang area, Ladakhi migrants settled in Leh from Changthang area, Tibetan born in Leh, and other Ladakhi people, almost of whom were born in Leh including some migrants from rural areas (non-Changthang).

The rural population was subdivided into six subdivisions as each subdivision had distinct characteristics which could influence the outcome. **Leh block subdivision** comprised of nearly 12 villages (Phyang, Sabu, Shey, Spituk, Stakmo, Stok, Taru, Thikse, Nyemo, Matho, Igu, and Shang) within 40 km of Leh town at an altitude varying between 3000-3700 meter and their

occupation being a mix of farming, service sector and business**. Nubra subdivision** is in the north of Ladakh about 120 kilometres from Leh after crossing Khardong Pass (18000 Feet) one of the highest motorable road in the world. We studied the population of seven villages (Burma, Charasa, Hundar, Kuri, Panamik, Sumur, and Tershey) here. The subdivision is located on the banks of shyok and Nubra rivers between the Karokoram and Ladakh range of mountains. People are predominantly farmers and the altitude of the valley generally is around 2600- 3000 m. **Kargil subdivision (Panikhar and Parkachik).** This subdivision is a green belt in Kargil District and is a fertile farming area on the Suru river. However fruit trees are not cultivated here. The population is mainly Muslim and the altitude is 2600-3100m. We studied the population of six villages (Maita-Panikhar, Paranti-Panikhar, Panti-Panikhar, Suru, Pursai-Panikhar, and Parkachik) representative of this subdivision. **Sham (Khalse) subdivision** is wide-ranged in altitude (2700-3900m), generally more fertile and many of the villages have fruit tree like apricot, apple, almond. We studied six representative villages (Domkhar, Phanjila, Skyurbukchan, Hinju, Ursi, and Wanla) in this subdivision. **Zanskar Subdivision** is a remote region on the trans Himalayan range of mountain which remains closed from the rest of the world for 6 months in a year due to heavy snow fall. Though people do farming, yet the harsh weather is not conducive for productive farming. Fresh fruit and fresh vegetable are very meagre here. People rear cattle which forms their secondary source of income by selling dairy products. Altitude of the subdivision is 3500-3900m. We studied ten villages (Abran, Aksho, Karsha, Kushul, Padum, Raru, Skyagam, Rantaksha, Phe, and Tungri) representative of this subdivision**. Changthang subdivision** is the biggest and highest plateau (Altitude 4000-4900m). The population is generally nomads moving from pasture to pasture every three months along with their cattle, live stock and lives in Yak wool woven tents. Life is very hard for them because of

the high altitude and severe cold. Farming is not possible, fresh vegetables and fresh fruits are not available to them throughout the year. Meat, barley flour and local tea are their staple diet. We studied six villages (Korzok, Hanle, Sumdo; Thadsang Karu, Rina & Nurchan; Samad Rokchen, Merak, and Zara; Kharnak) representative of the subdivision.

The occupation was interviewed from all the subjects and classified into eight groups; nomad, farmer, housewife, manual labor, monk, sedentary worker, retired sedentary worker, and no job. Housewife consist of housewife only, and both housewife and other job (nomad, famer and so on). Sedentary worker consist of office worker, shop keeper, taxi driver, government officer, travel agent, teacher and so on.

The procedure for obtaining informed consent was approved by Institutional review board of Ladakh institute of prevention and the District ethical committee, Leh, Ladakh and Research Institute for Humanity and Nature, Kyoto, Japan. The participants attended the village medical aid centre or the village community centre. Anthropometric measurement including weight and height were obtained using standard techniques. The body mass index (BMI) was calculated using the formula, weight(kg)/(Height)^2(m^2). The blood pressure was recorded with Home BP machine (Omron Dalian co., Ltd) twice in the sitting position after resting for 5 minutes. The mean of the two readings was taken as the blood pressure of the individual. Systolic blood pressure (SBP) ≥140 mm Hg and/or diastolic blood pressure (DBP) of ≥90 mm Hg was defined as hypertension. The mean rate of taking antihypertensive medicine was 15.8 %, but almost of their intake was not continuous. The age of the participants were confirmed with reference to a

carefully prepared cross tabulation correlating their date of birth with the animal year which the rural population always remembered and to historical sentinel events in case of elderly subjects.

Chi square test and ANOVA were conducted for the analysis of the prevalence rate of hypertension or overweight (BMI $\geq$ 25), mean SBP, DBP, BMI and SpO_2. The associations of the prevalence rate of hypertension with the above confounding factors including altitude, aging and sex were analyzed by multiple logistic regression. SPSS version 17.0 (SPSS Inc., Chicago, IL, USA) was used for the analysis.

Results

A total of 2800 subjects aged between 20 to 94 years were examined between 2007 to 2011. Table 2 shows the subjects surveyed and prevalence rates of hypertension, mean systolic blood pressure (SBP), diastolic BP (DBP), body mass index (BMI), rate of overweight (BMI $\geq$ 25) and mean SpO_2 in different age groups among male and female of total Ladakh region. We found 37.0% crude prevalence rate in total Ladakh population of both male and female. Prevalence rates of hypertension, mean SBP and DBP increased significantly with aging in both male and female. Upto the age of 60 years, males tend to have higher blood pressure than females, however above 60 years women catch up and there become no significant difference between male and female. The prevalence of overweight was highest (28.5%) in the 40-49 age group and males had higher prevalence rate of overweight than females upto 75 years. Mean SpO_2 decreased significantly with aging in both male and female.

Table 3 shows the crude and age-standardized prevalence rate of hypertension, mean SBP, DBP, BMI, overweight (%) and SpO_2 in seven subdivisions in Ladakh region in each age group. As the mean age were different among the subjects of the seven subdivisions (ANOVA; $p<0.0001$), age-standardized prevalence rates were calculated.

Leh town subdivision, which is inhabited by urban population have highest crude prevalence rate of hypertension (43.4%) with age-standardized prevalence rate (45.5%) than any other subdivisions comprising of rural population (Crude; 24.3-39.1, Age-Standardized; 24.6-36.8) (ANOVA, $p<0.0001$). Especially in the younger age group of 40-59 years, the prevalence of hypertension was extremely highest in Leh town (41.6 %) compared with other rural subdivisions (19.6- 30.7 %) (ANOVA, $p<0.0001$). Also in the old population above 60 years the prevalence of hypertension was highest in Leh town (61.7 %) compared with other rural subdivisions (34.1- 56.0 %)(ANOVA, $p=0.0001$). There was no significant difference in prevalence of hypertension in the young age group of 20-39 among the seven subdivisions (ANOVA; ns). Prevalence rates of hypertension, mean SBP and DBP increased with aging in the all subdivisions significantly (ANOVA, $p=0.0017\sim p<0.0001$) except for Kargil subdivision. Mean BMI and prevalence of overweight (BMI > 25) were highest in the middle age group of 40-59 in Leh town subdivision. SpO_2 showed decrease significantly with age in almost all the subdivisions.

Table 4 shows the prevalence rate of hypertension in different altitude levels in each age group. Upto the altitude of 4000 m, prevalence of hypertension rose with altitude and the subjects surveyed at altitude ranging 3500-3999m had highest prevalence rate of hypertension (40.8%)

than the other altitude range in the all subjects (ANOVA, p<0.0001). But in the age group of 20-59, people at altitude ranging 3000-3499m had higher prevalence rate of hypertension than the others. While In the age group above 60 years, upto the altitude of 5000 m prevalence rate of hypertension rose with altitude, and people at altitude ranging 4000-4499m had highest prevalence rate of hypertension (56.7%)(ANOVA, p=0.0094).

Table 5 shows the prevalence rate of hypertension in different altitude levels in each subdivision. In the only Sham subdivision, where altitude ranging is as wide as 2700-3900m, the prevalence rate of hypertension increased (29.1, 36.2, 46.4 %, p=0.0067) in accord with the elevation of altitude (2500-2999, 3000-3499, 3500-3999 m) in spite of the decrease in overweight (23.3, 18.9, 12.6%, p=0.040) with the altitude. In the other subdivisions there was no difference in the prevalence rate of hypertension among different altitudes.

Table 6 shows the prevalence rate of hypertension and overweight in people with different occupation in each age group. In the age group of 40-59 years sedentary workers had the highest prevalence of hypertension (48.3%) and obesity (43.9%), while nomads (hypertension/ obesity; 19.6%/ 22.5%) and manual labors (11.3%/ 20.8%) had lower prevalence compared with other workers (27.3-36.1%/ 20.1-61.1%) (ANOVA, p<0.0001). In the other age groups there was no significant difference in the prevalence of hypertension among different occupations.

Table 7 shows the prevalence of hypertension and overweight comparing among dwellers in rural areas and Leh town and rural-to-urban migrants. The prevalence of hypertension and overweight were highest in Tibetan migrants settled in Leh (hypertension/ overweight;

48.5%/42.3%) followed by Ladakhi migrants (47.2%/ 34.0%), Tibetans born in Leh (42.4%/ 32.4%) and other Ladakhi (almost born in Leh with some migrantas from non-Changthang areas) (40.7%/ 29.4%) compared with rural Ladakhi (33.9-34.5%/ 15.3-19.0%). The lowest prevalence of hypertension was shown in Tibetan nomads (19.7 %/ 38.2%) living at higher altitude (4000-4900m). The percentage of engagement in occupation were shown in each subject group.

The effect of altitude, occupation and rural-to-urban migration to hypertension were analysed in the all subjects by multiple logistic regression adjusted with age, sex and overweight in model 1-4 (Table 8). In model 1, the altitude range of 3000-3499 (odds ratio; 1.76) and 3500-3999 (odds ratio; 1.41) were significantly associated with high prevalence of hypertension compared with 2500-2999 (m) adjusted with age, sex and obesity. But the higher range of 4000-4499 or 4500- were not associated with prevalence of hypertension. In model 2, altitude (odds ratio; 1.32 for 1000 m elevation) and occupation were independently associated with the prevalence of hypertension adjusted with age, sex and overweight. Sedentary worker had the highest association (odds ratio; 3.48) followed by no job (2.44), farmer (2.32) and Retired sedentary worker (2.25) compared with nomad. In model 3, altitude became not significant with the confounding factor of migration. Rural-to-urban migration (odds ratio; Tibetan: 4.48 / Ladakhi: 5.57) and dwelling in Leh town (odds ratio; Tibetan: 10.75 / Ladakhi: 5.11) were significantly associated with high prevalence of hypertension compared with Tibetan native living in Changthang. In model 4, some occupations, rural-to-urban migration and dwelling in Leh town were significantly associated with hypertension but altitude was not significantly associated with hypertension adjusted with age, sex and overweight.

Discussion

In the current study, we found that the one third of the population is on higher risk of hypertension. As table 2 shows prevalence of hypertension tend to increase with age in both gender. Average systolic and diastolic blood pressure in men less than 60 years-of-age was found to be higher than in age-matched women. This is consistent with prevalence of adult hypertension in US population[6], in south Indian Chennai urban population study[7] and rural and urban communities of Rajasthan.[8] After 60 years blood pressure is found to be on the higher side (not significant) in women compared to men. This may be due to hormonal changes in females during this age,[9] which neglects the altitude effect on hypertension in females. This may be also due to the effect of obesity, as the prevalence of overweight in male was higher in people under 75 years compared with female. Epidemiology of hypertension on the Tibetan plateau carried out by Sun and shinfu[4] however reports a higher prevalence of hypertension in females in all age group. This difference of result might be influenced by the difference of the subjects, such as sample size of much more female representation at all age group and the possible difference of the rate of obesity not shown in this report.

Though age-standardized prevalence of hypertension in Leh block (30.7%) was not higher compared with other rural areas (24.6-36.8%), higher prevalence of hypertension in Leh town (45.5%) and higher prevalence of overweight in both Leh block (32.7%) and Leh town (33.6 %) were found compared with other rural areas (overweight; 7.8-20.2%). The high prevalence of overweight may be brought about because Leh block is somehow a developed subdivision than the others in this study. Urbanisation can change the life style of the people and their diet habits,

which may result in obesity and high prevalence of hypertension. Dietary quantity intake assessed by our nutritionist (Y.K) by 24 hour recall method showed that energy intake was higher in Leh town (2305 Kcal in men and 1933 kcal in women) as compared to higher altitude at Changthang (2029 Kcal in men and 1802 kcal in women). Food diversity as assessed by 11-item food diversity score Kyoto was higher in Leh (6.7±1.8) as compared to higher altitude Changthang (6.1 ±1.5).[10,11] Economic conditions, traditional food culture, harsh environment with limitation of resources affects energy intake and food diversity. In urban Leh and Leh block, economic condition of the population is better. Bread, mutton, rice, pulses, vegetables, Thugpa, and eggs forms top seven of the 11-item dietary food diversity, with snacks of sweet tea, biscuits, sweet and salt containing fast food. Such a diet increases their calories resulting in high BMI and increases their salt intake contributing to the higher prevalence of hypertension. One of the village in Leh block, Stok was a study centre in the Indian component of Intersalt study[12], an international study to determine the relationship of blood pressure with dietary ingredients particularly sodium and potassium. Urinary sodium [means (and SD) calculated for men aged 20-39, men aged 40-59, women aged 20-39, and women aged 40-59 and then averaged over age and sex groups] was 203.7 mmol/24 hour (75.0) and urinary potassium was 47.0 (19.2) mmol/24 hours with poor potassium sodium ratio. Although the data are that of 1988, there is every reason to surmise that the situation persists as condition of socio-economic improvement without parallel improvement in health awareness prevails even today.

Domkhar valley in sham subdivision situated along the Domkhar stream is about 25 km long and divided into three hamlets of different altitudinal contour and diversified environment. Paba, rice, bread ,thukpa, sku, kholak, and local beverage chang are their top seven of the 11-item

diverse food. Meat is rarely available. Fresh fruit are plenty in lower Domkhar and at some places at middle Domkhar, but none at upper Domkhar due to its high altitude location (Altitude 3800m). Prevalence of hypertension is very high here (39.1%) among the rural subdivisions. Especially prevalence of hypertension in Sham subdivision was as high as Leh town in the old age group above 60 years (Sham:56.0% vs Leh town: 61.7%) and in the higher altitude level of 3500-3999 (Sham:46.4%, Leh town: 43.5%) in spite of much lower rate of overweight in Sham (17.1%) compared with Leh town (33.6%). Different from people in Leh block subdivision, people in Sham had much poor availability of foods for a long time until recently and they may have vulnerability to the recent quick change of dietary habit especially in older people and those dwelling at remote area of higher altitude. We showed the high prevalence of impaired glucose tolerance (35%) in old people in Domkhar compared with Tibetan people in Qinghai, China in the previous report. We also suggested that there may be a vulnerability to glucose intolerance brought on by recent changes in lifestyle in people with long-term backgrounds of economically traditional lifestyles with limited food resource. [13]

Mutton, rice, momo (mutton), thukpa (comprising of Atta, vegetable mostly dry and dry cheese) kholak (Barley flour with local tea) and paba (A mix of baley flour,wheat flour and grounded pea cooked in plain water with salt added to taste) forms the top seven of the 11-item food diversity of Changthang population in both Ladakhi and Tibetan. Taking snackes is not in their food culture nor are modern snack items available at that remote high altitude region. Relatively lower prevalence of hypertension in Changthang Tibetan natives (19.7%) and Changthang Ladakhi (34.5%) living at higher altitude (4000-4900m) therefore clearly indicates that altitude do not play a major role in causation of hypertension.

Zanskar subdivision located at an intermediate high altitude (3500-3900m) has a population mainly concerned with farming and cattle rearing. Butter tea, local beverage chang, Thugpa, barley flour kholak, rice, pulses, and rarely meat forms the seven of the 11-item diverse food. Fresh vegetable and fruits are usually not available in Zanskar as well as in Changthang. The crude prevalence of hypertension in Zanskar appears to be high (36.3%) but age-standardized prevalence (32.1%) was the same as other rural areas, as the mean age was highest in Zanskar (Table 3).

Modernized sedentary workers, Ladakhi migrants, Tibetan migrants, and Tibetans in Leh town population (Altitude 3300m-3600m) had higher prevalence of hypertension and increased BMI as compared to rural population. Previous reports support our hypothesis of highlanders' vulnerability to hypertension by socioeconomic globalization. A higher prevalence of hypertension was reported in Tibetans compared with immigrant Hans in the Tibetan plateau with the prevalence greater in the urban population around Lhasa than in the rural population.[4] In another report a longitudinally survey was carried out in the prevalence of hypertension in people over 15 years in different ethnic groups in China in 1991 and 2002. The prevalence of hypertension in Tibetan people increased from 17.8% to 24.7%, which was the highest compared with other seven ethnic groups including Han (from 11.3% to 16.2%).[13] Blood pressure in 332 highlanders in Leh (13–81 years old, mean 50 years) was compared with those in U town, Hokkaido, Japan (24–79 years, mean 56.8) in 2004. Higher diastolic blood pressure and a larger increase in blood pressure with age were shown in people living at a high altitude, as compared with Japanese living at a low altitude.[14] Younger people, but not adults and elderly people,

among Tibetan immigrants from Leh to the lowlands in India were reported to have higher blood pressure compared with those living in the highlands. Measurements of adiposity had a significant effect on BP.[16] The prevalence of hypertension was higher (72.7%) in Tibetan highlanders in Shangrila (Alt: 3300 m) compared with lowlanders in Jing Hong (57.0%) and Tosa (59.9%). There was a significant association between living in an urban area with a higher prevalence of hypertension and obesity in younger people under 60 years compared with those living in a rural area.[17] Younger people may be more vulnerable to hypertension by quick modernized lifestyle change. Also in our report the higher prevalence of hypertension in Leh town (44.7%) were shown especially in middle-aged group of 40-59 years compared with other areas (19.6-30.7%). Tibetan people born in Leh had very high prevalence of hypertension in spite of younger age (40.2 years).

The limitation of this paper is that it did not look into the genetic factors, as both environmental and genetic factors may contribute to regional and racial variation of blood pressure and prevalence of hypertension. The strength of this study is that it looked into most of the environmental factors known to influence hypertension in population of different distinct geographical subdivisions of high altitude region. This study showed the influence of aging, overweight, modernized sedentary occupation, and rural-to-urban migration to hypertension with the confounding factor of altitude by multivariate analysis.

The conclusion reached is that like everywhere else in the world, hypertension prevalence in high altitude population has multifactorial aetiology. Our study shows that age, gender, socio-

economic factors, diet, culture, race and changing life style plays major role than altitude in prevalence of hypertension.

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Legend of the figure and tables

Figure 1. Map of Ladakh Region showing all the subdivisions

Table 1. Characteristics of the subdivisions

MSL, mean sea level

Table 2. Prevalence of hypertension, overweight and mean SpO_2 in different age groups among male and female

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; SpO_2, percutaneous oxygen saturation.

p; Chi square test for the comparison of the prevalence of hypertension and BMI $\geq$ 25 (%) among the 4 age groups, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 4 age groups.

#; p<0.10, *; p<0.05, **;p<0.01, ***; p<0.001, ****; p<0.0001:Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) between male and female, and ANOVA for the comparison of mean of SBP, DBP, BMI and SpO_2 between male and female.

Table 3. Prevalence of hypertension, mean SBP, DBP, BMI, overweight (%) and SpO_2 in different age groups in each subdivision

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 age groups in each subdivision, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 4 age groups in each subdivision.

Table 4. Prevalence of hypertension and overweight in different altitude levels in each age group

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 5 altitude groups, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 5 altitude groups.

Table 5. Prevalence of hypertension and overweight in different altitude levels in each subdivision

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the altitude groups.

Table 6. Prevalence of hypertension and overweight in people with different occupation in each age group.

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the occupation groups.

Table 7. Prevalence of hypertension and overweight comparing among dwellers in rural areas and Leh town and rural-to-urban migrants.

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the seven groups, and ANOVA for the comparison of mean age among the seven groups.

Table 8. The effect of altitude, occupation and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

Model 1: The effect of altitude to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

Model 2: The effect of altitude and occupation to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

Model 3: The effect of altitude and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

Model 4: The effect of altitude, occupation and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

Table 1. Characteristics of the subdivisions

Urban/ Rural	Subdivision	Altitude (meters above MSL)	Livelihood
Urban	Leh town (including colonies of migrants)	3300-3600m	Urban life style
Rural	Leh block villages	3000-3700m	Farmer
	Nubra	2600-3000m	Farmer
	Kargil (Panikhar and parkachik)	2600-3100m	Farmer
	Sham	2700-3900m	Farmer
	Zanskar	3500-3900m	Farmer and cattle rearing
	Changthang	4000-4900m	Livestock rearing nomads

MSL, mean sea level

Table 2. Prevalence of hypertension, overweight and mean SpO_2 in different age groups among male and female

	Age Group (years)					
	20-39	**40-59**	**60-74**	**75-**	p	**Total**
Male (n)	217	489	396	138		1240
Female (n)	288	709	448	115		1560
Total (n)	505	1198	844	253		2800
Hypertension (%)						
Male	18.4#	34.2#	48.2	63.8	<0.0001	39.2*
Female	12.5	29.8	50.4	67.0	<0.0001	35.3
Total	15.1	31.6	49.4	65.2	<0.0001	37.0
SBP (mmHg)						
Male	122.2±14.3****	127.7±18.0*	138.9±22.6	149.0±26.1	<0.0001	132.7±21.7***
Female	116.0±14.2	125.3±19.5	138.8±25.5	153.7±32.8	<0.0001	129.5±24.2
Total	118.7±14.5	126.3±18.9	138.8±24.2	151.1±29.4	<0.0001	130.9±23.2
DBP (mmHg)						
Male	78.5±11.4#	83.4±12.5***	85.2±12.8	87.5±14.2	<0.0001	83.6±12.9***
Female	76.4±11.9	80.9±12.0	84.5±14.9	88.4±17.3	<0.0001	81.7±13.7
Total	77.3±11.7	81.9±12.3	84.9±14.0	87.9±15.7	<0.0001	82.5±13.4
BMI						
Male	22.4±3.2***	23.3±3.6*	23.2±3.4****	22.4±3.4	0.0017	23.0±3.5****
Female	21.4±3.3	22.8±3.7	22.1±3.7	22.1±3.7	<0.0001	22.3±3.7
Total	21.8±3.3	23.0±3.7	22.6±3.6	22.3±3.5	<0.0001	
BMI ≥ 25 (%)						
Male	22.6*	31.7*	28.4**	19.6	0.0098	27.7***
Female	14.6	26.2	19.5	20.9	0.0003	21.8
Total	18.0	28.5	23.6	20.2	<0.0001	
SpO_2 (%)						
Male	90.8±4.4*	90.4±4.6	89.1±5.3**	89.0±5.4**	<0.0001	89.9±5.0#
Female	91.6±3.6	90.3±4.8	87.7±6.4	86.6±6.5	<0.0001	89.5±5.0
Total	91.2±4.0	90.4±4.7	88.3±5.9	87.9±6.0	<0.0001	

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; SpO_2, percutaneous oxygen

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 age groups, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 4 age groups.

#; p<0.10, *; p<0.05, **;p<0.01, ***; p<0.001, ****; p<0.0001:Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) between male and female, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 between male and female.

Table 3. Prevalence of hypertension, overweight and mean SpO_2 in different age groups in each subdivision

	Age Group (years)				
	20-39	40-59	60-	p	Total
Leh (n=1002) (mean 51.9±15.5 years)	n=223	n=447	n=332		
Hypertension,% (Age-Standardized Prevalence Rate,%)	19.7	41.6	61.7	<0.0001	43.4 (45.5)
SBP	120.2±15.8	130.0±17.9	146.7±24.7	<0.0001	133.3±22.4
DBP	79.8±12.5	85.8±11.7	88.4±14.0	<0.0001	85.3±13.1
BMI	22.1±3.4	24.1±3.8	23.4±4.1	<0.0001	23.4±3.9
BMI ≥ 25 (%)	20.6	40.7	32.6	<0.0001	33.6
SpO_2 (%)	92.3±3.1	91.7±2.9	89.8±5.1	<0.0001	91.2±3.9
Leh block (n=349) (mean 55.6±16.1 years)	n=60	n=127	n=162		
Hypertension,% (Age-Standardized Prevalence Rate,%)	6.7	22.0	51.2	<0.0001	33.0 (30.7)
SBP	115.5±11.6	121.6±17.0	139.6±22.9	<0.0001	128.9±21.9
DBP	76.1±10.8	79.4±10.4	83.1±12.9	<0.0001	80.5±12.0
BMI	22.5±3.6	23.4±3.4	23.2±3.6	ns	23.1±3.6
BMI ≥ 25 (%)	30.0	34.6	32.1	ns	32.7
SpO_2 (%)	90.1±5.1	90.9±4.4	89.4±5.3	0.035	90.0±5.0
Nubra (n=247) (mean 50.5±15.5 years)	n=78	n=88	n=82		
Hypertension,% (Age-Standardized Prevalence Rate,%)	11.5	29.5	41.5	0.0001	27.8 (31.0)
SBP	116.8±14.0	127.6±19.3	139.7±25.9	<0.0001	128.2±22.3
DBP	75.2±10.5	82.5±10.5	84.5±14.4	<0.0001	80.9±12.5
BMI	21.2±2.8	22.0±3.2	21.4±3.2	ns	21.6±3.1
BMI ≥ 25 (%)	9.0	17.0	14.6	ns	13.4
SpO_2 (%)	91.6±2.9	90.3±5.1	88.8±4.7	0.0003	90.2±4.5
Kargil (n=115) (mean 51.9±13.5 years)	n=25	n=46	n=44		
Hypertension,% (Age-Standardized Prevalence Rate,%)	16	19.6	34.1	ns	24.3 (24.6)
SBP	119.4±15.5	124.2±23.7	129.8±21.4	ns	125.3±21.5
DBP	74.2±10.8	74.0±12.6	77.1±11.6	ns	75.2±11.8
BMI	21.3±3.3	19.6±2.9	21.0±2.9	0.028	20.5±3.1
BMI ≥ 25 (%)	16.0	2.2	9.1	0.108	7.8
SpO_2 (%)	93.4±2.4	92.2±4.1	90.7±6.9	0.107	91.9±5.1
Sham (n=451) (mean 56.2±13.8 years)	n=62	n=189	n=200		
Hypertension,% (Age-Standardized Prevalence Rate,%)	9.7	30.7	56.0	<0.0001	39.1 (36.8)
SBP	115.8±12.5	124.1±19.9	140.2±24.8	<0.0001	130.1±23.3
DBP	75.6±11.5	83.0±12.4	87.7±14.1	<0.0001	84.1±13.6
BMI	21.2±2.8	22.1±3.2	21.9±3.2	ns	21.9±3.1
BMI ≥ 25 (%)	11.3	19.6	16.6	ns	17.1
SpO^2 (%)	91.0±3.9	90.3±4.2	87.9±5.4	<0.0001	89.3±4.9
Zanskar (n=284) (mean 59.5±12.8 years)	n=10	n=115	n=159		
Hypertension,% (Age-Standardized Prevalence Rate,%)	20.0	25.2	45.3	0.0017	36.3 (32.1)
SBP	126.1±14.3	122.7±20.7	138.4±29.4	<0.0001	131.6±26.8
DBP	78.6±19.3	76.8±11.9	83.3±15.8	0.0009	80.5±14.5
BMI	23.3±4.3	21.8±2.7	22.0±2.8	ns	22.0±2.8
BMI ≥ 25 (%)	30.0	13.9	13.8	ns	14.4
SpO_2 (%)	93.9±2.7	88.6±6.2	85.5±7.3	<0.0001	87.1±7.0
Changthang (n=351) (mean 52.9±13.6 years)	n=47	n=186	n=118		
Hypertension,% (Age-Standardized Prevalence Rate,%)	14.9	22.6	51.7	<0.0001	31.3 (32.6)
SBP	120.2±13.7	124.8±17.7	143.0±29.6	<0.0001	130.3±23.7
DBP	74.1±10.3	78.0±12.0	84.3±14.9	<0.0001	79.6±13.3
BMI	21.6±2.9	22.9±3.9	22.3±3.5	0.077	22.5±3.6
BMI ≥ 25 (%)	12.8	24.7	16.1	0.074	20.2
SpO_2 (%)	85.8±3.8	87.5±6.1	85.4±6.1	0.0076	86.5±5.9

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 age groups in each subdivision, and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 4 age groups in each subdivision.

Table 4. Prevalence of hypertension and overweight in different altitude levels in each age group

	Altitude (meters above MSL)					
	2500-2999	**3000-3499**	**3500-3999**	**4000-4499**	**4500-4999**	**p**
All						
n	417	428	1604	174	177	
Hypertension (%)	27.1	37.2	40.8	30.5	32.2	<0.0001
SBP	126.3±21.6	128.9±19.9	132.8±24.0	129.7±23.9	130.9±23.8	<0.0001
DBP	80.8±12.2	83.5±13.1	83.3±13.7	80.0±13.7	79.2±12.8	<0.0001
BMI	21.8±3.1	22.7±3.7	22.8±3.6	22.4±3.6	22.6±3.7	<0.0001
BMI ≥ 25 (%)	16.6	25.0	27.1	20.1	20.3	<0.0001
SpO_2	90.2±4.7	90.6±4.2	90.0±5.2	86.1±5.8	87.0±6.2	<0.0001
20-39 years						
n	119	128	211	30	17	
Hypertension (%)	10.1	22.7	13.3	10.0	23.5	0.038
BMI ≥ 25 (%)	11.8	17.2	23.2	6.7	23.5	0.039
40-59 years						
n	155	197	660	77	109	
Hypertension (%)	27.1	40.6	32.4	15.6	27.5	0.0008
BMI ≥ 25 (%)	20.6	32.5	30.2	28.6	22.0	0.052
60- years						
n	143	103	733	67	51	
Hypertension (%)	41.3	48.5	56.2	56.7	45.1	0.0094
BMI ≥ 25 (%)	16.2	20.4	25.5	16.4	15.7	0.040

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 5 altitude groups and ANOVA for the comparison of means of SBP, DBP, BMI and SpO_2 among the 5 altitude groups.

Table 5. Prevalence of hypertension and overweight in different altitude levels in each subdivision

	Altitude (meters above MSL)					
	2500-2999	**3000-3499**	**3500-3999**	**4000-4499**	**4500-4999**	**p**
Leh (3300-3600m)						
n		189	813			
Hypertension (%)		42.9	43.5			ns
BMI ≥ 25 (%)		32.8	33.7			ns
Leh block (3000-3700m)						
n		49	300			
Hypertension (%)		28.6	33.7			ns
BMI ≥ 25 (%)		40.8	31.3			ns
Nubra (2600-3000m)						
n	248					
Hypertension (%)	27.8					
BMI ≥ 25 (%)	13.7					
Kargil (2600-3100m)						
n	52	63				
Hypertension (%)	19.2	28.6				ns
BMI ≥ 25 (%)	15.4	1.6				0.0061
Sham (2700-3900m)						
n	117	127	207			
Hypertension (%)	29.1	36.2	46.4			0.0067
BMI ≥ 25 (%)	23.3	18.9	12.6			0.040
Zanskar (3500-3900m)						
n			284			
Hypertension (%)			36.3			
BMI ≥ 25 (%)			14.4			
Changthang (4000-4900m)						
n				174	177	
Hypertension (%)				30.5	32.2	ns
BMI ≥ 25 (%)				20.1	20.3	ns

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the altitude groups.

Table 6. Prevalence of hypertension and overweight in people with different occupation in each age group.

	20-39 years			40-59 years			60- years		
	n	Hypertension (%)	BMI ≥ 25 (%)	n	Hypertension (%)	BMI ≥ 25 (%)	n	Hypertension (%)	BMI ≥ 25 (%)
Farmer	46	16.7	7.1	206	27.3	20.1	371	54.4	15.7
Housewife	155	11.2	16.1	407	28.7	23.2	341	52.7	19.6
Manual labor	1	0	0	56	11.3	20.8	10	33.3	11.1
Monk	47	4.7	30.2	38	36.1	61.1	86	55.1	48.7
No job	40	13.5	16.2	27	36	36.0	81	60.8	34.2
Nomad	4	0	25	147	19.6	22.5	66	43.3	15.0
Retired sedentary	1	0	0	30	35.7	35.7	68	53.2	33.9
Sedentary	211	19.5	19.1	286	48.3	43.9	75	45.6	40.3
p		ns	ns		<0.0001	<0.0001		ns	<0.0001

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the occupation groups.

Table 7. Prevalence of hypertension and overweight comparing among dwellers in rural areas and Leh town and rural-to-urban migrants.

	Rural areas			Urban: Leh town				
	Changthang		Others	Migrants from Changthang		Born in Leh	Others #	
	Tibetan	Ladakhi	Ladakhi	Tibetan	Ladakhi	Tibetan	Ladakhi	
n	76	275	1447	266	53	170	513	p
age (years)	54.2±11.7	52.5±14.2	55.4±14.8	58.8±12.1	55.0±12.7	40.2±9.9	51.9±16.5	<0.0001
Hypertension (%)	19.7	34.5	33.9	48.5	47.2	42.4	40.7	<0.0001
BMI ≥ 25 (%)	38.2	15.3	19.0	42.3	34.0	32.4	29.4	<0.0001
Occupation (%)								
Nomad	89.5	50.6	0	0.8	3.8	0	0.3	
Farmer	1.3	27.3	35.2	1.1	0	0	9.1	
Housewife	9.2	10	41.8	31.4	17	11.8	31.2	
Manual labor	0	0	0	17.8	18.9	0	1.3	
Monk	0	5.2	8.4	0.4	0	0	7.17	
Sedentary	0	5.2	9.4	22.3	49.1	87.1	34.2	
Retired sedentary	0	0	3.2	1.9	1.9	0	9.1	
No job	0	1.6	1.8	24.2	9.4	1.2	8	

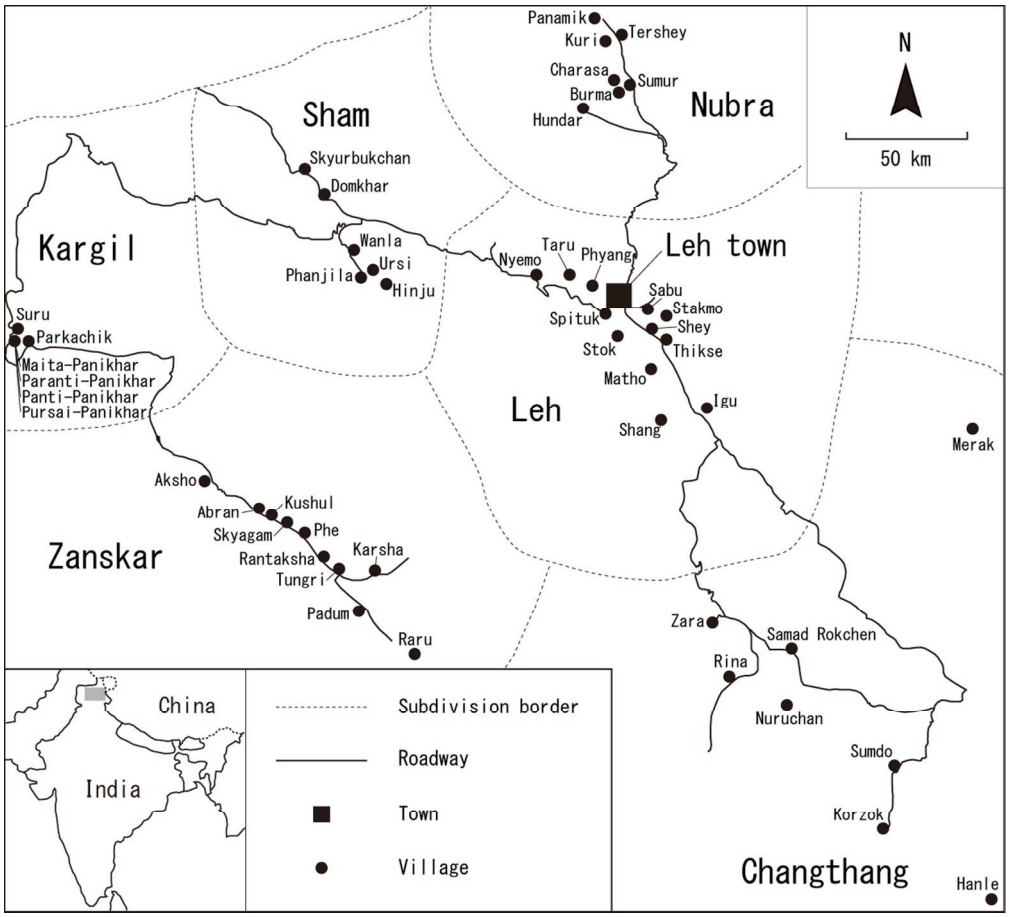
Others #; Almost born in Leh with some migrants from non-Changthang areas

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the seven groups, and ANOVA for the comparison of mean age among the seven groups.

Table 8. The effect of altitude, occupation and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.

	Model-1			Model-2			Model-3			Model-4		
	Odds ratio	Confidence interval	p	Odds ratio	Confidence interval	p	Odds ratio	Confidence interval	p	Odds ratio	Confidence interval	p
Male	1.03	0.87-1.21	ns	1.01	0.81-1.27	ns	1.03	0.87-1.22	ns	1.08	0.86-1.36	ns
BMI ≥ 25	2.58	2.13-3.11	<0.0001	2.58	2.12-3.15	<0.0001	2.52	2.08-3.06	<0.0001	2.54	2.07-3.12	<0.0001
Age (years)												
20-39	1.00											
40-59	2.42	1.83-3.21	<0.0001	2.89	2.13-3.91	<0.0001	2.81	2.10-3.77	<0.0001	3.07	2.24-4.21	<0.0001
60-74	5.64	4.23-7.53	<0.0001	6.71	4.88-9.24	<0.0001	6.97	5.13-9.47	<0.0001	7.32	5.23-10.24	<0.0001
75-	11.35	7.86-16.39	<0.0001	13.11	8.82-19.48	<0.0001	14.01	9.56-20.53	<0.0001	13.93	9.23-21.03	<0.0001
Altitude												
2500-2999 (m)	1.00											
3000-3499	1.76	1.28-2.40	0.0005									
3500-3999	1.41	1.09-1.82	0.0088									
4000-4499	1.00	0.67-1.53	ns									
4500-	1.18	0.79-1.78	ns									
Altitude (continuous)												
(/1000 m)				1.32	1.004-1.75	0.047	1.30	0.92-1.83	ns	1.24	0.85-1.81	ns
Occupation												
Nomad				1.00						1.00		
Farmer				2.32	1.45-3.70	0.0005				2.01	1.18-3.40	0.0096
Housewife				2.21	1.35-3.63	0.0017				1.77	1.02-3.10	0.043
Manual labor				0.75	0.32-1.75	ns				0.40	0.16-0.02	0.055
Monk				1.68	0.95-2.99	0.076				1.35	0.72-2.53	ns
Sedentary worker				3.48	2.13-5.68	<0.0001				1.87	1.05-3.32	0.033
Retired sedentary worker				2.25	1.19-4.25	0.012				1.56	0.78-3.13	ns
No job				2.44	1.36-4.39	0.0028				1.46	0.74-2.87	ns
Migration												
Tibetan in Changthang							1.00			1.00		
Ladakhi in Changthang							3.24	1.69-6.20	0.0004	2.62	1.32-5.18	0.0057
Ladakhi in other rural areas							3.50	1.69-7.23	0.0007	1.94	0.86-4.42	ns
Ladakhi in Leh							5.11	2.50-10.45	<0.0001	3.04	1.34-6.91	0.0081
Ladakhi migrant to Leh							5.57	2.27-13.65	0.0002	4.13	1.52-11.26	0.0055
Tibetan migrant to Leh							4.48	2.15-9.34	<0.0001	3.31	1.41-7.77	0.0059
Tibetan born in Leh							10.75	4.83-23.94	<0.0001	6.03	2.42-15.03	0.0001

Model 1: The effect of altitude to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.
Model 2: The effect of altitude and occupation to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.
Model 3: The effect of altitude and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.
Model 4: The effect of altitude, occupation and rural-to-urban migration to prevalence of hypertension by multiple logistic regression analysis adjusted with age, sex and overweight.



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Prevalence of hypertension at high altitude: cross sectional survey in Ladakh, Northern India 2007-2011.

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Abstract

Objective: This population-based cross-sectional epidemiological study was aimed to determine the prevalence of hypertension and its relation to wide-ranged altitude (2600-4900m) of hypoxic environment and lifestyle change in a widely dispersed (45110 square kilometre) representative group of Ladakhi in Northern India.

Methods: 2800 subjects (age 20-94 years) were enrolled. Systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure of ≥90 mm Hg and/or taking current anti-hypertensive medicine was defined as hypertension. Height and weight for body mass index and SpO_2 were examined. The rural population comprised of six subdivisions with distinct altitude, dietary and occupational pattern. Subjects in the urban area of Leh consist of two groups, i.e. migrants settled in Leh from Changthang nomadic area, and dwellers born in Leh. Their prevalence of hypertension were compared with the farrmers and nomads in rural areas. The effect of aging, hypoxia, dwelling in high-altitude, obesity, modernized occupation, dwelling in urban area, and rural-to-urban migration to hypertension were analysed by multiple logistic regression.

Results: The prevalence of hypertension was 37.0 % in the all subjects and highest in migrants settled in Leh (48.3 %) followed by dwellers born in Leh town (41.1%) compared with rural areas (33.5%). The prevalence of hypertension in nomads (all: 27.7 %, Tibetan/ Ladakhi: 19.7/ 31.9 %)) living at higher altitude (4000-4900m) were relatively low. The associated factors with hypertension were aging, overweight, dwelling at higher altitude, engagement in modernized sedentary occupation, dwelling in urban area, and rural-to-urban migration. The effect of lifestyle change and dwelling at high-altitude were independently associated with hypertension by multivariate analysis adjusted with confounding factors.

Conclusions: Socio-economic and cultural factors play big role with the effect of high altitude itself on high prevalence of hypertension in highlanders in Ladakh.

Strengths and limitations of this study

▪This study examined most of the socio-economic environmental factors known to influence hypertension in population of different distinct geographical subdivisions of high altitude region. Though we did not carry out the nutritional survey in the all subjects but overweight was a decisive factor for hypertension according to lifestyle change.

▪This study showed the influence of aging, overweight, modernized sedentary occupation, and rural-to-urban migration and dwelling in urban area to hypertension as well as the effect of altitude by multivariate analysis.

▪ This study did not look into the genetic factors, as both environmental and genetic factors may contribute to regional and racial variation of blood pressure and prevalence of hypertension.

Introduction

Systemic arterial hypertension at high Altitude has evoked great interest amongst high altitude researchers as well as in sojourners and natives. There have been conflicting reports with investigators generally reporting slight increase in the blood pressure level soon after arrival at high altitude[1,2] and investigators reporting no such change[3,4] or decrease followed by increase. [5,6] There is no standard way of treating hypertension at high altitude for sojourners till now.[7,8] Similar contradictory views also exist between the investigators of the two high altitude continents regarding the blood pressure status of the high altitude natives. Studies done in Spiti India (4000m) shows lower prevalence of hypertension.[9] Andean residents are reported to have low prevalence of hypertension[1,10,11] while prevalence of hypertension in Tibet Lhasa was found to be higher than Han migrants residing in Tibet.[12] Recent report showed prevalence of hypertension were higher in Tibetan highlanders[13,14] than that of Chinese lowlanders.[15]

The risk of developing hypertension may depend on socio-economic factors, geographic and racial differences. It is in the backdrop of this difference in opinion that we planned this study in Ladakh, one of the highest inhabited regions in northen most part of India. The population of the two districts of Ladakh (Leh and Kargil) was about 270,000 (Leh: 130,000, Kargil: 140,000) in 2011 by Census. [16] 77% of the population in Leh are Buddhist and 80% of the Kargil population are Muslim. Spread over 45110 sq km, sandwiched between

Karakorum in the North and Trans-Himalaya in the south and 80% comprising of rural population with many villages high up in the mountains remaining inaccessible during winter, logistics for conducting a comprehensive epidemiological study representative of the whole population is formidable. The purpose of the study is twofold. One, to determine the prevalence of hypertension in different geographical subdivisions of this widely dispersed high altitude district (from median high 2500~ to very high ~4500 m) and second which factors among the altitude, occupation, socio-economic, and lifestyle play predominant role in association with hypertension.

Methods

This cross-sectional epidemiological study was carried out from 2007 to 2011. A total of 2800 subjects aged between 20 to 94 years were examined. Figure 1 shows the map of Ladakh region showing all the villages in the subdivisions where the study was conducted. Two-stage stratified sampling method was used to select a representative sample of the adult population over 20 years of age. The population was first stratified as urban versus rural and then in the rural sector into six geographical areas (Sub-divisions). Each geographical sub-division has different characteristics in altitude, occupation, dietary habits and socio-economic conditions and is separate administrative blocks (Table 1). Migrants from rural population now settled in Leh town subdivision since 1970s were included in the urban population as they have adopted a life style similar to the city dwellers. Tata institute of Social Sciences Mumbay (TISS) and Ladakh Autonomous hill development council (LAHDC) conducted a house to house survey of the total population of Leh (urban population) in 2007 for developing a micro-level planning in the region. [17] Since this census data was the latest, we corrected and used this population survey list (age group 20-90 years) to draw our sample of urban population for the study. The list of 2000 eligible subjects were representative of the age and gender structure of Ladakhi family and they were invited as the volunteered participants to the research center in Leh town. While in the rural villages, announcement was carried out to the all people of age group of 20-90 years of both gender in the collaboration

of health staffs and village leaders. We carried out health checks of the volunteered participants in health centers or community halls in the rural villages.

There were no criteria for exclusion except absentees and critical and terminal illness patients who cannot report to the study centre to complete the study. Subjects in **Leh town subdivision** was classified into two groups, i.e. migrants settled in Leh town from Changthang area, and dwellers in Leh town. The former consisted of Tibetan and Ladakhy nomads. The latter consisted of Tibetan born in Leh, and other Ladakhi people, almost of whom were born in Leh including some migrants from rural areas (non-Changthang).

The rural population was subdivided into six subdivisions as each subdivision had distinct characteristics which could influence the outcome.

Leh block subdivision comprised of nearly 12 villages within 40 km of Leh town at an altitude varying between 3000-3700 meter and their occupation being a mix of farming, service sector and business**. Nubra subdivision** is in the north of Ladakh about 120 kilometres from Leh after crossing Khardong Pass (5400 m) one of the highest motorable road in the world. We studied the population of seven villages here. The subdivision is located on the banks of shyok and Nubra rivers between the Karokoram and Ladakh range of mountains. People are predominantly farmers and the altitude of the valley generally is around 2600- 3000 m. **Kargil subdivision (Panikhar and Parkachik).** This subdivision is a green belt in Kargil District and is a fertile farming area on the Suru river. However fruit trees are not cultivated here. The population is mainly Muslim and the altitude is 2600-3100m. We studied the population of six villages representative of this subdivision. **Sham (Khalse) subdivision** is wide-ranged in altitude (2700-3900m), generally more fertile and many of the villages have fruit tree like apricot, apple, almond. We studied six representative villages in this subdivision. **Zanskar Subdivision** is a remote region on the trans Himalayan range of mountain which remains closed from the rest of the world for 6 months in a year due to heavy snow fall. Though people do farming, yet the harsh weather is not conducive for productive farming. Fresh fruit and fresh vegetable are very meagre here.

People rear cattle which forms their secondary source of income by selling dairy products. Altitude of the subdivision is 3500-3900m. We studied ten villages representative of this subdivision**. Changthang subdivision** is the biggest and highest plateau (Altitude 4000-4900m). The population is generally nomads moving from pasture to pasture every three months along with their cattle, livestock and lives in Yak wool woven tents. Life is very hard for them because of the high altitude and severe cold. Farming is not possible, fresh vegetables and fresh fruits are not available to them throughout the year. Meat, barley flour and local tea are their staple diet. We studied six villages representative of the subdivision.

The occupation was interviewed from all the subjects and classified into four groups; farmer, nomad, sedentary worker and others (housewife, manual labor, monk, retired sedentary worker, and no job). Full-time housewife was ragarded as housewife. Housewife who also work as nomad or farmer was classified as nomad or farmer. People engaged in work closely associated with urban lifestyle are classified into sedentary worker consisting of office worker, business, shop keeper, taxi driver, government officer, travel agent, teacher and so on.

The procedure for obtaining informed consent was approved by Institutional review board of Ladakh institute of prevention and the District ethical committee, Leh, Ladakh and Research Institute for Humanity and Nature, Kyoto, Japan. The participants attended the village medical aid centre or the village community centre. Anthropometric measurement including weight and height were obtained using standard techniques. The body mass index (BMI) was calculated using the formula, weight(kg)/(Height(m))^2. Blood pressure was measured in an arm using an automatic device (HEM 7000; OMRON Life Science Co. Ltd, Kyoto, Japan) based on the cuff oscillometric principle, and its accuracy has been validated in previous studies.[18-20] Oxyhemoglobin saturation (SpO2) was measured by a pulse oximeter (PULSOX-300; KONICA MINOLTA Co. Ltd, Tokyo, Japan). Blood pressure and SpO2 were measured twice after taking at least a 5-minute rest in a sitting position and the mean of systolic blood pressure (SBP), diastolic blood pressure (DBP) and SpO2 were calculated. SBP ≥140 mm Hg and/or DBP of ≥90 mm Hg and/or taking current anti-hypertensive medicine was defined as hypertension.[21] The mean rate of current antihypertensive medication was 2.1 %.

The age of the participants were confirmed with reference to a carefully prepared cross tabulation correlating their date of birth with the animal year which the rural population always remembered and to historical sentinel events in case of elderly subjects.

Statistical analysis

Chi square test, Student's t-test and one-way ANOVA were conducted for the analysis of the prevalence rate of hypertension or overweight (BMI ≥ 25), mean SBP, DBP, BMI and SpO_2. The associations of hypertension with the above confounding factors including altitude, aging, sex, obesity, occupation and dwelling area were analyzed by multiple logistic regression. Hypertension as the dependent variable was defined as SBP ≥140 mm Hg and/or DBP of ≥90 mm Hg and/or taking current anti-hypertensive medicine.[21] SPSS version 17.0 (SPSS Inc., Chicago, IL, USA) was used for the analysis. Statistically significant level was $p< 0.05$.

Results

A total of 2800 subjects aged between 20 to 94 years were examined between 2007 to 2011.

Table 2 shows the characteristics of all variables and those association with hypertension was overviewed. We found 37.0% crude prevalence rate in total Ladakh population of both male and female. Male and older people, and those with overweight had more prevalence of hypertension but SpO2 was not associated with hypertension. Dwelling at altitude of 3000-3999 m had more prevalence of hypertension compared with altitude below 3000 or above 4000 m. People dwelling at urban area had more prevalence of hypertension compared with those in rural areas. Nomad had lower prevalence of hypertension compared with farmer or sedentary worker.

Table 3 shows the subjects surveyed and prevalence rates of hypertension, mean systolic blood pressure (SBP), diastolic BP (DBP), body mass index (BMI), rate of overweight (BMI ≥ 25) and mean SpO_2 according to sex and age groups in Ladakh region. Prevalence rates of hypertension, mean SBP and DBP increased significantly

with aging in both male and female. Upto the age of 60 years, males tend to have higher blood pressure than females, however there become no significant difference between male and female aged 60 years or over. The prevalence of overweight was highest (28.5%) in the 40-59 age group and males had higher prevalence rate of overweight than females upto 75 years. Mean SpO_2 decreased significantly with aging in both male and female.

Table 4 shows the crude and age-standardized prevalence rate of hypertension, and overweight (%) in seven subdivisions in Ladakh region in each age group. As the mean age were different among the subjects of the seven subdivisions (ANOVA; $p<0.0001$), age-standardized prevalence rates were calculated.

Leh town subdivision, which is inhabited by urban population have highest crude prevalence rate of hypertension (43.4%) with age-standardized prevalence rate (45.5%) than any other subdivisions comprising of rural population (Crude; 24.3-39.1, Age-Standardized; 24.6-36.8) (ANOVA, $p<0.0001$). Especially in the younger age group of 40-59 years, the prevalence of hypertension was extremely highest in Leh town (41.6 %) compared with other rural subdivisions (19.6- 30.7 %) (ANOVA, $p<0.0001$). Also in the old population above 60 years the prevalence of hypertension was highest in Leh town (61.7 %) compared with other rural subdivisions (34.1- 56.0 %)(ANOVA, $p=0.0001$). There was no significant difference in prevalence of hypertension in the young age group of 20-39 among the seven subdivisions (ANOVA; ns). Prevalence rates of hypertension increased with aging in the all subdivisions significantly (ANOVA, $p<0.01 \sim p<0.0001$) except for Kargil subdivision. Prevalence of overweight (BMI ≥ 25) were highest in the middle age group of 40-59 in Leh town subdivision.

Table 5 shows the prevalence rate of hypertension in different altitude levels according to age and occupation group. Upto the altitude of 4000 m, prevalence of hypertension rose with altitude and the subjects surveyed at altitude ranging 3500-3999m had highest prevalence rate of hypertension (40.8%) than the other altitude range in the all subjects (ANOVA, $p<0.0001$). But in the age group of 20-59, people at altitude ranging 3000-3499m had higher prevalence rate of hypertension than the others. While In the age group of 60~74 years, upto the

altitude of 4499 m prevalence rate of hypertension rose with altitude, and people at altitude ranging 4000-4499m had highest prevalence rate of hypertension (55.8%)(ANOVA, $p<0.05$). In the age group of 75 years and more, the prevalence of hypertension was highest and there was no difference among altitude levels.

According to occupation group, prevalence of hypertension rose closely with altitude remarkably in agriculture ($p<0.001$), mildly in sedentary worker ($p=0.09$) and insignificantly in nomad.

Table 6 shows the prevalence rate of hypertension in different altitude levels in each subdivision. In the only Sham subdivision, where altitude ranging is as wide as 2700-3900m, the prevalence rate of hypertension increased (29.1, 36.2, 46.4 %, $p=0.0067$) in accord with the elevation of altitude (2500-2999, 3000-3499, 3500-3999 m) in spite of the decrease in overweight (23.3, 18.9, 12.6%, $p=0.040$) with the altitude. In the other subdivisions there was no difference in the prevalence rate of hypertension among different altitudes.

Table 7 shows the prevalence rate of hypertension and overweight in people with different occupation. In the age group of 40-59 years sedentary workers had the highest prevalence of hypertension (48.3%) and obesity (43.9%), while nomads (hypertension/ obesity; 19.6%/ 22.5%) and manual labors (11.3%/ 20.8%) had lower prevalence compared with other workers (27.3-36.1%/ 20.1-61.1%) (ANOVA, $p<0.0001$). In the other age groups there was no or little significant difference in the prevalence of hypertension among different occupations.

Table 8 shows the prevalence of hypertension and overweight comparing among dwellers in rural areas and Leh town and rural-to-urban migrants. The prevalence of hypertension and overweight were highest in migrants settled in Leh (hypertension/ overweight; 48.3%/40.9%) followed by dwelling in Leh town (41.1%/ 30.2%) compared with rural areas (33. 5%/ 15.3-19.3%). The percentage of engagement in occupation were shown in each subject group.

There was the difference in the prevalence of hypertension between Tibetan and Ladakhi nomads. The lowest prevalence of hypertension in spite of higher prevalence of overweight was shown in Tibetan nomads (n=76)

(hypertension/ overweight; 19.7 %/ 39.5%) compared with Ladakhi nomads (n=144) (31.9%/ 10.4%) living at higher altitude (4000-4900m).

The effect of altitude, occupation and dwelling area to hypertension were analysed in the all subjects by multiple logistic regression adjusted with age, sex and overweight in model 1-3 (Table 9). In model 1, the altitude range of 3000-3499 (odds ratio; 1.78) and 3500-3999 (odds ratio; 1.42) were significantly associated with high prevalence of hypertension compared with 2500-2999 (m) adjusted with age, sex and obesity. But the higher range of 4000-4499 or 4500- were not associated with hypertension. In model 2 with further adjustment by occupation, the altitude range of 3000-3499 (odds ratio; 1.62), 3500-3999 (odds ratio; 1.34) and the highest range of 4500- (odds ratio; 2.57) became significantly associated with hypertension. Sedentary worker had the higher association (odds ratio; 1.56) compared with farmer, while nomad had lower association (odds ratio; 0.42). In model 3, with further adjustment by dwelling area, the altitude range of 3000-3499 (odds ratio; 1.44) and the highest altitude range of 4500- (odds ratio; 2.69) kept significant association with hypertension independent of occupation and dwelling area. People dwelling in Leh town (odds ratio; 1.92) and migrants from Changthang (odds ratio; 1.70) were significantly associated with high prevalence of hypertension compared with those dwelling in rural areas.

Discussion

In the current study, we found that the one third of the population is on higher risk of hypertension. As table 3 shows prevalence of hypertension tend to increase with age in both gender. Average systolic and diastolic blood pressure in men less than 60 years-of-age was found to be higher than in age-matched women. This is consistent with prevalence of adult hypertension in US population,[22] in south Indian Chennai urban population study[23] and rural and urban communities of Rajasthan.[24] The cause of lower blood pressure in women below 60 years may be due to hormonal effect in females during this age, i.e. premenopausal women having a lower arterial blood pressure than age-matched men. [25] This may be also due to the effect of obesity, as the prevalence of overweight

in male was higher in people under 75 years compared with female. Epidemiology of hypertension on the Tibetan plateau carried out by Sun and shinfu[12] however reports a higher prevalence of hypertension in females in all age group. This difference of result might be influenced by the difference of the subjects, such as sample size of much more female representation at all age group and the possible difference of the rate of obesity not shown in this report.

Though age-standardized prevalence of hypertension in Leh block (30.7%) was not higher compared with other rural areas (24.6-36.8%), higher prevalence of hypertension in Leh town (45.5%) and higher prevalence of overweight in both Leh block (32.7%) and Leh town (33.6 %) were found compared with other rural areas (overweight; 7.8-20.2%). The high prevalence of overweight may be brought about because Leh block is somehow a developed subdivision than the others in this study. Urbanisation can change the life style of the people and their diet habits, which may result in obesity and high prevalence of hypertension. Dietary quantity intake assessed by our nutritionist (Y.K) by 24 hour recall method showed that energy intake was higher in Leh town (2305 Kcal in men and 1933 kcal in women) as compared to higher altitude at Changthang (2029 Kcal in men and 1802 kcal in women). Food diversity as assessed by 11-item food diversity score Kyoto was higher in Leh (6.7±1.8) as compared to higher altitude Changthang (6.1 ±1.5).[26,27,28] Economic conditions, traditional food culture, harsh environment with limitation of resources affects energy intake and food diversity. In urban Leh and Leh block, economic condition of the population is better. Bread, mutton, rice, pulses, vegetables, Thugpa, and eggs forms top seven of the 11-item dietary food diversity, with snacks of sweet tea, biscuits, sweet and salt containing fast food. Such a diet increases their calories resulting in high BMI and increases their salt intake contributing to the higher prevalence of hypertension. One of the village in Leh block, Stok was a study centre in the Indian component of Intersalt study[29], an international study to determine the relationship of blood pressure with dietary ingredients particularly sodium and potassium. Urinary sodium [means (and SD) calculated for men aged 20-39, men aged 40-59, women aged 20-39, and women aged 40-59 and then averaged over age and sex groups] was 203.7 mmol/24 hour (75.0) and urinary potassium was 47.0 (19.2) mmol/24 hours with poor potassium sodium ratio. Although the data are that of 1988, there is every reason to surmise that the

situation persists as condition of socio-economic improvement without parallel improvement in health awareness prevails even today. There is a recent report on the effect of using a low-sodium, high-potassium salt substitute for Tibetan highlanders with hypertension.[30]

Domkhar valley in sham subdivision situated along the Domkhar stream is about 25 km long and divided into three hamlets of different altitudinal contour and diversified environment. Paba, rice, bread ,thukpa, sku, kholak, and local beverage chang are their top seven of the 11-item diverse food. Meat is rarely available. Fresh fruit are plenty in lower Domkhar and at some places at middle Domkhar, but none at upper Domkhar due to its high altitude location (Altitude 3800m). Prevalence of hypertension is very high here (39.1%) among the rural subdivisions. Especially prevalence of hypertension in Sham subdivision was as high as Leh town in the old age group above 60 years (Sham:56.0% vs Leh town: 61.7%) and in the higher altitude level of 3500-3999 (Sham:46.4%, Leh town: 43.5%) in spite of much lower rate of overweight in Sham (17.1%) compared with Leh town (33.6%). Different from people in Leh block subdivision, people in Sham had much poor availability of foods for a long time until recently and they may have vulnerability to the recent quick change of dietary habit especially in older people and those dwelling at remote area of higher altitude. We showed the high prevalence of impaired glucose tolerance (35%) in old people in Domkhar compared with Tibetan people in Qinghai, China in the previous report. We also suggested that there may be a vulnerability to glucose intolerance brought on by recent changes in lifestyle in people with long-term backgrounds of economically traditional lifestyles with limited food resource. [31]

Mutton, rice, momo (mutton), thukpa (comprising of Atta, vegetable mostly dry and dry cheese) kholak (Barley flour with local tea) and paba (A mix of baley flour, wheat flour and grounded pea cooked in plain water with salt added to taste) forms the top seven of the 11-item food diversity of Changthang population in both Ladakhi and Tibetan. Taking snackes is not in their food culture nor are modern snack items available at that remote high altitude region. Relatively lower prevalence of hypertension in Changthang Tibetan natives (19.7%) and Changthang Ladakhi (31.9%) living at higher altitude (4000-4900m) were shown.

Zanskar subdivision located at an intermediate high altitude (3500-3900m) has a population mainly concerned with farming and cattle rearing. Butter tea, local beverage chang, Thugpa, barley flour kholak, rice, pulses, and rarely meat forms the seven of the 11-item diverse food. Fresh vegetable and fruits are usually not available in Zanskar as well as in Changthang. The crude prevalence of hypertension in Zanskar appears to be high (36.3%) but age-standardized prevalence (32.1%) was the same as other rural areas, as the mean age was highest in Zanskar (Table 4).

Modernized sedentary workers, rural-to urban migrants, and dwelling in urban area population (Altitude 3300m-3600m) had higher prevalence of hypertension and increased BMI as compared to rural population. Previous reports support our hypothesis of highlanders' vulnerability to hypertension by socioeconomic globalization.[12-14, 31-34] A higher prevalence of hypertension was reported in Tibetans compared with immigrant Hans in the Tibetan plateau with the prevalence greater in the urban population around Lhasa than in the rural population.[12] In another report a longitudinally survey was carried out in the prevalence of hypertension in people over 15 years in different ethnic groups in China in 1991 and 2002. The prevalence of hypertension in Tibetan people increased from 17.8% (in 1991) to 24.7% (in 2002), which was the highest compared with other seven ethnic groups including Han (from 11.3% to 16.2%).[32] Recent report showed the prevalence of hypertension (SBP≥140 or DBP≥90 or treatment) in 1289 Tibetan highlanders (Lhasa and suburbs; 3700~4200 m) aged 18 and more were 39 %.[13] Another report showed the prevalence of hypertension in 692 Tibetan highlanders (rural area of Lhasa; 3700 m) aged 30-80 years were 37 % (SBP≥130 or DBP≥85 or treatment).[14] Those prevalence of hypertension were close to our result of 37% and higher than that of Chinese lowlanders aged 20 years and more (27% in 2007-2008).[15] Blood pressure in 332 highlanders in Leh (13–81 years old, mean 50 years) was compared with those in U town, Hokkaido, Japan (24–79 years, mean 56.8) in 2004. Higher diastolic blood pressure and a larger increase in blood pressure with age were shown in people living at a high altitude, as compared with Japanese living at a low altitude.[35] Younger people, but not adults and elderly people, among Tibetan immigrants from Leh to the lowlands in India were reported to have higher blood

pressure compared with those living in the highlands. Measurements of adiposity had a significant effect on BP.[33] The prevalence of hypertension was higher (72.7%) in Tibetan highlanders in Shangrila (Alt: 3300 m) compared with lowlanders in Jing Hong (57.0%) and Tosa (59.9%). There was a significant association between living in an urban area with a higher prevalence of hypertension and obesity in younger people under 60 years compared with those living in a rural area.[34] Younger people may be more vulnerable to hypertension by quick modernized lifestyle change. Also in our report the higher prevalence of hypertension in Leh town (44.7%) were shown especially in middle-aged group of 40-59 years compared with other areas (19.6-30.7%).

The higher Odds ratio of altitudes from 3000m-3999 m compared with altitude below 3000 m was shown after adjustment with age, sex and overweight. One reason may be socio-economic factor, as this altitude level was compatible with that of urban area of Leh town and urban dwellers had higher rate of hypertension and obesity by lifestyle change compared with rural dwellers. Another reason may be the effect of high altitude itself, as the dwellers in Sham subdivision at the altitude of 3000 to 3999 m had higher prevalence of hypertension in spite of lower prevalence of overweight compared with those dwelling below 3000 m. The highest prevalence in older people was shown at more higher altitude over 4000 m. Moreover prevalence of hypertension rose closely with altitude remarkably in farmer ($p<0.001$), mildly in sedentary worker ($p=0.09$) and insignificantly in nomad (Table 5). That's why the higher altitude range of 3000-3999 and 4500- (odds ratio; 2.18) kept significant association with hypertension after adjustment with age, occupation or dwelling area by the multivariate analysis, which also support the effect of high altitude itself to hypertension.

The limitation of this paper is that it did not look into the genetic factors, as both environmental and genetic factors may contribute to regional and racial variation of blood pressure and prevalence of hypertension. Genetic evidence for high-altitude adaptation in Tibetan people were reported recently.[36,37] Relatively lower prevalence of hypertension in spite of higher one of overweight in Changthang Tibetan natives (hypertension/ overweight; 19.7% vs 31.9 %/ 39.5% vs 10.4%) compared with Changthang Ladakhi living at higher altitude (4000-4900m) were shown in our report. The association between hypoxic adaptation gene and hypertension

should be further studied. The strength of this study is that it looked into most of the environmental factors known to influence hypertension in population of different distinct geographical subdivisions of high altitude region. This study showed the influence of aging, overweight, modernized sedentary occupation, and rural-to-urban migration and dwelling in urban area to hypertension as well as the effect of high altitude to hypertension by multivariate analysis.

The conclusion reached is that like everywhere else in the world, hypertension prevalence in high altitude population has multifactorial aetiology. Our study shows that age, gender, socio-economic factors, culture, race and changing life style plays big role with the effect of high altitude itself on high prevalence of hypertension.

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Legend of the figure and tables

Figure 1. Map of Ladakh Region showing all the field sites

The map of Ladakh region showing all the villages in the subdivisions where the study was conducted.

Table 1. Characteristics of the subdivisions in Ladakh region.

MSL, mean sea level

Table 2. Characteristics of all variables and those association with hypertension in Ladakh region.

#; Almost born in Leh with some migrants from no-Changthang areas.

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; SpO2, oxyhemoglobin saturation measured by pulse oximeter.

p; Chi square test for the comparison of the rate of valuables, and Student's t-test for the comparison of mean of valuables between hypertension and non-hypertension.

Table 3. Prevalence of hypertension and related variables according to sex and age groups in Ladakh region.

p ✝ ; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 age groups, and ANOVA for the comparison of mean of SBP, DBP, BMI and SpO2 among the 4 age groups in the whole population (n=2800).

*; p<0.05, **;p<0.01, ***; p<0.001, ****; p<0.0001:Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) and SpO2<89 (%) between male and female, and Student's t-test for the comparison of mean of SBP, DBP, BMI and SpO2between male and female in each age group.

Table 4. Prevalence of hypertension and related variables in different age groups in each subdivision in Ladakh region.

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of Hypertension and BMI ≥ 25 (%) among the 4 age groups in each subdivision.

Table 5. Prevalence of hypertension and related variables according to altitude, age and occupation in Ladakh region.

p; Chi square test for the comparison of the prevalence of Hypertension, BMI ≥ 25 (%) and SpO2<89 (%) among the 5 altitude groups.

Table 6. Prevalence of hypertension and overweight in different altitude levels in each subdivision in Ladakh region.

p; Chi square test for the comparison of the prevalence of Hypertension and BMI ≥ 25 (%) among the altitude groups.

Table 7. Prevalence of hypertension and overweight in people with different occupation in each age group in Ladakh region.

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 occupation groups; farmer, nomad, sedentary worker and others.

Table 8. Prevalence of hypertension and related variables in different dwelling areas in Ladakh region.

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 3 groups, and ANOVA for the comparison of mean age among the 3 groups.

Table 9. The effect of altitude, occupation and dwelling area to hypertension adjusted with age, sex and overweight by multiple logistic regression analysis.

Model-1: The effect of altitude to hypertension adjusted with age, sex and overweight.

Model-2: The effect of altitude and occupation to hypertension adjusted with age, sex and overweight.

Model-3: The effect of altitude, occupation and dwelling area to hypertension adjusted with age, sex and overweight.

Table 1. Characteristics of the subdivisions

Urban/ Rural	Subdivision	Altitude (meters above MSL)	Livelihood
Urban	Leh town (including colonies of migrants)	3300-3600 m	Urban life style
Rural	Leh block villages	3000-3700 m	Farmer
	Nubra	2600-3000 m	Farmer
	Kargil (Panikhar and parkachik)	2600-3100 m	Farmer
	Sham	2700-3900 m	Farmer
	Zanskar	3500-3900 m	Farmer and cattle rearing
	Changthang	4000-4900 m	Livestock rearing nomads

MSL, mean sea level

Table 2. Characteristics of all variables and those association with hypertension in Ladakh region.

	All	Hypertension (+)	Hypertension (-)	P
n	2800	1037	1763	
(%)		37.0 (35.2-38.8)	63.0 (61.2-64.8)	
Male (%)	44.3 (41.8-46.8)	46.9 (43.9-49.9)	42.8 (40.5-45.1)	0.03
age (years)	53.8±15.0	60.1±13.8	50.1±14.4	<0.0001
weight (kg)	55.3±11.1	57.4±12.2	54.1±10.2	<0.0001
BMI	22.6±3.6	23.6±3.9	22.0±3.3	<0.0001
Overweight (BMI ≥ 25) (%)	24.4 (22.8-26.0)	34.9 (32.0-37.8)	18.2 (16.4-20.0)	<0.0001
SpO2 (%)	89.7±5.2	89.5±5.4	89.8±5.2	ns
SpO2 < 89 (%)	32.5 (30.8-34.2)	32.1 (29.3-34.9)	32.7 (30.5-34.9)	ns
SBP (mmHg)	130.9±23.2	153.8±19.9	117.5±11.7	<0.0001
DBP (mmHg)	82.5±13.4	94.6±11.2	75.4±8.5	<0.0001
Altitude (m)	3514.4±432.2	3524.6±388.6	3508.3±455.9	ns

	n	Hypertension (+)	Hypertension (-)	P
Altitude (n=2800)		(%)	(%)	<0.0001
2500-2999 m	417	27.1 (22.8-31.4)	72.9 (68.6-77.2)	
3000-3499 m	428	37.4 (32.8-42.0)	62.6 (58.0-67.2)	
3500-3999 m	1604	40.8 (38.4-43.2)	59.2 (56.8-61.6)	
4000-4499 m	174	30.5 (23.7-37.3)	69.5 (62.7-76.3)	
4500-4999 m	177	32.2 (25.3-39.1)	67.8 (60.9-74.7)	

	n	Hypertension (+)	Hypertension (-)	
Dwelling area (n=2800)		(%)	(%)	<0.0001
Rural areas	1798	33.5 (31.3-35.7)	66.5 (64.3-68.7)	
Leh block (3000-3700m)	349	33.0 (28.1-37.9)	67.0 (62.1-71.9)	
Nubra (2600-3000m)	248	27.8 (22.2-33.4)	72.2 (66.6-77.8)	
Kargil (2600-3100m)	115	24.3 (16.5-32.1)	75.7 (67.9-83.5)	
Sham (2700-3900m)	451	39.2 (34.7-43.7)	60.8 (56.3-65.3)	
Zanskar (3500-3900m)	284	36.3 (30.7-41.9)	63.7 (58.1-69.3)	
Changthang (4000-4900m)	351	31.3 (26.4-36.2)	68.7 (63.8-73.6)	
Urban area: Leh town (3300-3600m)	1002	43.4 (40.3-46.5)	56.6 (53.5-59.7)	
Dwellers in Leh town#	683	41.1 (37.4-44.8)	58.9 (55.2-62.6)	
Migrants from Changthang	319	48.3 (42.8-53.8)	51.7 (46.2-57.2)	

	n	Hypertension (+)	Hypertension (-)	
Occupation (n=2800)		(%)	(%)	<0.0001
Farmer	1247	36.6 (33.9-39.3)	63.4 (60.7-66.1)	
Nomad	220	27.7(21.8-33.6)	72.3 (66.4-78.2)	
Sedentary worker	549	37.3 (33.3-41.3)	62.7 (58.7-66.7)	
Others	784	40.2 (36.8-43.6)	59.8 (56.4-63.2)	
Housewife	325	42.5 (37.1-47.9)	57.5 (52.1-62.9)	
Manual labor	63	14.3 (5.7-22.9)	85.7 (77.1-94.3)	
Monk	157	36.9 (29.4-44.4)	63.1 (55.6-70.6)	
No job	138	44.2 (35.9-52.5)	55.8 (47.5-64.1)	
Retired sedentary	101	48.5 (38.8-58.2)	51.5 (41.8-61.2)	

Mean ± SD, % (95% CI)

#; Almost born in Leh with some migrants from no-Changthang areas.

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; SpO2, oxyhemoglobin saturation measured by pulse oximeter.

p; Chi square test for the comparison of the rate of valuables, and Student's t-test for the comparison of mean of valuables between hypertension and non-hypertension.

Table 3. Prevalence of hypertension and related variables according to sex and age groups in Ladakh region.

	Age Group (Years)					
	20-39	**40-59**	**60-74**	**75-**	p ǂ	**All**
Male (n)	217	489	396	138		1240
Female (n)	288	709	448	115		1560
All (n)	505	1198	844	253		2800
Hypertension (%)						
Male	18.4 (13.2-23.6)	34.2 (30.0-38.4)	48.2 (43.3-53.1)	63.8 (55.8-71.8)	<0.0001	39.2 (36.5-41.9)*
Female	12.5 (8.7-16.3)	29.9 (26.5-33.3)	50.4 (45.8-55.0)	67.0 (58.4-75.6)	<0.0001	35.3 (32.9-37.7)
All	15.1 (12.0-18.2)	31.6 (29.0-34.2)	49.4 (46.0-52.8)	65.2 (59.3-71.1)	<0.0001	37.0 (35.2-38.8)
SBP (mmHg)						
Male	122.2±14.3****	127.7±18.0*	138.9±22.6	149.0±26.1	<0.0001	132.7±21.7***
Female	116.0±14.2	125.3±19.5	138.8±25.5	153.7±32.8	<0.0001	129.5±24.2
All	118.7±14.5	126.3±18.9	138.8±24.2	151.1±29.4	<0.0001	130.9±23.2
DBP (mmHg)						
Male	78.5±11.4	83.4±12.5***	85.2±12.8	87.5±14.2	<0.0001	83.6±12.9***
Female	76.4±11.9	80.9±12.0	84.5±14.9	88.4±17.3	<0.0001	81.7±13.7
All	77.3±11.7	81.9±12.3	84.9±14.0	87.9±15.7	<0.0001	82.5±13.4
BMI						
Male	22.4±3.2***	23.3±3.6*	23.2±3.4****	22.4±3.4	0.0017	23.0±3.5****
Female	21.4±3.3	22.8±3.7	22.1±3.7	22.1±3.7	<0.0001	22.3±3.7
All	21.8±3.3	23.0±3.7	22.6±3.6	22.3±3.5	<0.0001	22.6±3.6
BMI ≥ 25 (%)						
Male	22.6 (17.0-28.2)*	31.7 (27.6-35.8)*	28.4 (24.0-32.8)**	19.6 (13.0-26.2)	0.0098	27.7 (25.2-30.2)***
Female	14.6 (10.5-18.7)	26.2 (23.0-29.4)	19.5 (15.8-23.2)	20.9 (13.5-28.3)	0.0003	21.8 (19.8-23.8)
All	18.0 (14.6-21.4)	28.5 (25.9-31.1)	23.6 (20.7-26.5)	20.2 (15.3-25.1)	<0.0001	24.4 (22.8-26.0)
SpO2 (%)						
Male	90.8±4.4*	90.4±4.6	89.1±5.3**	89.0±5.4**	<0.0001	89.9±5.0
Female	91.6±3.6	90.3±4.8	87.7±6.4	86.6±6.5	<0.0001	89.5±5.0
All	91.2±4.0	90.4±4.7	88.3±5.9	87.9±6.0	<0.0001	89.7±5.2
SpO2 < 89 (%)						
Male	25.7 (19.9-31.5)*	29.0 (25.0-33.0)	37.1 (32.3-41.9)**	39.4 (31.2-47.6)*	0.0029	32.2 (29.6-34.8)
Female	17.7 (13.3-22.1)	27.2 (23.9-30.5)	46.3 (41.7-50.9)	52.2 (43.1-61.3)	<0.0001	32.8 (30.5-35.1)
All	21.1 (17.5-24.7)	27.9 (25.4-30.4)	42.0 (38.7-45.3)	45.2 (36.1-54.3)	<0.0001	32.5 (30.8-34.2)

p ǂ ; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 age groups, and ANOVA for the comparison of mean of SBP, DBP, BMI and SpO2 among the 4 age groups in the whole population (n=2800).
*; p<0.05, **;p<0.01, ***; p<0.001, ****; p<0.0001:Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) and SpO2<89 (%) between male and female, and Student's t-test for the comparison of mean of SBP, DBP, BMI and SpO2 between male and female in each age group.

Table 4. Prevalence of hypertension and related variables in different age groups in each subdivision in Ladakh region.

	Age Group (years)					
	20-39	40-59	60-74	75-	p	All
Leh (n=1002) (mean 51.9±15.5 years)	n=223	n=447	n=245	n=87		
Hypertension,%	19.7 (14.5-24.9)	41.6 (37.0-46.2)	58.8 (52.6-65.0)	70.1 (60.5-79.7)	<0.0001	43.4 (40.3-46.5)
(Age-Standardized Prevalence Rate,%)						45.5 (42.4-48.6)
BMI ≥ 25 (%)	20.6 (15.3-25.9)	40.7 (36.1-45.3)	34.8 (28.8-40.8)	26.4 (17.1-35.7)	<0.0001	33.6 (30.7-36.5)
Leh block (n=349) (mean 55.6±16.1 years)	n=60	n=127	n=123	n=39		
Hypertension,%	6.7 (0.4-13.0)	22.0 (14.8-29.2)	48.0 (39.2-56.8)	61.5 (46.2-76.8)	<0.0001	33.0 (28.1-37.9)
(Age-Standardized Prevalence Rate,%)						30.7 (25.9-35.5)
BMI ≥ 25 (%)	30.0 (18.4-41.6)	34.6 (26.3-42.9)	35.0 (26.6-43.4)	23.1 (9.9-36.3)	ns	32.7 (27.8-37.6)
Nubra (n=248) (mean 50.5±15.5 years)	n=78	n=88	n=64	n=18		
Hypertension,%	11.5 (4.4-18.6)	29.5 (20.0-39.0)	37.5 (25.6-49.4)	55.6 (32.6-78.6)	0.0001	27.8 (22.2-33.4)
(Age-Standardized Prevalence Rate,%)						31.0 (25.2-36.8)
BMI ≥ 25 (%)	9.0 (2.6-15.4)	17.0 (9.2-24.8)	14.1 (5.6-22.6)	16.7 (0-33.9)	ns	13.4 (9.2-17.6)
Kargil (n=115) (mean 51.9±13.5 years)	n=25	n=46	n=42	n=2		
Hypertension,%	16.0 (1.6-30.4)	19.6 (8.1-31.1)	33.3 (19.0-47.6)	50.0 (0-100)	ns	24.3 (16.5-32.1)
(Age-Standardized Prevalence Rate,%)						24.6 (16.7-32.5)
BMI ≥ 25 (%)	16.0 (1.6-30.4)	2.2 (0-6.4)	9.5 (0.6-18.4)	0	ns	7.8 (2.9-12.7)
Sham (n=451) (mean 56.2±13.8 years)	n=62	n=189	n=150	n=50		
Hypertension,%	9.7 (2.3-17.1)	31.2 (24.6-37.8)	50.7 (42.7-58.7)	72.0 (59.6-84.4)	<0.0001	39.2 (34.7-43.7)
(Age-Standardized Prevalence Rate,%)						36.9 (32.4-41.4)
BMI ≥ 25 (%)	11.3 (3.4-19.2)	19.6 (13.9-25.3)	17.5 (11.4-23.6)	14.0 (4.4-23.6)	ns	17.1 (13.6-20.6)
Zanskar (n=284) (mean 59.5±12.8 years)	n=10	n=115	n=127	n=32		
Hypertension,%	20.0 (0-44.8)	25.2 (17.3-33.1)	42.5 (33.9-51.1)	56.3 (39.1-73.5)	<0.01	36.3 (30.7-41.9)
(Age-Standardized Prevalence Rate,%)						32.1 (26.7-37.5)
BMI ≥ 25 (%)	30.0 (1.6-58.4)	13.9 (7.6-20.2)	13.4 (7.5-19.3)	15.6 (3.0-28.2)	ns	14.4 (10.3-18.5)
Changthang (n=351) (mean 52.9±13.6 years)	n=47	n=186	n=93	n=25		
Hypertension,%	14.9 (4.7-25.1)	22.6 (16.6-28.6)	49.5 (39.3-59.72)	60.0 (40.8-79.2)	<0.0001	31.3 (26.4-36.2)
(Age-Standardized Prevalence Rate,%)						32.6 (27.7-37.5)
BMI ≥ 25 (%)	12.8 (3.2-22.4)	24.7 (18.5-30.9)	16.1 (8.6-23.6)	16.0 (1.6-30.4)	ns	20.2 (16.0-24.4)

p; Chi square test for the comparison of the prevalence of Hypertension and BMI > 25 (%) among the 4 age groups in each subdivision.

Table 5. Prevalence of hypertension and related variables according to altitude, age and occupation in Ladakh region.

	Altitude (meters above MSL)					
	2500-2999 m	**3000-3499 m**	**3500-3999 m**	**4000-4499 m**	**4500-4999 m**	**p**
All	n=417	n=428	n=1604	n=174	n=177	
Hypertension (%)	27.1 (22.8-31.4)	37.4 (32.8-42.0)	40.8 (38.4-43.2)	30.5 (23.7-37.3)	32.2 (25.3-39.1)	<0.0001
SBP	126.3±21.6	128.9±19.9	132.8±24.0	129.7±23.9	130.9±23.8	<0.0001
DBP	80.8±12.2	83.5±13.1	83.3±13.7	80.0±13.7	79.2±12.8	<0.0001
BMI	21.8±3.1	22.7±3.7	22.8±3.6	22.4±3.6	22.6±3.7	<0.0001
BMI ≥ 25 (%)	16.6 (13.0-20.2)	25.0	27.1	20.1	20.3	<0.0001
SpO_2	90.2±4.7	90.6±4.2	90.0±5.2	86.1±5.8	86.7±5.7	<0.0001
SpO2 <89 (%)	26.2 (22.0-30.4)	23.6 (19.6-27.6)	28.8 (26.6-31.0)	67.1 (60.1-74.1)	68.2 (61.3-75.1)	<0.0001
20-39 years	n=119	n=128	n=211	n=30	n=17	
Hypertension (%)	10.1 (4.7-15.5)	22.7 (15.4-30.0)	13.3 (8.7-17.9)	10.0 (0-20.7)	23.5 (3.3-43.7)	<0.05
BMI ≥ 25 (%)	11.8 (6.0-17.6)	17.2 (10.7-23.7)	23.2 (17.5-28.9)	6.7 (0-15.6)	23.5 (3.3-43.7)	<0.05
SpO2 <89 (%)	15.4 (8.9-21.9)	16.4 (10.0-22.8)	14.5 (9.7-19.3)	69.0 (52.4-85.6)	100.0	<0.0001
40-59 years	n=155	n=197	n=660	n=77	n=109	
Hypertension (%)	27.1 (20.1-34.1)	41.1 (34.2-48.0)	32.4 (28.8-36.0)	15.6 (7.5-23.7)	27.5 (19.1-35.9)	<0.001
BMI ≥ 25 (%)	20.6 (14.2-27.0)	32.5 (26.0-39.0)	30.2 (26.7-33.7)	28.6 (18.5-38.7)	22.0 (14.2-29.8)	ns
SpO2 <89 (%)	22.6 (16.0-29.2)	24.1 (18.1-30.1)	20.5 (17.4-23.6)	55.8 (44.7-66.9)	67.9 (59.1-76.7)	<0.0001
60-74 years	n=114	n=81	n=556	n=52	n=41	
Hypertension (%)	38.6 (29.7-47.5)	44.4 (33.6-55.2)	52.3 (48.1-56.5)	55.8 (42.3-69.3)	41.5 (26.4-56.6)	<0.05
BMI ≥ 25 (%)	15.9 (9.2-22.6)	23.5 (14.3-32.7)	26.5 (22.8-30.2)	15.4 (5.6-25.2)	17.1 (5.6-28.6)	ns
SpO2 <89 (%)	36.6 (27.8-45.4)	30.4 (20.4-40.4)	40.2 (36.1-44.3)	78.8 (67.7-89.9)	56.1 (40.9-71.3)	<0.0001
75- years	n=29	n=22	n=177	n=15	n=10	
Hypertension (%)	51.7 (33.5-69.9)	63.6 (43.5-83.7)	68.4 (61.6-75.2)	60.0 (35.2-84.8)	60.0 (29.6-90.4)	ns
BMI ≥ 25 (%)	17.2 (3.5-30.9)	9.1 (0-21.1)	22.6 (16.4-28.8)	20.0 (0-40.2)	10.0 (0-28.6)	ns
SpO2 <89 (%)	48.3 (30.1-66.5)	36.4 (16.3-56.5)	41.5 (34.2-48.8)	80.0 (59.8-100)	70.0 (41.6-98.4)	<0.05
Farmer	n=348	n=178	n=620	n=81	n=20	
Hypertension (%)	27.6 (22.9-32.3)	33.7 (26.8-40.6)	41.3 (37.4-45.2)	40.7 (30.0-51.4)	55.0 (33.2-76.8)	<0.001
BMI ≥ 25 (%)	14.7 (11.0-18.4)	12.4 (7.6-17.2)	15.6 (12.7-18.5)	19.8 (11.1-28.5)	20.0 (2.5-37.5)	ns
SpO2 <89 (%)	23.8 (19.3-28.3)	24.4 (18.1-30.7)	41.5 (37.6-45.4)	85.0 (77.2-92.8)	94.7 (84.9-100)	<0.0001
Nomad				n=67	n=145	
Hypertension (%)				22.4 (12.4-32.4)	29.0 (21.6-36.4)	ns
BMI ≥ 25 (%)				25.4 (15.0-35.8)	17.9 (11.7-24.1)	ns
SpO2 <89 (%)				46.3 (34.4-58.2)	63.9 (56.1-71.7)	<0.05
Sedentary worker	n=33	n=176	n=340			
Hypertension (%)	21.2 (7.3-5.1)	40.9 (33.6-48.2)	38.8 (33.6-44.0)			ns(0.09)
BMI ≥ 25 (%)	21.2 (7.3-5.1)	35.2 (28.1-42.3)	36.6 (31.5-41.7)			
SpO2 <89 (%)	42.4 (25.5-59.3)	20.2 (14.3-26.1)	15.7 (11.8-19.6)			<0.001

p; Chi square test for the comparison of the prevalence of Hypertension, BMI ≥ 25 (%) and SpO2<89 (%) among the 5 altitude groups.

Table 6. Prevalence of hypertension and overweight in different altitude levels in each subdivision in Ladakh region.

	Altitude (meters above MSL)					
	2500-2999 m	**3000-3499 m**	**3500-3999 m**	**4000-4499 m**	**4500-4999 m**	**p**
Leh (3300-3600m)						
n		189	813			
Hypertension (%)		42.9 (35.8-50.0)	43.5 (40.1-46.9)			ns
BMI ≥ 25 (%)		32.8 (26.1-39.5)	33.7 (30.5-36.9)			ns
Leh block (3000-3700m)						
n		49	300			
Hypertension (%)		28.6 (15.9-41.3)	33.7 (28.4-39.0)			ns
BMI ≥ 25 (%)		40.8 (35.8-63.8)	31.3 (26.1-36.5)			ns
Nubra (2600-3000m)						
n	248					
Hypertension (%)	27.8 (22.2-33.4)					
BMI ≥ 25 (%)	13.7 (9.4-18.0)					
Kargil (2600-3100m)						
n	52	63				
Hypertension (%)	19.2 (8.5-29.9)	28.6 (17.4-39.8)				ns
BMI ≥ 25 (%)	15.4 (5.6-25.2)	1.6 (0-4.7)				<0.01
Sham (2700-3900m)						
n	117	127	207			
Hypertension (%)	29.1 (20.9-37.3)	37.0 (28.6-45.4)	46.4 (39.6-53.2)			<0.01
BMI ≥ 25 (%)	23.3 (15.6-31.0)	18.9 (12.1-25.7)	12.6 (8.1-17.1)			<0.05
Zanskar (3500-3900m)						
n			284			
Hypertension (%)			36.3 (30.7-41.9)			
BMI ≥ 25 (%)			14.4 (10.3-18.5)			
Changthang (4000-4900m)						
n				174	177	
Hypertension (%)				30.5 (23.7-37.3)	32.2 (25.3-39.1)	ns
BMI ≥ 25 (%)				20.1 (14.1-26.1)	20.3 (14.4-26.2)	ns

MSL, mean sea level

p; Chi square test for the comparison of the prevalence of Hypertension and BMI ≥ 25 (%) among the altitude groups.

Table 7. Prevalence of hypertension and overweight in people with different occupation in each age group in Ladakh region.

	20-39 years			40-59 years			60-74 years			75- years		
	n	Hypertension (%)	BMI ≥ 25 (%)	n	Hypertension (%)	BMI ≥ 25 (%)	n	Hypertension (%)	BMI ≥ 25 (%)	n	Hypertension (%)	BMI ≥ 25 (%)
Farmer	171	12.9 (7.9-17.9)	12.3 (7.4-17.2)	476	26.3 (22.3-30.3)	16.0 (12.7-19.3)	465	47.3 (42.8-51.8)	15.9 (12.6-19.2)	135	65.9 (57.9-73.9)	14.1 (8.2-20.0)
Nomad	4	0	25.0 (0-67.4)	146	19.9 (13.4-26.4)	23.3 (16.4-30.2)	54	40.7 (27.6-53.8)	11.1 (2.7-19.5)	16	62.5 (38.8-86.2)	25.0 (3.8-46.2)
Sedentary worker	204	19.5 (14.1-24.9)	19.1 (13.7-24.5)	277	48.0 (42.1-53.9)	44.0 (38.2-49.8)	61	45.9 (33.4-58.4)	39.3 (27.0-51.6)	7	42.9 (6.2-79.6)	42.9 (6.2-79.6)
Others	126	10.3 (5.0-15.6)	23.8 (16.4-31.2)	299	30.8 (25.6-32.1)	36.5 (23.2-36.0)	264	55.7 (49.7-61.7)	36.4 (30.6-42.2)	95	66.3 (56.8-75.8)	26.3 (17.4-35.2)
Housewife	44	13.6 (3.5-23.7)	25.0 (12.2-37.8)	157	29.0 (21.9-36.1)	36.3 (28.8-43.8)	98	57.1 (47.3-66.9)	25.5 (16.9-34.1)	26	84.6 (70.7-98.5)	23.1 (12.1-31.7)
Manual labor	1	0	0	53	11.3 (2.8-19.8)	20.8 (9.9-31.7)	9	33.3 (2.5-64.1)	11.1 (0-31.6)	0		
Monk	43	4.7 (0-11.0)	30.2 (16.5-43.9)	36	36.1 (20.4-51.8)	61.1 (45.2-77.0)	57	56.1 (43.2-69.0)	52.6 (39.6-65.6)	21	52.4 (31.0-73.8)	38.1 (17.3-58.9)
No job	37	13.5 (2.5-24.5)	16.2（4.3-28.1）	25	36.0 (17.2-54.8)	36.0 (17.2-54.8)	44	61.4 (47.0-75.8)	38.6 (24.2-53.0)	32	62.5 (45.7-79.3)	28.1 (12.5-43.7)
Retired sedentary	1	0	0	28	35.7 (18.0-53.4)	35.7 (18.0-53.4)	56	51.8 (38.7-64.9)	41.1 (28.2-54.0)	16	62.5 (38.8-86.2)	12.5 (0-28.7)
p		ns (0.05)	ns (0.07)		<0.0001	<0.0001		ns (0.07)	<0.0001		ns	<0.05

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 4 occupation groups; farmer, nomad, sedentary worker and others.

Table 8. Prevalence of hypertension and related variables in different dwelling areas in Ladakh region.

	Rural areas	Urban: Leh town		
		Dwellers in Leh town#	Migrants from Changthang	
n	1798	683	319	p
age (years)	54.9±14.6	49.0±15.9	58.2±12.3	<0.0001
Hypertension (%)	33.5 (31.3-35.7)	41.1 (37.4-44.8)	48.3 (42.8-53.8)	<0.0001
BMI ≥ 25 (%)	19.3 (17.5-21.1)	30.2 (26.8-33.6)	40.9 (35.5-46.3)	<0.0001
SpO2	88.8±5.6	90.7±4.2	92.3±3.2	<0.0001
SpO2<89 (%)	40.6 (38.3-42.9)	21.7 (18.6-24.8)	10.1 (6.8-13.4)	<0.0001
Altitude (m)	3543.2±534.1	3449.0±86.9	3491.9±39.6	<0.0001
Occupation (%)				
Farmer	66.8 (64.6-69.0)	6.3 (4.5-8.1)	0.9 (0-1.9)	
Nomad	12.0 (10.5-13.5)	0	1.3 (0.1-2.5)	
Sedentary	8.0 (6.7-9.3)	47.0 (43.3-50.7)	26.6 (21.8-31.4)	
Others	13.2 (11.6-14.8)	46.7 (43.0-50.4)	71.2 (66.2-76.2	
Housewife	2.6 (1.9-3.3)	27.2 (23.9-30.5)	28.8 (23.8-33.8)	
Manual labor	0	0.9 (0.2-1.6)	17.9 (13.7-22.1)	
Monk	6.8 (5.6-8.0)	5.0 (3.4-6.6)	0.3 (0-0.9)	
No job	1.5 (0.9-2.1)	5.9 (4.1-7.7)	22.3 (17.7-26.9)	
Retired sedentary	2.3 (1.6-3.0)	7.8 (5.8-9.8)	1.9 (0.4-3.4)	

p; Chi square test for the comparison of the prevalence of hypertension and BMI ≥ 25 (%) among the 3 groups, and ANOVA for the comparison of mean age among the 3 groups.

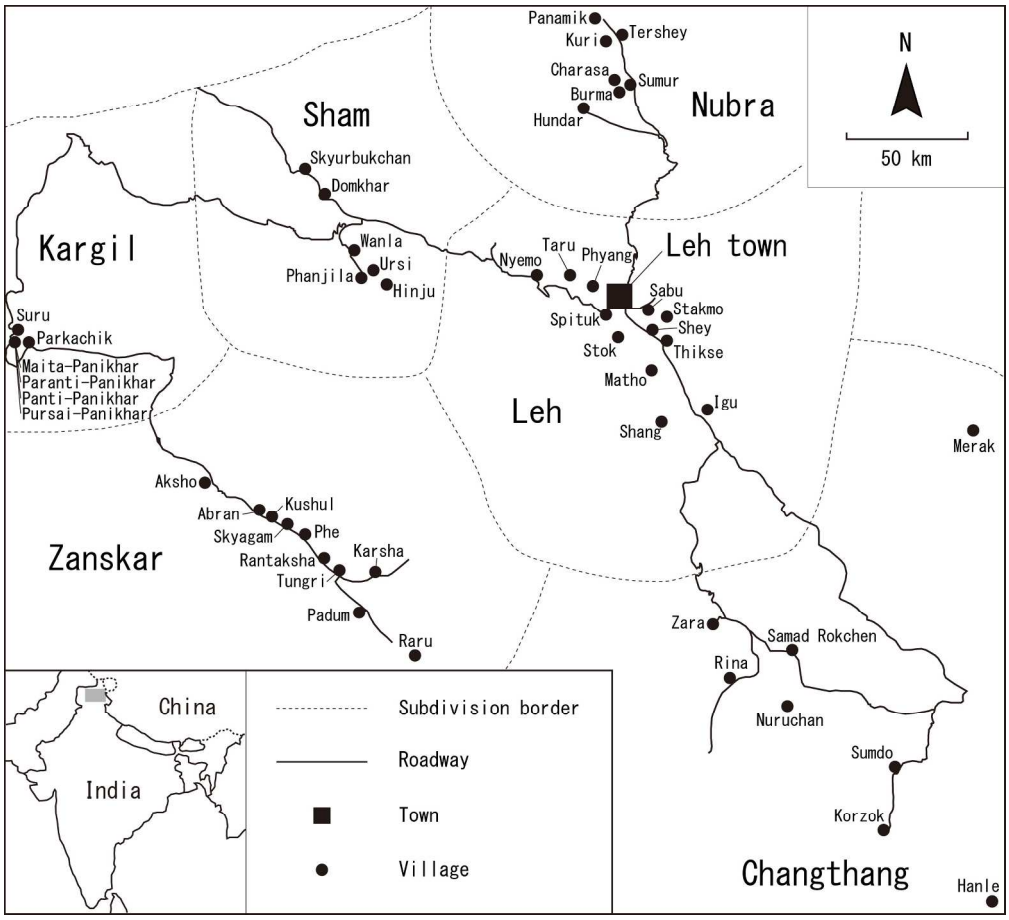
Table 9. The effect of altitude, occupation and dwelling area to hypertension adjusted with age, sex and overweight by multiple logistic regression analysis.

	n	Model-1			Model-2			Model-3		
		Odds ratio	Confidence interval	p	Odds ratio	Confidence interval	p	Odds ratio	Confidence interval	p
Age (year)										
20-39	505	1.00			1.00			1.00		
40-59	1198	2.43	1.84-3.22	<0.0001	2.78	2.08-3.71	<0.0001	2.85	2.12-3.83	<0.0001
60-74	844	5.66	4.24-7.55	<0.0001	6.93	5.09-9.43	<0.0001	7.20	5.26-9.86	<0.0001
75-	253	11.40	7.89-16.46	<0.0001	14.45	9.82-21.26	<0.0001	14.71	9.93-21.79	<0.0001
Male (vs Female)	1240 (1560)	1.02	0.86-1.21	ns	0.95	0.80-1.13	ns	1.00	0.84-1.20	ns
BMI ≥ 25 (vs BMI<25)	683 (2117)	2.60	2.14-3.13	<0.0001	2.51	2.07-3.05	<0.0001	2.52	2.08-3.06	<0.0001
Altitude										
2500-2999 (m)	417	1.00			1.00			1.00		
3000-3499	428	1.78	1.30-2.44	<0.001	1.62	1.17-2.23	<0.01	1.44	1.04-2.01	<0.05
3500-3999	1604	1.42	1.10-1.83	<0.01	1.34	1.02-1.75	<0.05	1.16	0.88-1.54	ns
4000-4499	174	1.01	0.67-1.53	ns	1.37	0.87-2.15	ns	1.40	0.88-2.20	ns
4500-	177	1.19	0.79-1.79	ns	2.57	1.41-4.68	<0.01	2.69	1.48-4.90	<0.01
Occupation										
Farmer	1247				1.00			1.00		
Nomad	220				0.42	0.24-0.72	<0.01	0.37	0.22-0.64	<0.001
Sedentary worker	549				1.56	1.20-2.02	<0.001	1.02	0.74-1.40	ns
Others	784				0.99	0.80-1.23	ns	0.68	0.52-0.90	<0.01
Dwelling area										
Rural areas	1798							1.00		
Dwellers in Leh town	683							1.92	1.45-2.55	<0.0001
Migrants from Changthang	319							1.70	1.21-2.38	<0.01

Model-1: The effect of altitude to hypertension adjusted with age, sex and overweight.

Model-2: The effect of altitude and occupation to hypertension adjusted with age, sex and overweight.

Model-3: The effect of altitude, occupation and dwelling area to hypertension adjusted with age, sex and overweight.



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