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Disparities in Prevalence and Determinants of Hypertension amongst Baméléké Adults Residing in Two Different Agroecological Zones of Cameroon

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Abstract

Background: Cardiovascular diseases such as hypertension (HTN) are one of the main causes of death in Cameroon. This study aimed at assessing prevalence disparities and determinants of hypertension amongst Baméléké adults residing in two different agroecological zones of Cameroon. **Methods:** A cross-sectional and descriptive survey was conducted among Baméléké population living in the Highlands zone (Western region) and in the Monomodal Rainforest zone (Littoral region) of Cameroon from August 2016 to August 2017. Participants (962) were aged at least 20 years old. Data on sociodemographic, hemodynamic, anthropometric, and biochemical parameters and lifestyle of the participants were collected. **Results:** Results obtained revealed that 34.2% were hypertensive and those residing in the highland zone were more affected than those living in the monomodal rainforest zone (44.5% vs 22.9%). The different subtypes of HTN (Isolated systolic hypertension (14.1%), isolated diastolic hypertension (7.2%) and Systo-diastolic hypertension (23.3%)) were also more prevalent in the Highlands Zone. The most prevalent stage of HTN was pre-HTN (31.5%). However, people living in the monomodal rainforest zone were more affected by pre-HTN compared to Baméléké living in the highland zone (33.6% vs. 29.6%). Results also showed

that high consumption (≥ 3 times/week) of carbohydrate- and fat-rich foods, ageing, obesity, and marital status were associated with high blood pressure in both agroecological zones. Besides, secondary education (OR = 0.68; 95% CI: 0.42 - 0.99) in the Highlands Zone and high (≥3 times/week) vegetable consumption (OR = 0.66; 95% CI: 0.44 - 0.98) in the Monomodal Rainforest Zone had a protective effect on elevated blood pressure of population. **Conclusion:** There is a disparity in the prevalence of hypertension and some of its determinants among Bamiléké adults residing in different agroecological zones. This work highlights the need to advocate for local and ethno-cultural health policies to prevent, diagnose and manage hypertension.

Keywords

Hypertension, Disparities, Determinants, Bamiléké Ethnic Group, Agroecological Zone

1. Introduction

Hypertension (HTN) is defined as an abnormal elevation of systolic blood pressure, diastolic blood pressure or both, and is characterized by a blood pressure of 140/90 mmHg or higher [1] [2]. Due to its negative impact on the health status of populations, HTN is a global public health problem [3]. Worldwide, cardiovascular disease (CVD) is responsible for approximately 17 million deaths per year, or one third of all deaths. Of these deaths, 9.4 million are related to complications of HTN [4]. Available statistical data reveal that HTN places a heavy burden on the health system in Africa and is the leading cause of premature death in underdeveloped countries, where the cardiovascular mortality rate is estimated at 80% [5].

Hypertension (HTN) is a complex abnormality that is believed to result from the combination between genetic predisposition and diverse environmental factors (including unhealthy diets, physical inactivity, consumption of tobacco and alcohol, and obesity) [6] [7]. In fact, genetic epidemiological studies have shown the association between diverse genes or certain polymorphisms in the genes and predisposition to HTN [8] [9]. Given that HTN is a major leading cause of chronic kidney and cardiovascular diseases, its prevention become an important public health issue [1] [3]. One aspect of preventing the development of this disease is to identify its determinants such as disease susceptibility genes or environmental risk factors in the population [6] [10]. Furthermore, due to ethnic disparate of gene polymorphisms [6] and geography-based differences in environmental risk factors [11] of HTN in different populations, it is of great clinical interest to identify specifically related factors in each ethnic group to improve primary prevention of HTN.

In Cameroon, the national prevalence of hypertension is steadily increasing, with estimates ranging from 29.6% to 32.1% between 1994 and 2018 [11]. The

study conducted by Kuate *et al.* [11] on the relationship between hypertension and ethnic groups living in Cameroon, showed that there is a disparity in the prevalence of HTN between ethnic groups. These authors also reported that the prevalence of HTN is higher among the Bamiléké ethnic group. This suggests that ethnic dispositions and the influence of the agroecological zone play a dominant role in the development of HTN in Cameroon. Additionally, studies have shown that moving to a new environment could substantively modify the cardiovascular disease risk of migrants [12] [13]. There are several reports in the literature highlighting that Bamiléké ethnic group is a great migrant group across the country [11] [14]. The study conducted by Barbier *et al.* [15] revealed that although the native region of that ethnic group is highlands zone, they have massively immigrated to the Monomodal rainforest zone of Cameroon. These two zones are distinguishable by dominant physical, climatic and vegetative features. Maize, dry beans, potatoes, peanuts, cassava, plantain and oil palm are the main crops grown in the highland zone while maize, peanuts, soybeans, sweet banana, plantain, cassava, macabo, white yam, vegetables and oil palm are the main crops grown in the monomodal rain forest zone [16]. According to Chan *et al.* [17] and Schwingshackl *et al.* [18], dietary patterns and intake of specific nutrients are major determinants of the development of HTN. Given that Bhatnagar [19] highlighted in their study that dietary choices are constrained by the cultural conditions, social environment and conditions related to food security, and taking into consideration the gap in the literature concerning the Cameroonian population it therefore arises a research question related to the determinants or characteristics specific to the Bamiléké ethnic group and its residing agroecological zones that are associated to the development of HTN. It is for answer to this question**,** that the present study was designed and aimed to assess disparities in prevalence and determinants of hypertension amongst Bamiléké adults residing in two different agroecological zones of Cameroon.

2. Materials and Methods

2.1. Study Sites Description

An agroecological zone is a geographical unit defined in terms of climate, geomorphology and soils, and/or vegetation cover and having a specific range of potentials and constraints for land use. Cameroon has five agro-ecological zones: Sudano-Sahelian (Far North and North regions); Guinean High Savannah (Adamaoua region); Bimodal Rainforest (Centre, East and South regions); Highlands (Western and North-western regions) and Monomodal Rainforest (Littoral and South-West regions) [20]. A cross-sectional, descriptive and analytic survey was conducted in the Highlands zone (Western region) and the Monomodal Rainforest zone (Littoral region) of Cameroon. The study site in the Monomodal Rainforest zone was the city of Nkongsamba (capital of the Moungo Department). In the Highlands zone, the study sites were the cities of Bangangté (capital of Ndé Department), Mbouda (capital of Bamboutos Department) and

Bafoussam (capital of Mifi Department).

2.2. Study Design and Sampling Procedure

A multi-stage sampling approach was adopted for the survey. Regions were selected first, then cities, and finally participants from the Bamiléké ethnic group were targeted in the various study sites. Semi-urban cities, which are departmental capitals, are known to be places of residence (Bangangté, Mbouda, Bafoussam) and migration (Nkongsamba) for the Bamileke ethnic group [15], were selected randomly, using a simple random sampling method. The study occurred during the period from August 2016 to August 2017. Participants of both sexes were enrolled during health campaigns on chronic non-communicable diseases, organized by the Laboratory of Nutrition and Nutritional Biochemistry (LNNB) of the University of Yaoundé 1. The Magnani [21] formula was used to calculate the size of the study population. Taking into account the prevalence of hypertension in Cameroon 32.1% [11], the 95% confidence level, and the 5% margin of error. The required sample size was estimated at 335 persons for each ecological zone. To this end, using a survey design based on a simple random sampling, 2153 individuals freely consented to participate in the study during the health campaign. After the application of the inclusion and exclusion criteria, 962 participants were finally retained.

2.3. Inclusion and Exclusion Criteria

Inclusion criteria for each participant were as follows: to be of Bamiléké ethnicity, to have resided in the Western Region or Littoral region for at least 1 year, to be at least 20 years of age, to be healthy, and to be undiagnosed as positive for hypertension or any other cardiometabolic disease before the survey. Excluded were pregnant and lactating women, mentally unstable persons, and persons on antihypertensive or any other medication that could influence metabolism.

2.4. Data collection

2.4.1. Questionnaire

Data collection at the study sites was done through a face-to-face interview. A questionnaire adapted from the WHO stepwise approach [22] was used to collect information on participants' sociodemographic characteristics (age, gender, ethnicity, occupation, education, marital status, possession, tobacco, alcohol, and physical activity). A household amenity score was used as a proxy for income to determine the socioeconomic status [23]. Socioeconomic status (SES) was classified as low (Score 0 to 2), medium (Score 3 to 4), and high (Score ≥ 5) according to the method described by Ntandou *et al.* [24]. Smoking use was classified into nonsmokers and smokers; alcohol use was grouped into non-drinkers and drinkers. Participants' physical activity was assessed based on the Global Physical Activity Questionnaire (GPAQ, developed by WHO) analysis guide. Participants' physical activity level was classified as low, moderate, and high, based on their mode of travel, main occupation, and leisure activity.

2.4.2. Dietary Habits

A food frequency questionnaire (FFQ) related to the assessment of dietary habits and including different foods consumed was used. This questionnaire collected data on the number of days in the last seven days before the field survey that the participant consumed specific foods. The different foods consumed were subsequently grouped into nine categories: cereal group; tuber group; legume group; dairy group; meat, fish, and egg group; vegetable group; fruit group; oil and fat group; and sweets group [25]. The consumption frequencies of foods within a group were summed. The 7-day consumption frequency data for each food group were used to classify the consumption of each of the nine food groups into two categories: low consumption (1 - 2 times per week) and high consumption (≥3 times per week). Subsequently, the different food groups were then grouped into 4 food groups according to their specific nutritional contributions: carbohydrate-rich foods, protein-rich foods, lipids and fast sugars-rich foods, and fiber, vitamins and mineral rich foods.

2.4.3. Anthropometric Measurements and Nutritional Status

A physical examination (Weight, height, waist circumference, and percentage of body fat) was performed on all participants using standard methods. Weight was measured to the nearest 0.1 kg using an electronic scale (Tanita™ BC-418 Analyzer/Segmental Body Composition Scale) in moderately clothed participants. Height was measured to the nearest 0.1 cm using a stadiometer (Harpended™). Waist circumference was measured using a soft, non-stretch tape measure. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2) squared. WHO [26] criteria were used to classify participants according to their BMI as follows: normal weight ($18.5 \geq BMI \leq 24.9$), overweight ($25 \geq BMI \leq 29.9$ kg/m^2), and obese ($BMI \geq 30$ kg/m^2).

2.4.4. Arterial Blood Pressure Measurements and Diagnosis of Hyper Tension

Blood pressure was measured in the participant after a 10-minute rest and in the sitting position. Two blood pressure measurements were recorded using an *OMRON* electronic radial sphygmomanometer with an interval of 5 minutes. The mean of the two measurements was used to assess the presence or absence of elevated blood pressure. The WHO [27] definition was used to diagnose hypertension (systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg). Subtypes of HTN hypertension were then identified based on the following criteria: isolated systolic hypertension (ISH): SBP ≥ 140 mm Hg and DBP < 90 mm Hg, isolated diastolic hypertension (IDH): SBP < 140 mm Hg and DBP ≥ 90 mm Hg, and systo-diastolic hypertension (SDH): SBP ≥ 140 mm Hg and DBP ≥ 90 mm Hg [28]. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7) classified hypertensive participants according to the criteria of Chobanian *et al.* [29] (Pre-HTN (SBP: 120 - 139 mmHg or DBP: 80 - 89 mmHg), Stage 1 HTN (SBP: 140 - 159 mmHg or DBP: 90 - 99 mmHg), and

Stage 2 HTN (SBP ≥ 160 mmHg or DBP ≥ 100 mmHg).

2.4.5. Blood Sampling and Biochemical Analyses

Fasting venous blood samples were collected in EDTA tubes using a standardized aseptic technique and transported to the laboratory for analysis. Plasma obtained by centrifugation was stored in aliquots in the freezer at −20˚C for subsequent biochemical analysis. Glucose was measured directly on-site using a glucometer and test strips (One-touch plus). Triglyceride and total cholesterol concentrations were measured by standard enzymatic spectrophotometric methods using Chronolab kits. The method of Manish *et al.* [30] was used to assess plasma nitric oxide levels.

2.5. Ethical Consideration

The study protocol was approved by the National Committee on Research Ethics for Human Health of Cameroon under N°2014/08/488/CE/CNERSH. Authorization for the conduct of the survey in the different study sites was granted by the competent administrative authorities. Free and informed consent was obtained from all participants in the survey. Participants with a positive diagnosis of hypertension or any other cardiometabolic diseases were referred to health centers for further follow-up. The study was conducted in strict compliance with medical ethics by the principles described in the Declaration of Helsinki.

2.6. Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) for Windows version 20.0 was used for statistical analyses. The results of the descriptive analysis were expressed as mean ± standard error and frequency (%). The cross-tabulation followed by the Chi-square test allowed the comparison of proportions between categorical variables. The Student's t-test for unpaired samples was used to detect differences in means between two groups of a continuous dependent variable. Bivariate and multivariate logistic regression analyses were used to determine associations between hypertension and selected risk factors. The statistical significance was set at $p < 0.05$.

3. Results

3.1. Basic Characteristics of the Study Population

The socio-demographic and lifestyle characteristics of the population presented in Table 1 show that of the 962 participants selected, 52.3% resided in the highland zone and 47.7% resided in the monomodal rainforest zone. The proportion of women was higher than that of men in both ecological zones. Individuals aged of 50 years old or more were most represented in both the highland zone (54.1%) and the monomodal rainforest zone (47.5%). Obese people were more represented in the monomodal rainforest zone (42.3%) while overweight people were more frequent in the highland zone (43.7%). With regard to occupation, unemployed people were more numerous, with 81.9% in the highland zone and

Table 1. Socio-demographic and lifestyle characteristics of the study population according to the agroecological zone.

	Highlands zone	Monomodal rainforest zone	*p*-value
General population	503 (52.3)	459 (47.7)	
Sexe			
Woman	381	307	
Man	122	152	0.003
Age			
20 - 39 years	120 (23.9)	142 (30.9)	
40 - 49 years	111 (22.1)	99 (21.6)	0.039
≥ 50 years	272 (54.1)	218 (47.5)	
Body mass index			
Normal	115 (22.9)	83 (18.0)	
Overweight	220 (43.7)	182 (39.7)	0.013
Obese	168 (33.4)	194 (42.3)	
Profession			
Unemployed	412 (81.9)	343 (74.7)	0.008
Employed	91 (18.1)	116 (25.3)	
Marital status			
Single	106 (21.1)	88 (19.2)	
Married	301 (59.8)	310 (67.5)	0.022
Widowed/Divorced	96 (19.1)	61 (13.3)	
Education			
Primary	313 (62.2)	171 (37.3)	
Secondary	167 (33.2)	223 (48.6)	<0.001
University	23 (4.6)	65 (14.2)	
Socioeconomic level			
Low	94 (18.7)	96 (20.9)	
Medium	262 (52.1)	233 (50.8)	0.686
High	147 (29.2)	130 (28.3)	
Tobacco			
Non-smoker	491 (97.6)	432 (94.1)	0.008
Smoker	12 (2.4)	27 (5.9)	
Alcohol			
Non-drinker	349 (71.2)	298 (65.1)	0.043
Drinker	141 (28.8)	160 (34.9)	
Physical activity			
Low	92 (21.6)	164 (35.8)	
Medium	280 (65.9)	190 (41.5)	<0.001
High	53 (12.5)	104 (22.7)	

74.7% in the monomodal rainforest zone. Married people were more represented in both ecological zones. Regarding the socio-economic level, 52.1% of participants living in the highland zone and 50.8% of participants living in the monomodal rainforest zone had an average socio-economic level. Regarding tobacco and alcohol consumption, 2.4% of participants living in the highland zone and 5.9% of participants living in the monomodal rainforest zone respectively smoked tobacco. While 28.8% of participants living in the highland zone and 34.9% of participants living in the monomodal rainforest zone drank alcohol. Regarding the level of physical activity, 12.5% of the people living in the highland zone and 22.7% of the people living in the monomodal rainforest zone had a high level of physical activity.

3.2. Clinical Characteristics of the Study Population

Table 2 provides an overview of the clinical characteristics of the study population. It shows that the mean values of age, systolic blood pressure, diastolic blood pressure and triglycerides were significantly higher in the Bamiléké living in the highland zone compared to those living in the monomodal rainforest zone ($p < 0.05$). In contrast, mean values of body mass index, heart rate, nitric oxide, glucose and total cholesterol were significantly higher in Bamiléké living in the monomodal rainforest zone compared to those living in the highland zone ($p < 0.05$). However, no significant differences in mean values for body fat and waist circumference were observed in the two agro-ecological zones.

3.3. Distribution of Hypertension in the Population

In this analysis (Table 3), the prevalence of hypertension was 38.5% in the general population and men were more affected than women (36.1% vs. 33.4%). Concerning

Table 2. Anthropometric, hemodynamic, and biochemical characteristics of the study population by agroecological zone.

Parameters	Highlands zone	Monomodal rainforest zone	*p*-value
Age (years)	49.94 ± 0.68[a]	46.87 ± 0.68[b]	0.002
Body Mass Index (kg/m^2)	28.47 ± 0.22[a]	29.68 ± 0.25[b]	<0.001
Body fat (%)	35.37 ± 0.45[a]	35.45 ± 0.51[a]	0.902
Waist circumference (cm)	93.98 ± 0.62[a]	92.62 ± 0.61[a]	0.124
SBP (mmHg)	134.64 ± 1.11[a]	123.29 ± 1.04[b]	<0.001
DBP (mmHg)	81.69 ± 0.80[a]	73.19 ± 0.59[b]	<0.001
Pulse (beats/min)	73.64 ± 0.56[a]	78.50 ± 0.62[b]	<0.001
Nitric Oxide (µmol/L)	18.08 ± 0.60[a]	20.85 ± 0.63[b]	0.002
Blood glucose (mg/dL)	96.36 ± 1.64[a]	106.47 ± 1.65[b]	<0.001
Triglyceride (mg/dL)	106.50 ± 2.70[a]	92.12 ± 2.41[b]	<0.001
Total cholesterol (mg/dL)	122.63 ± 1.55[a]	183.00 ± 2.92[b]	<0.001

SBP: systolic blood pressure; DBP: diastolic blood pressure; in the rows, the mean values assigned by the same letter were not significantly different at $p < 0.05$.

Table 3. Distribution of hypertension in the population according to gender, age, body mass index and agroecological zone.

Parameters		HTN		Subtypes of HTN				Stage of HTN			
		n (%)	*p*-value	ISH	IDH	SDH	*p*-value	Pre-HTN	Stage 1 HTN	Stage 2 HTN	*p*-value
Population		329 (34.2)		128 (13.3)	50 (5.2)	151 (15.7)		303 (31.5)	183 (19.6)	140 (14.6)	
Gender	Woman	230 (33.4)	0.452	80 (11.6)	42 (6.1)	108 (15.7)	0.027	209 (30.4)	123 (17.9)	107 (15.6)	
	Man	99 (36.1)		48 (17.5)	8 (2.9)	43 (15.7)		94 (34.3)	66 (24.1)	33 (12)	0.030
Age	20 - 39 years	43 (16.4)	<0.001	10 (3.8)	16 (6.1)	17 (6.5)	<0.001	78 (29.8)	31 (11.8)	12 (4.6)	
	40 - 49 years	54 (25.7)		19 (9.0)	7 (3.3)	28 (13.3)		79 (37.6)	30 (14.3)	24 (11.4)	<0.001
	≥50 years	232 (47.3)		99 (20.2)	27 (5.5)	106 (21.6)		146 (29.8)	128 (26.1)	104 (21.2)	
BMI	Normal	61 (30.8)		10 (5.1)	23 (11.6)	28 (14.1)		44 (22.2)	33 (16.7)	28 (14.1)	
	Overweight	149 (37.1)	0.251	68 (16.9)	11 (2.7)	70 (17.4)	<0.001	110 (27.4)	90 (22.4)	59 (14.7)	<0.001
	Obese	119 (32.9)		28 (14.1)	70 (17.4)	53 (14.6)		149 (41.2)	66 (18.2)	53 (14.6)	
Agroecological zone	Highlands zone	224 (44.5)	<0.001	71 (14.1)	36 (7.2)	117 (23.3)	<0.001	149 (29.6)	121 (24.1)	103 (20.5)	
	Monomodal rainforest zone	105 (22.9)		57 (12.4)	14 (3.1)	34 (7.4)		154 (33.6)	68 (14.8)	37 (8.1)	<0.001

BMI: body mass index; ISH: isolated systolic hypertension; IDH: isolated diastolic hypertension; SDH: systo-diastolic hypertension; HTN: hypertension.

HTN subtypes, SDH was the most prevalent in the general population (15.7%), followed by ISH (13.3%). However, men were more prone to ISH (17.5%) while IDH was more prevalent in women (15.7%). The results also revealed that pre-hypertension was 31.5% in the general population and men were more affected than women (34.3% vs. 30.4%). In addition, 19.6% of the population had stage 1 HTN with a preponderance of men compared with women (24.1% vs. 17.9%). On the other hand, stage 2 HTN was 14.6% in the study population, 15.6% in women, and 12% in men.

The distribution of HTN according to the age groups illustrated in Table 3 shows that the prevalence of HTN increased with age. Indeed, it varied from 16.4% in individuals aged 20-29 years to 47.3% in those aged 50 years and over. Regarding the subtypes of hypertension, ISH (20.2%) and SDH (21.6%) were more prevalent in individuals aged 50 years or older, whereas IDH (6.1%) was more prevalent in individuals aged 20 - 49 years. Prehypertension (37.6%) was more prevalent in individuals aged 40 - 49 years. For stage 1 HTN (26.1%) and stage 2 HTN (21.2%), participants aged 50 years or older were the most affected compared to the other age groups.

The prevalence of HTN was proportional to the increase in BMI. HTN was 30.8% in normal-weight individuals, 37.1% in overweight individuals, and 32.9% in obese individuals. Regarding the subtypes of HTN, 16.9% and 17.4% of overweight individuals had ISH and SDH, respectively, whereas 17.4% of obese individuals were affected by IDH. However, pre-HTN increased with BMI, while stage 1 HTN and stage 2 HTN were 22.4% and 14.7% in overweight individuals

(Table 3).

The distribution of hypertension according to ecological zone shows that Bamiléké residing in the highland zone are more prone to hypertension compared to Bamiléké residing in the monomodal rainforest zone (44.5% vs 22.9%). Bamiléké residents in the highland zone were more affected by ISH, IDH and SDH than Bamiléké residents in the monomodal forest zone ($p < 0.05$). As for hypertension grades, Pre-HTN was more prevalent among Bamiléké residents in the monomodal rainforest zone compared to those in the highland zone (33.6% vs 29.6%). However, grade 1 and grade 2 hypertension were more prevalent in the highland zone (Table 3).

3.4. Dietary Profile of the Study Population

The distribution of consumption frequency of different food groups according to agroecological zone is shown in Table 4. Foods rich in oils and fats (70.2%), carbohydrate-rich foods such as cereals (70%) and protein-rich foods such as pulses (60. 4%) are the foods most consumed by Bamiléké residents in the highland zone (≥3 times/week) while carbohydrate-rich foods such as tubers (91, 7%), protein-rich foods such as pulses (86.5%) and meat, fish and eggs (87.6%) are the foods most consumed (≥3 times/week) by Bamiléké residents in the monomodal rainforest zone ($p < 0.05$).

3.5. Distribution of Socio-Demographic and lifEstyle Characteristics among Hypertensive Individuals between Agroecological Zone

The distribution of socio-demographic and lifestyle characteristics in the hypertensive population revealed that HTN was more prevalent among the unemployed than the employed in the highland zone (83.5% vs. 16.5%) and in the monomodal rainforest zone (77.1% vs. 22.9%). With regard to marital status, 60.7% of married people in the highland zone and 69.5% of married people in the monomodal rainforest zone were hypertensive. The results also revealed that hypertension was more prevalent among people with primary education in both ecological zones. As for socio-economic level, 49.1% of hypertensive residents in the highland zone and 48.1% of hypertensive residents in the monomodal rainforest zone had a medium socio-economic level. Regarding lifestyle factors, hypertension was present in 3.6% of smokers and 29.7% of alcohol drinkers in the highland zone while 6.7% of hypertensives smoked tobacco and 35.6% of hypertensives drank alcohol in the monomodal rainforest zone. However, the proportion of hypertensive individuals with an average level of physical activity was 63.7% in the highland zone and 39% in the monomodal rainforest zone (Table 5).

3.6. Distribution of Food Group Consumption Frequency among Hypertensive Individuals between Agroecological Zones

The frequency of consumption of the different food groups among hypertensive individuals according to agroecological zone (Table 6) shows a higher

Table 4. Dietary profile of the study population according to the agroecological zone.

Parameters	Highlands zone	Monomodal rainforest zone	*p*-value
Carbohydrate rich foods			
Cereals (rice, pasta, corn, bread, wheat flour, etc.)			
1 - 2 times/week	151 (30)	119 (25.9)	0.172
≥3 times/week	352 (70)	340 (74.1)	
Tubers (plantain, cassava, macabo, white yam, sweet potato, etc.)			
1 - 2 times/week	247 (49.1)	38 (8.3)	<0.001
≥3 times/week	256 (50.9)	421 (91.7)	
Protein rich foods			
Meat, fish, eggs (goat, pork, beef, chicken, shrimp, mackerel, chicken egg, etc.)			
1 - 2 times/week	256 (50.9)	57 (12.4)	<0.001
≥3 times/week	247 (49,1)	402 (87.6)	
Dairy products (yogurt, Whole milk powder, cheeses, sweetened condensed milk, etc.)			
1 - 2 times/week	472 (93.8)	325 (70.8)	<0.001
≥3 times/week	31 (6.2)	134 (29.2)	
pulses (beans, soybeans, peanuts, etc.)			
1 - 2 times/week	199 (39.6)	62 (13.5)	<0.001
≥3 times/week	304 (60.4)	397 (86.5)	
Lipid and fast sugar rich foods			
Sweets (Sugar, chocolate, candy etc.)			
1 - 2 times/week	321 (63.8)	197 (42.9)	<0.001
≥3 times/week	182 (36.2)	262 (57.1)	
Oils and fats (margarine, Vegetable oils, butter, etc.)			
1 - 2 times/week	150 (29.8)	120 (26.1)	0.222
≥3 times/week	353 (70.2)	339 (73.9)	
Fiber, Vitamin, and Mineral rich foods			
Vegetables (Cabbage, lettuce, tomato, okra, green beans, green leafy vegetables, etc.)			
1 - 2 times/week	311 (61.8)	202 (44)	<0.001
≥3 times/week	192 (38.2)	257 (56)	
Fruits (oranges, melons, pineapples, bananas, guavas, avocados, Mangoes, etc.)			
1 - 2 times/week	382 (75.9)	269 (58.6)	<0.001
≥3 times/week	121 (24.1)	190 (41.4)	

Table 5. Distribution of other socio-demographic and lifestyle characteristics among hypertensive individuals by agroecological zone.

Parameters	Highlands zone	Monomodal rainforest zone	*p*-value
Profession			
Unemployed	187 (83.5)	81 (77.1)	0.174
Employed	37 (16.5)	24 (22.9)	
Marital status			
Single	34 (15.2)	15 (14.3)	
Married	136 (60.7)	73 (69.5)	0.224
Widowed/Divorced	54 (24.1)	17 (16.2)	
Education			
Primary	153 (68.3)	46 (43.8)	
Secondary	59 (26.3)	45 (42.9)	<0.001
University	12 (5.4)	14 (13.3)	
Socioeconomic level			
Low	48 (21.4)	24 (22.9)	
Medium	110 (49.1)	51 (48.6)	0.001
High	66 (29.5)	30 (28.5)	
Tobacco			
Non-smoker	216 (96.4)	98 (93.3)	0.165
Smoker	8 (3.6)	7 (6.7)	
Alcohol			
Non-drinker	156 (70.3)	67 (64.4)	0.308
Drinker	66 (29.7)	37 (35.6)	
Physical activity			
Low	46 (22.9)	40 (38.1)	
Medium	128 (63.7)	41 (39)	<0.001
High	27 (13.4)	24 (22.9)	

Table 6. Distribution of food group consumption frequency among hypertensive individuals by agroecological zone.

Parameters	Highlands zone	Monomodal rainforest zone	*p*-value
	Hypertension	Hypertension	
Carbohydrate rich foods			
Cereals (rice, pasta, corn, bread, wheat flour, etc.)			
1 - 2 times/week	55 (24.6)	11 (10.5)	0.003
≥3 times/week	169 (75.4)	94 (89.5)	
Tubers (plantain, cassava, macabo, white yam, sweet potato, etc.)			
1 - 2 times/week	94 (42)	9 (8.6)	<0.001
≥3 times/week	130 (58)	96 (91.4)	

Continued

Protein rich foods			
Meat, fish, eggs (goat, pork, beef, chicken, shrimp, mackerel, chicken egg, etc.)			
1 - 2 times/week	109 (48.7)	12 (11.4)	<0.001
≥3 times/week	115 (51.3)	93 (88.6)	
Dairy products (yogurt, Whole milk powder, cheeses, sweetened condensed milk, etc.)			
1 - 2 times/week	209 (93.3)	70 (66.7)	<0.001
≥3 times/week	15 (6.7)	35 (33.3)	
pulses (beans, soybeans, peanuts, etc.)			
1 - 2 times/week	69 (30.8)	15 (14.3)	0.001
≥3 times/week	155 (69.2)	90 (85.7)	
Lipid and fast sugar rich foods			
Sweets (Sugar, chocolate, candy etc.)			
1 - 2 times/week	141 (62.9)	45 (42.9)	<0.001
≥3 times/week	83 (37.1)	60 (57.1)	
Oils and fats (margarine, Vegetable oils, butter, etc.)			
1 - 2 times/week	54 (24.1)	9 (8.6)	0.001
≥3 times/week	170 (75.9)	96 (91.4)	
Fiber, Vitamin, and Mineral rich foods			
Vegetables (Cabbage, lettuce, tomato, okra, green beans, green leafy vegetables, etc.)			
1 - 2 times/week	127 (56.7)	64 (61)	0.475
≥3 times/week	97 (43.3)	41 (39)	
Fruits (oranges, melons, pineapples, bananas, guavas, avocados, Mangoes, etc.)			
1 - 2 times/week	168 (75)	65 (61,9)	0.019
≥3 times/week	56 (25)	40 (38.1)	

consumption (≥3 times/week) of cereals (75.4%), pulses (69.2%) and oils (75.9%) in hypertensive Bamiléké residents in the highland zone. In hypertensive Bamiléké residents in the monomodal rainforest zone, cereals (89.5%), tubers (91.4%) and oils (91.4%) were the mostly consumed food groups (≥3 times/week).

3.7. Association between Elevated Blood Pressure and Socio-Demographic and Lifestyle Risk Factors

Table 7 shows that the risk of developing high blood pressure in Bamiléké residents

Table 7. Crude odds ratios associating elevated blood pressure with sociodemographic and lifestyle risk factors by agroecological zone.

Risk factors	Highlands zone		Monomodal rainforest zone	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)	*p*-value
Gender				
Woman	1	0.610	1	0.238
Man	1.11 (0.73 - 1.68)		1.23 (0.82 - 1.85)	
Age				
20 - 39 years	1		1	
40 - 49 years	1.82 (1.07 - 3.10)	0.026	2.88 (1.61 - 5.15)	<0.001
≥50 years	4.96 (3.13 - 7.87)	<0.001	3.35 (2.03 - 5.51)	<0.001
Body mass index				
Normal	1		1	
Overweight	1.38 (0.88 - 2.18)	0.157	2.80 (1.50 - 5.21)	0.001
Obese	1.99 (1.23 - 3.24)	0.005	2.58 (1.39 - 4.78)	0.003
Profession				
Employed	1	0.934	1	0.529
Unemployed	0.98 (0.61 - 1.55)		1.15 (0.74 - 1.77)	
Marital status				
Single	1		1	
Married	2.43 (1.54 - 3.82)	<0.001	2.52 (1.43 - 4.44)	0.001
Widowed/Divorced	3.04 (1.71 - 5.42)	<0.001	2.35 (1.13 - 4.89)	0.022
Education				
Primary	1		1	
Secondary	0.68 (0.42 - 0.99)	0.046	0.79 (0.52 - 1.19)	0.845
University	1.85 (0.71 - 4.84)	0.205	0.87 (0.48 - 1.57)	0.649
Socioeconomic level				
High	1		1	
Medium	0.68 (0.41 - 1.10)	0.121	0.78 (0.48 - 1.28)	0.342
Low	0.84 (0.49 - 1.44)	0.537	0.96 (0.56 - 1.66)	0.897
Tobacco				
Non-smoker	1		1	
Smoker	1.47 (0.43 - 4.94)	0.534	1.26 (0.57 - 2.79)	0.559
Alcohol				
Non-drinker	1		1	
Drinker	1.09 (0.73 - 1.62)	0.666	1.01 (0.68 - 1.52)	0.934
Physical activity				
High	1		1	
Medium	1.07 (0.66 - 1.72)	0.777	1.05 (0.63 - 1.75)	0.845
Low	1.85 (0.71 - 4.84)	0.205	0.99 (0.64 - 1.54)	0.984

in the highland zone was highest for those aged 50 years old or more (OR = 4.96; 95% CI: 3.13 - 7.87), married (OR = 2.43; 95% CI: 1.54 - 3.82) and widowed/divorced (OR = 3.04; 95% CI: 1.71-5.42). However, those with secondary education were at lower risk of developing high blood pressure (OR = 0.68; 95% CI: 0.42 - 0.99). In Bamiléké residents in the monomodal rainforest zone, people aged 40 - 49 years old (OR = 2.88; 95% CI: 1.61 - 5.15), people aged 50 years old or more (OR = 3.35; 95% CI: 2.03 - 5.51), married people (OR = 2.52; 95% CI: 1.43 - 4.44) and widowed/divorced people (OR = 2.35; 95% CI: 1.13 - 4.89) were at higher risk to develop high blood pressure.

3.8. Association between Elevated Blood Pressure and Frequency of Consumption of Food Groups

The risk of developing high blood pressure in Bamiléké residents in the highland zone was increased by a consumption frequency ≥ 3 times/week of cereals (OR = 2.04; 95% CI: 1.35 - 3.10), tubers (OR = 2.00; 95% CI: 1.36 - 2.94), pulses (OR = 1.95; 95% CI: 1.32 - 2.88) and oils (OR = 2.08; 95% CI: 1.37 - 3.16). Furthermore, the risk of developing high blood pressure in Bamiléké residents in the monomodal rainforest zone was increased by consumption ≥3 times/week of cereals (OR = 1.79; 95% CI: 1.10 - 2.91) and oils (OR = 2.18; 95% CI: 1.32 - 3.59). However, vegetable consumption ≥3 times/week (OR = 0.66; 95% CI: 0.44 - 0.98) had a protective effect on blood pressure elevation in Bamiléké residents in the monomodal rainforest zone (**Table 8**).

4. Discussion

Hypertension (HTN) is one of the cardiometabolic diseases that weighs heavily on the reduction of life expectancy in populations. This study aimed to assess the disparities in prevalence and determinants of hypertension amongst Bamiléké adults residing in two different agroecological zones of Cameroon**.** In the current study, the prevalence of HTN in the general population was 38.5%. This prevalence is higher than that observed in studies conducted on the Cameroonian population living in the cities of Yaoundé and Douala [31] [32]. Higher hypertension prevalence was found in aging population (≥50 years old) and men compared to women (36.1% versus 33.4%). These findings are in agreement with those generally described in Africa and particularly in Cameroon [14] [33] [34] [35]. Concerning HTN subtypes, systo-diastolic hypertension (SDH) was the most prevalent in the general population (15.7%). This observation is consistent with the work of Biyegue *et al.* [32] and Ntentié *et al.* [36] who showed a predominance of SDH in the Cameroonian population. Regarding the distribution of hypertension by ecological zone, Bamiléké residents in the highland zone had higher hypertension as well ISH, IDH, SDH, grade 1 and grade 2 hypertension prevalences than those residents in the monomodal rainforest zone. In fact, the prevalence of hypertension in highland zone residents was 2-fold higher than those in monomodal rainforest (44.5 versus 22.9 %). Such findings strengthen

Table 8. Adjusted odds ratios associating elevated blood pressure with food group consumption frequency according to agroecologic zone.

Risk factors	Highlands zone		Monomodal rainforest zone	
	Odds ratio (95% CI)	*p*-value	Odds ratio (95% CI)	*p*-value
Carbohydrate rich foods				
Cereals (rice, pasta, corn, bread, wheat flour, etc.)				
1 - 2 times/week	1	0.001	1	0.018
≥3 times/week	2.04 (1.35 - 3.10)		1.79 (1.10 - 2.91)	
Tubers (plantain, cassava, macabo, white yam, sweet potato, etc.)				
1 - 2 times/week	1	<0.001	1	0.244
≥3 times/week	2.00 (1.36 - 2.94)		0.66 (0.33 - 1.32)	
Protein rich foods				
Meat, fish, eggs (goat, pork, beef, chicken, shrimp, mackerel, chicken egg, etc.)				
1 - 2 times/week	1	0.799	1	0.352
≥3 times/week	1.05 (0.71 - 1.54)		1.33 (0.72 - 2.46)	
Dairy products (yogurt, Whole milk powder, cheeses, sweetened condensed milk, etc.)				
1 - 2 times/week	1	0.694	1	0.066
≥3 times/week	1.16 (0.53 - 2.55)		1.50 (0.97 - 2.32)	
pulses (beans, soybeans, peanuts, etc.)				
1 - 2 times/week	1	0.001	1	0.118
≥3 times/week	1.95 (1.32 - 2.88)		1.63 (0.88 - 3.03)	
Lipid and fast sugar rich foods				
Sweets (Sugar, chocolate, candy, etc.)				
1 - 2 times/week	1	0.409	1	0.577
≥3 times/week	0.84 (0.56 - 1.25)		1.12 (0.75 - 1.67)	
Oils and fats (margarine, Vegetable oils, butter, etc.)				
1 - 2 times/week	1	0.001	1	0.002
≥3 times/week	2.08 (1.37 - 3.16)		2.18 (1.32 - 3.59)	
Fiber, Vitamin, and Mineral rich foods				
Vegetables (Cabbage, lettuce, tomato, okra, green beans, green leafy vegetables, etc.)				
1 - 2 times/week	1	0.351	1	0.044

Continued

≥3 times/week	1.20 (0.81 - 1.79)		0.66 (0.44 - 0.98)	
Fruits (oranges, melons, pineapples, bananas, guavas, avocados, Mangoes, etc.)				
1 - 2 times/week	1	0.799	1	0.551
≥3 times/week	0.82 (0.54 - 1.25)		1.13 (0.75 - 1.69)	
Adjustment was made for age, body mass index and marital status				

the fact that changes in the environment (different geographic locations, modifications in lifestyle choices, and shifts in social policies and cultural practices) may considerably influence hypertension risk, even without significant genetic changes. This is in line with the work of Cohen *et al.* [37], who showed that the migration of Bamiléké people to the urban areas of Yaoundé and Paris, marked by the phenomenon of dietary transition and food choice, contributes to the deterioration of cardio-metabolic health.

We further examined the association between the environmental and lifestyle changes and the development of hypertension among Bamiléké residents in the two zones. We firstly examine the association between food choices and hypertension risk. Food choices are important determinants for the development of hypertension. There was found an association between the higher frequency of cereals and tubers (Carbohydrate rich foods) consumption and the development of hypertension in both residents although it was significant only in highland zone residents. In fact, cereals and tubers are starch-based complements of traditional dishes. Within cereals, the most present were maize and rice while within the tubers, they were cassava, cocoyam, sweet potato or yam [37]. All of these foods have a high energy density and a low protein energy ratio. In fact, like other less developed countries' populations, Cameroonians usually have a high percentage of energy coming from low-quality carbohydrate (dietary starch) (mean values about 60%). Corroborating our findings, a cohort study in Chinese population demonstrated that both high and low energy intake from carbohydrates were associated with an increased risk of HTN [38]. A minimal risk was observed at 50 to 55 % of energy intake from carbohydrates. There are several possible explanations for our findings. Dietary starch is a polysaccharide made up of glucose molecules linked together and for which hydrolysis by alpha amylase produces glucose [39]. The latter is known for its ability to significantly increase cytotoxic free calcium in vascular smooth muscle cells, which contributes to vasoconstriction and vascular resistance, leading to increased blood pressure [40]. We also found that the increased risk of HTN was noticed in those with high intake frequency of oil and fats in both zones. This is in line with epidemiological studies suggesting that the intake of fat adversely affects blood pressure [41]. In fact, Cohen *et al.* [37] noted that many lifestyle factors of the Bamiléké are potentially obesogenic, such as fattening practices and a traditional diet based principally on palm oil. As palm oil is mainly rich in saturated fatty acids,

it has been shown that high levels of saturated fatty acids, mainly palmitic acid, are associated with a high risk of HTN [42]. This may explain why the frequency of consumption of unhealthy foods such as oils increases the risk of hypertension in both study populations. Indeed, overconsumption of saturated fatty acids leads to hypertrophy and hyperplasia of adipocytes, resulting in the development of insulin resistance, associated with impaired endothelium-dependent vasodilation, thus contributing to increase the blood pressure [43] [44]. Concerning the association between the risk of HTN and protein rich food intake, there was found an increased risk of HTN with high protein rich foods frequency intake (principally pulses) in the highland zone. Pulses play a key role in the traditional diets, in less developed countries of the world. They are high in protein and low in fats, sodium and calories. The high quantities of specific protein fractions are responsible for important physiological and metabolic effects [45]. In fact, several studies showed evidences that plant proteins have a favorable effect on blood pressure. Some amino acids like arginine provided through protein digestion may dilate the blood vessels by producing nitric oxide and act as an antioxidant by regulating redox-sensitive proteins, thereby having an antihypertensive effect [46]. In addition, pulses via their richness in polyphenols have the ability to prevent hypertension by decreasing intracellular levels of reactive oxygen species [47]. A possible explanation of our findings is that pulses are used as sauces in traditional dishes into which palm oil or groundnuts are usually added contributing in terms of fat content [47] [48] [49]. Therefore, the fat content might play an important role in affecting blood pressure as it is well known that massive saturated fatty acid, is positively correlated with elevated blood pressure.

In the current study, it was also found that a high frequency of fruits and vegetable consumption reduces the incidence of HTN. This observation is consistent with the work of Utsugi *et al.* [50] who found that high vegetable consumption significantly reduced the risk of hypertension. The results of our study could be explained by the fact that vegetables and fruits contain numerous antioxidants (flavonoids), dietary fibers and essential minerals such as potassium, which have potential hypotensive effects [51] [52]. In fact, potassium-rich diets were associated with lower blood pressure in communities with high sodium (salt) consumption. It was found that extracellular potassium modulates the activity of the renal NaCl cotransporter [53]. Concerning flavonoids, they could increase the activation of inducible NO synthase and endothelial NO synthase thus contributing to the improvement of NO bioavailability in blood, which exerts vasorelaxant effects on vascular smooth muscle cells [54].

Investigation of sociodemographic risk factors for hypertension revealed that increasing body mass index was associated with an increased risk of hypertension in both highland and monomodal rainforest zones Bamiléké residents. This may reflect the fact that the prevention of obesity in the population may have a great impact on reducing the burden of hypertension. Although the etiology of obesity is highly complex and includes dietary, physiological, genetic, psychological, environmental, social, and economic components [55]. Regarding marit-

al status, married and divorced/widowed individuals were more likely to develop hypertension than single individuals in both ecological zones. This could be explained by the psychosocial stress. Indeed, stress is responsible for the release of the adrenocorticotropic hormone into the systemic circulation. This later acts on the adrenal cortex, stimulating the synthesis and release of glucocorticoids that contribute to the development of HTN [56]. Conversely, regular physical activity was associated with reduced hypertension risk. Indeed, regular physical activity has been shown to attenuate endothelial dysfunction by possibly increasing NO synthesis to counteract the generation of reactive oxygen species [57]. Furthermore, there was found a decreased risk of hypertension with a higher education level which is in contradiction with the work of Biyegue *et al.* [32].

Therefore, the disparities in hypertension prevalence between highland zone Bamiléké residents and monomodal rainforest zone Bamiléké residents may be the result of differences in diet and lifestyle. A plausible explanation was that the high intake frequency of vegetables and fruits observed in monomodal rainforest zone Bamiléké residents might contribute to reducing the risk of abnormal blood pressure. Regular physical activity may offset the adverse cardiovascular effects of high oil, fats or carbohydrates intake, which could be another explanation for this pattern and hypertension. Although a genetic predisposition may be evoked, because it may have intra-ethnic variations in genetic determinants of hypertension [57].

There were some limitations to this study. First of all, this study only mentioned the association of food consumption frequency with hypertension, but not the association between dietary intake and the risk of hypertension. Secondly, the association of certain gene polymorphisms with hypertension was not shown in this study. Finally, this study only included Bamiléké ethnic group, future research should also encompass different ethnic groups due to genetic and environmental heterogeneity among different ethnic groups of Cameroon. Despite these limitations, this study is the first of its kind to examine the prevalence and determinants of hypertension in a specific ethnic group residing in different agroecological zones in Cameroon. Results still have practical implications for the improvement of the management of hypertension according to the ethnocultural and agroecological context.

5. Conclusion

In conclusion, the results of this study revealed that Bamiléké adults residing in the highland zone are more affected by hypertension than their counterparts living in the monomodal rainforest zone. Older age, obesity, widowed/divorced marital status, and high consumption of carbohydrate- and fat-rich foods contributed to an increased risk of developing high blood pressure. On the other hand, high education and high vegetable consumption had a protective effect on the occurrence of hypertension. These observations suggest that preventive and educational policies aimed at improving the lifestyle of the population should take into account the sociodemographic and ethno-cultural background of indi-

viduals to reduce the health and economic burden of this silent killer.

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List of Abbreviations

HTN: hypertension; ISH: isolated systolic hypertension; IDH: isolated diastolic hypertension; SDH: systo-diastolic hypertension; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure.

Ethics Approval and Consent to Participate

The study protocol was approved by the National Committee on Research Ethics for Human Health of Cameroon under N°2014/08/488/CE/CNERSH. During the study, the investigators emphasized the importance of obtaining informed consent specifying that the participant could choose not to answer any question or to withdraw at any time. Signed consent was obtained from all participants in the survey.

Consent for Publication

Not applicable.

Availability of Data and Materials

The data collected is not freely available. Upon request, data from this study are available from the corresponding author (JLN).

Competing Interests

The authors declare that they have no conflict of interest in the publication of this article.

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Authors' Contributions

Maxwell Wandji Nguedjo: Conceptualization, Methodology, Collected the data, Data Curation, Validation, Writing-original draft, Writing-Review & Editing. Nanhah Kamga Jules Vidal: Methodology, Writing-original draft. Alice Louise Woguia, Pauline Vervaine Hagbe and David Goda collected the data, Writing-Review & Editing. Hippolyte Tene Mouafo and Dany Ngassa Ngoumen conducted the laboratory analyses, analyzed the data, Writing-Review & Editing. Gabin Kingue Azantsa Writing-Review & Editing. Judith Laure Ngondi and Julius Enyong Oben supervised the work. All authors read and approved the final

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