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Diabetes and Hypertension Are Associated with Food Insecurity in a Cameroonian Population: A Case-Control Study

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Abstract

Diabetes and hypertension are the most prevalent cardiovascular risk factors. Recent studies showed an increase in the prevalence of food insecurity in our country. The aim of this study was to assess how food insecurity affects the dietary habits, socio-demographic characteristics and metabolic profile of individuals with diabetes or hypertension. This case-control study was conducted among diabetic and hypertensive participants (cases) and diabetic and hypertensive normal (controls) during the screening campaigns for nutrition-related chronic diseases. The sociodemographic, clinical and biochemical parameters of the participants were analyzed. Logistic regression analyses were performed to identify factors associated with diabetes and hypertension in the study population. Bivariate analyses showed that male gender (OR = 1.972; 95% CI: 1.250 - 3.089), regular alcohol consumption (OR = 2.012; 95% CI: 1.294 - 3.130), low fruit consumption (OR = 1.590; 95% CI: 1.016 - 2.488), low dietary diversity (OR = 2.915; 95% CI: 1.658 - 5.127) and abdominal obesity (OR = 1.893, CI 95% 1.203 - 2.978) were significantly associated with hypertension. In addition, low fruit consumption (OR = 1.829; 95% CI 1.092 - 3.064), low legume consumption (OR = 3.515; 95% CI 1.861 - 6.635), and hypertriglyceridaemia (OR = 2.241, 95% CI 1.139 - 4.408) were significantly associated with diabetes. The indirect association observed between food insecurity and diabetes and hypertension suggests the need for nutritional policies aimed at popularizing the production and consumption of fruits and legumes. Similarly, health services need to be aware and informed of the important role that food insecurity can play in the development of diabetes and hypertension.

Keywords

Food Insecurity, Diabetes, Hypertension, Cameroon

1. Introduction

Cardiovascular disease (CVD) is the world's leading cause of morbidity and mortality, and the greatest burden of disease, with approximately 18 million deaths per year [1]. The prevalence of cardiovascular risk factors, notably diabetes and hypertension (HTN), is increasing, particularly in urban areas [2]. Indeed, hypertension affects one-third of the world's population [3]. WHO data forecast a 1.56 billion (60%) increase in the global burden by 2025. In low- and middle-income countries, one in three adults suffers from HTN [4]. It accounts for 20% - 50% of deaths, particularly in developing countries [5]. Diabetes stands out with approximately 537 million adults worldwide, with a projection of 643 million in 2030 and 783 million in 2045 [6]. In Africa, data from the IDF [7] estimate the number of adults suffering from diabetes at 23,633,000, with a projection of 33,446,000 in 2030. In Cameroon, the prevalence of HTN is estimated at 31% [8]. It steadily increased from 29.6% to 32.1% between 1994 and 2018 [9]. Around 620,000 Cameroonian adults living with diabetes in 2021 have been identified, with a projection of 877,000 Cameroonian adults in 2030 [7]. The main factors contributing to HTN and diabetes are related to lifestyle habits such as smoking, high consumption of high-calorie and/or high-salt diets, urbanization and genetics [10]. HTN and diabetes can be prevented by controlling risk factors and adopting a healthy lifestyle. However, there are barriers to implementing healthy behaviors, including food insecurity [11]. Food insecurity (FI) is defined as limited or inadequate access to nutritious food to meet dietary needs and preferences for an active and healthy life, often linked to individual factors such as poverty, disability and systemic factors [12].

FI is a complex socio-medical concept that has been the subject of several definitions over the years, and more recently, it has broadened its scope from food supply to food access and quality [13].

Owing to the 2019 COVID pandemic and food cost inflation, the number of people in FI situations is rising sharply. The Food and Agriculture Organization of the United Nations estimates that FI has risen from 25.3% in 2019 to 29.6% in 2022 [14]. Cameroon is not an exception. Indeed, it has been estimated that 16% of households are food insecure [15] in addition to the scourges mentioned above, Cameroon is experiencing several crises (the Boko Haram crisis in the far north of the country, Central African refugees in the east of the country and the crisis in the North-West and South-West regions); prevalence has risen from 2.1 million to 4.9 million people experiencing acute food insecurity [16]. A study showed that 33.8% of rural households in Cameroon were food insecure [17]

Due to its high prevalence, food insecurity has become a major public health issue [18]. Previous studies have shown that food insecurity is influenced by various factors such as age, household head status, economic level, employment status, ethnicity, family size, and eating habits [19].

The economic constraints of food-insecure populations lead them to purchase cheaper, calorie-dense foods, which can contribute to increased exposure to chronic diseases such as hypertension [20] and diabetes [2]. To date, several studies have presented the relationship between food insecurity and HTN [21] [22] and diabetes [2] [23]. The work of Ntentie *et al.* [24] revealed that semi-urban Cameroonian cities are more affected by HTN and diabetes than rural and urban cities. However, the authors were not interested in the food security status of these populations. However, other studies have shown that FI contributes to an increase in the incidence of diabetes and HTN. Given this observation, the research question that follows is that of the association between FI and diabetes and HTN in populations living in semi-urban areas of Cameroon, which are the most affected by these scourges. Indeed, the objective of this study was to assess how food insecurity affects the dietary habits, socio-demographic characteristics and metabolic profile of individuals with diabetes or hypertension.

2. Materials and Methods

2.1. Study Design and Sampling Procedure

This case-control study was carried out between August 2016 and August 2017 in Cameroonian adults of both sexes, aged 20 and over. This case-control study was chosen because it allows the identification of factors that could lead to the onset of diabetes or hypertension in people exposed to food insecurity. In addition, since only retrospective data were available, this type of study was the most appropriate. Participants were recruited during massive free screening campaigns for nutrition-related chronic diseases (obesity, hypertension, diabetes, etc...) organized by the Laboratory of Nutrition and Nutritional Biochemistry at the University of Yaoundé I. The study was carried out in four regions of Cameroon (Littoral region, West region, North-West region and Far-North region). These regions were chosen based on previous studies that highlighted high prevalence of diabetes and hypertension [24]. In the Littoral region, the department of Moungo was selected. In the West region, it was the department of Mifi and Bamboutos. In the North-West region, it was the department of Momo, Menchum and Donga-Mentum. While in the Far-North region, it was the department of Mayo-Kani. The case group included people with hypertension or diabetes. The control group comprised non-hypertensive and non-diabetic individuals. 207 participants were needed to provide a 95% confidence interval around the prevalence of food insecurity of 16% [15], with a variation of ±5%. At the end of the campaign, 364 individuals were selected.

2.2. Inclusion and Exclusion Criteria

Cameroonian participants aged 20 and over who had been living in each study site for at least one year and were food insecure were included. Participants with incomplete questionnaires, the intellectually impaired and those suffering from diabetes, hypertension or any other cardiometabolic disease prior to the study were excluded due to changes in dietary and lifestyle habits or drug treatments likely to influence metabolism.

2.3. Ethical Considerations

This study was conducted with strict respect for the physical, moral and psychological integrity of all participants, following approval of the protocol by the National Ethics Committee under registration number 2014/08/488/CE/CNERSH. Furthermore, only fully informed participants who had given their oral or written consent to take part in the study were enrolled.

2.4. Data Collection

Data were collected using a structured questionnaire, adapted from previous studies conducted in Cameroon and WHO guidelines [25]. The questionnaire was pre-tested and validated prior administration to the participants.

2.4.1. Administration of the Questionnaire

A structured questionnaire designed on the basis of the WHO stepwise approach for monitoring nutrition-related chronic disease risk factors - instrument V2.1 [25] was administered to each participant during a face-to-face interview. The questionnaire was structured as follows: socio-demographic and socio-economic data (age, gender, place of residence, marital status, socio-economic level, and education level), food security status (using two indicators), lifestyle (alcohol consumption, smoking, etc.…) and dietary habits (frequency of consumption of food groups) of each participant. Socio-economic status (SES) was assessed using the Household amenity Score [26] as a proxy of income. This score is composed of 12 items characterizing participants' possessions. These are: materials for walls and floors, type of fuel for cooking, motorcycle, real estate, television, car, electricity, cell phone, landline phone, indoor water, and refrigerator. The first two items were coded dichotomously: "0" for other materials and "1" for a cement floor or wall. Fuel used for cooking was coded "1", "0.5" and "0" for oil or gas, charcoal and firewood, respectively. The last nine items were also dichotomous, coded "0" if there was none, and "1", if convenience was present. The sum of these items, for a maximum of 12, constituted the amenity score (or SES). The score values were grouped into three classes according to the method described by Ntandou *et al.* [27]. This classification includes SES: low [0 - 2], medium [3 - 4] and high [5 - 10], as in all cases participants' scores could not reach 12. Level of education was classified into three categories: illiteracy/primary, secondary and university. Tobacco consumption was classified into two categories: non-smokers and smokers. Similarly, alcohol consumption was classified into two categories: non-drinkers and drinkers. Participants' physical activity was determined on the basis of the Global Physical Activity Questionnaire. Participants' level of physical activity was classified as low, moderate or high, depending on their mode of transport, main occupation and leisure activities.

2.4.2. Assessment of Eating Habits

Assessment of frequency of consumption of food group

A 7-day food frequency questionnaire was used to assess the frequency of consumption of different food groups (cereals, tubers, oils and fats, pulses, fruit and vegetables) [28]. The data obtained then enabled us to classify each food group into 2 categories: 0 - 3 days per week as low consumption and 4 - 7 days per week as high consumption. These food groups are classified into protective foods (legumes, fruits, vegetables) and deleterious foods (cereals, tubers, oils and fats).

Assessment of participants' Food Security status

The concept of food security is complex and the result of many interdependent factors. It is now recognized that the use of a single indicator gives an incomplete picture of food security [29] and that multiple indicators should be used to capture the complexity of food security [30]. Two indicators were therefore used 1) the food consumption score and 2) the individual dietary diversity score. These food security indicators used in the survey were proxies. Food security status was assessed according to the modified protocol described by the National Food Safety Coordination *et al*. [31].

Assessment of food Consumption Score (FCS)

It's a composite score based on the diversity of the diet, the frequency of food consumption and the importance of the nutrients present in the different food groups. Each food group was assigned a quality weighting factor that reflected its energy value. This weighting factor is based on the density of the nutrients contained in the food consumed. 8 food groups (cereals and tubers, pulses, vegetables, fruit, animal proteins, sugar, milk and dairy products, oils and fats) are considered in the food consumption score. Respondents were asked to provide an estimate of the frequency of consumption in days of each food group. To calculate the FCS, the consumption frequencies are added together and multiplied by the standardized weight of the food group, as shown in the formula below [32].

$$FCS = a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8$$

where: a = Weight assigned to the food group; X = Number of days of consumption for each food group (≤7 days) 1 = cereals; 2 = vegetables; 3 = pulses; 4 = fruit; 5 = animal protein; 6 = sugar; 7 = milk and milk products; 8 = oil and fat.

The scores obtained were used to classify participants into three categories with the following thresholds. A food consumption score between 0 and 28 corresponds to poor food consumption; a food consumption score between 28.5 and 42 corresponds to borderline food consumption; and a food consumption score above 42 corresponds to acceptable food consumption [32]. These three categories have been grouped into two groups: unacceptable food consumption (poor food consumption + borderline food consumption) and acceptable food consumption.

Assessment of individual Dietary Diversity Score (***IDDS***)

IDDS is an indicator of a diet's micronutrient adequacy, an important dimension of its quality. A qualitative food group consumption questionnaire created as a part of the FANTA (Food and Nutrition Technical Assistance) project was used to measure IDDS [33]. A score of "1" was assigned if a food group was present in the 24-hour recall, and a score of "0", if a food group was absent. The IDDS was determined by counting the number of food groups (9) (cereals; roots and tubers; vitamin A-rich plants; other fruits and vegetables; legumes/nuts; meat, poultry, fish and seafood; eggs; milk and dairy products; oils and fats) consumed by the respondent in the previous day or night. Participants were classified into three categories according to their dietary diversity score: IDDS [1 - 2] = low dietary diversity; IDDS [3 - 4] = moderate dietary diversity, and IDDS [>4] = high dietary diversity [33]. These three categories were grouped into 2 groups: low dietary diversity (IDDS 1 - 2) and IDDS 3 - 4) and high dietary diversity (IDDS greater than 4).

A synthetic food security index (SFSI) was determined by combining the scores of the two previously assessed indicators. Four levels of food security were derived: high food security, characterized by high and stable food access (FCS > 42) and high dietary diversity (IDDS) (IDDS > 4); moderate food security, defined by high (FCS > 42) or medium (28. 5 < FCS ≤ 42) and medium (3 < IDDS ≤ 4) or high (IDDS > 4) dietary diversity; moderate food insecurity, defined by very low (0 < FCS ≤ 28) or medium (28.5 < FCS ≤ 42) to food or high dietary diversity (IDDS > 4); and high food insecurity, which is defined by very low access to food (0 < FCS ≤ 28) and low dietary diversity (1< IDDS <2).

After determining the four levels of food security, we considered only food insecure participants (high food insecurity and moderate food insecurity).

2.5. Anthropometric Measurements

The various anthropometric measurements were carried out on each participant. Weight was measured using a TANITA TM scale (BC-418 Segmental Body Composition Analyzer/Scale); height was measured using a SECA 217 vertical tape measure graduated to the nearest centimeter. Waist circumference was measured with a tape measure at the midpoint between the lower edge of the last palpable rib and the top of the iliac crest. Body mass index (BMI) was then calculated using the following formula:

$$\text{BMI}\left(\text{Kg/m}^2\right) = \frac{\text{Weight}\left(\text{Kg}\right)}{\text{Height}^2\left(\text{m}\right)}$$

2.6. Measurement of Blood Pressure and Diagnosis of Hypertension

Blood pressure was measured using an A&D Medical radial electronic sphygmomanometer (*A&D company*, *Limited Kitamoto-shi*, *Saitama Japan*) at rest. The participant remained seated for at least 10 minutes, with the left arm placed parallel to the heart. The values obtained on the dial of the device were used to assess the presence or absence of hypertension. The WHO [34] definition was used to diagnose hypertension (systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg).

2.7. Blood Sampling and Biochemical Analyses

2.7.1. Blood Sampling

Blood samples were taken from participants who had fasted for at least 12 hours. Approximately 4 mL of blood was collected by venipuncture at the elbow into an EDTA (ethylene diamine tetra acetic) tube. Plasma was centrifuged at 1500 g for 10 minutes.

2.7.2. Biochemical Analyses

The parameters of interest were: glucose, total cholesterol, triglycerides, insulin, highly sensitive C-reactive protein (hsCRP) and tumor necrosis factor (TNF*α*). Fasting blood glucose was assessed by the Glucose Oxidase-Peroxidase (GOP-POD) method immediately in the field using a glucometer (GlucoPlusTM). Plasma total cholesterol and triglyceride levels were assessed by the standard enzymatic method using ChronoLab kits (*Traverssia Prat de la Riba* 34 *B* 08849 *Sant Climent de Llobregat Barcelona*, *Spain*). Fasting plasma insulin, hs-CRP and TNF-*α* were determined by ELISA and microplate reader spectrophotometer. Insulin resistance was assessed using the Homeostasis Model Assessment Insulin Resistance (HOMA-IR) formula described by Mathews *et al.* [35] as follows : HOMA-IR = fasting insulin (IU/mL) × fasting plasma glucose (mM)/22.5.

2.8. Data Analysis

Data were entered in duplicate into Microsoft Excel 2016, cleaned and coded before being exported to *Statistical Package for Social Sciences* (*SPSS*) version 25.0 for Windows for statistical analyses. Results were presented as mean ± standard deviation (continuous variables) and frequency (%) (categorical variables). Descriptive statistics were used to describe the distributions of each variable studied, in order to determine their characteristics (frequency, mean, standard deviation). Pearson's chi-square test was used to compare proportions between categorical variables. Student's t-test was used to detect differences in means between the control and case groups. To determine the association between hypertension, diabetes and certain risk factors (sociodemographic factors, biological factors and dietary factors), bivariate logistic regression was performed. The significance threshold was set at $p < 0.05$.

3. Results

3.1. Socio-Demographic and Lifestyle Characteristics of Participants with and without Hypertension and Diabetes

Table 1 presents the socio-demographic and lifestyle characteristics of the participants. It shows that 43.4% of the study population were hypertensive and 50% were diabetic. Men (57.70%) were significantly more affected by hypertension than women (38.00%) ($p < 0.05$). In addition, we observed that participants who consumed alcohol were significantly more hypertensive (56.50%) than normotensive (43.50%) ($p < 0.05$). With regard to diabetes, participants with a low socio-economic status were more affected by diabetes (59.50%) than those with a high socio-economic status (47.70%) ($p < 0.05$).

Table 1. Sociodemographic and lifestyle characteristics of participants with and without hypertension and diabetes.

Variables		Hypertension			Diabetes		
		Controls % (N)	Case % (N)	P value	Controls % (N)	Case % (N)	P value
General population		56.60 (201)	43.40 (153)		50.00 (135)	50.00 (135)	
sex	Women	62.00 (147)	38.00 (90)	0.00	49.70 (90)	50.30 (91)	0.966
	Male	45.30 (53)	57.70 (64)		50.00 (44)	50.00 (44)	
Age group	20 - 39 years	56.10 (74)	43.90 (58)	0.56	41.90 (44)	58.10 (61)	0.09
	40 - 59 years	59.10 (94)	40.90 (65)		53.70 (65)	46.30 (56)	
	≥60 years	50.9 (28)	49.10 (27)		59.50 (22)	40.50 (15)	
Level of education	Illiterate/primary	53.60 (89)	46.40 (77)	0.57	46.90 (60)	53.10 (68)	
	Secondary	59.00 (98)	41.00 (68)		51.20 (65)	48.80 (62)	0.11
	University	60.00 (12)	40.00 (8)		76.90 (10)	23.10 (3)	
Marital status	Single	62.50 (40)	37.50 (24)	0.08	12.70 (17)	18.90 (25)	0.37
	Married	52.20 (119)	47.80 (109)		70.10 (94)	65.20 (86)	
	Widowed/Divorced	66.10 (39)	33.90 (20)		17.20 (23)	15.90 (21)	
Socioeconomic level	Low	53.20 (41)	46.80 (36)	0.51	40.50 (19)	59.50 (40)	0.00
	Medium	58.90 (132)	41.10 (92)		52.20 (96)	47.80 (75)	
	High	51.90 (28)	48.10 (26)		52.30 (20)	47.70 (20)	
Physical activity	Low	50.70 (36)	49.30 (35)	0.80	43.10 (25)	56.90 (33)	0.14
	Medium	55.20 (53)	44.80 (43)		52.60 (41)	47.40 (37)	
	High	55.10 (65)	44.90 (53)		59.80 (52)	40.20 (35)	
Alcohol	No	63.60 (140)	36.40 (80)		47.90 (81)	52.10 (88)	0.37
	Yes	46.50 (60)	53.50 (69)	0.00	53.50 (53)	46.50 (46)	
Tabacco	No	57.20 (194)	42.80 (145)		50.40 (128)	49.60 (126)	0.51
	Yes	50.00 (5)	50.00 (5)	0.64	40.00 (4)	60.00 (6)	

3.2. Anthropometric, Hemodynamic and Biochemical Characteristics of Participants with and without Hypertension and Diabetes

Table 2 provides an overview of the anthropometric, hemodynamic and biochemical characteristics of the study population. The mean values for age and waist circumference were significantly higher in hypertensive participants living with food insecurity ($p < 0.05$). In contrast, the mean values for triglycerides, total cholesterol, CRP and TNF alpha were significantly higher in normal-tense participants living with food insecurity ($p < 0.05$). Similarly, these results show that weight, body mass index and CRP were significantly higher in food insecure, non-diabetic participants than in diabetic participants ($p < 0.05$). In contrast, mean values for triglycerides and total cholesterol were significantly higher in participants living with food insecurity and diabetes than in those without diabetes ($p < 0.05$).

Table 2. Anthropometric, hemodynamic and biochemical characteristics in participants with and without hypertension and diabetes.

Parameters	Hypertension			Diabetes		
	Controls (Mean ± SD)	Cases (Mean ± SD)	P value	Controls (Mean ± SD)	Cases (Mean ± SD)	P value
Age (years)	40.65 ± 13.43	45.26 ± 13.62	0.02	42.33 ± 12.71	42.67 ± 14.14	0.83
Anthropometric characteristics						
Weight (Kg)	67.04 ± 21.39	70.25 ± 24.24	0.18	74.67 ± 18.90	66.29 ± 23.52	0.00
Waist circumference (cm)	82.80 ± 23.85	91.10 ± 20.61	0.00	90.44 ± 18.07	87.61 ± 21.17	0.25
BMI (Kg/m^2)	26.77 ± 6.22	28.02 ± 5.50	0.05	28.71 ± 5.63	26.94 ± 6.16	0.01
Biochemical characteristics						
Triglycerides (mg/dL)	112.77 ± 65.07	93.76 ± 43.45	0.03	93.78 ± 45.98	119.08 ± 67.85	0.00
Total cholesterol (mg/dL)	171.79 ±84.00	152.22 ±75.47	0.02	146.55 ± 75.49	175.12 ± 79.47	0.00
Glucose (mg/dL)	121.53 ± 45.76	123.48 ± 51.70	0.74	91.49 ± 12.41	155.59 ± 50.19	<0.00
HOMA-IR	4.69 ± 0.35	4.61 ± 0.30	0.06	4.47 ± 0.24	4.82 ± 0.31	<0.00
CRP (mg/L)	7.18 ± 2.39	6.57 ± 1.59	0.00	7.20 ± 2.43	6.19 ± 2.26	0.00
TNF-α (pg/L)	21.14 ± 11.20	19.98 ± 9.80	0.02	23.53 ± 10.30	22.73 ± 10.95	0.67
Insulin (µU/mL)	16.27 ± 10.74	12.95 ± 7.27	0.07	11.81 ± 7.80	19.48 ± 10.38	<0.00
Haemodynamic characteristics						
PAS (mmHg)	116.79 ± 10.78	146.12 ± 19.83	<0.001	132.71 ± 22.54	129.93 ± 29.76	0.301
PAD (mmHg)	66.90 ± 22.64	97.18 ± 14.14	<0.001	82.40 ± 19.60	83.42 ± 23.46	0.703
Pulses (beats/min)	71.84 ± 22.85	66.95 ± 25.16	0.057	69.39 ± 21.14	69.10 ± 26.91	0.923

3.3. Food Profile and Quality of Diet in Participants with and without Hypertension and Diabetes

Table 3 shows the distribution of the food group consumption frequency, food consumption score and dietary diversity score in participants with and without hypertension and diabetes. In terms of the consumption of protective foods, participants with hypertension consumed more fruit than those with normal blood pressure (51.10% high consumption vs. 39.70%) ($p < 0.05$). In contrast, normal glycaemic consumed more fruit than diabetics (53.20% vs 38.30%) ($p < 0.05$). Similarly, a higher frequency of legume consumption was observed in normal glycaemic participants (88.10%) than in diabetics (67.90%) ($p < 0.05$). In terms of deleterious foods, we observed a higher frequency of consumption of tubers and oils and fats in normal glycaemic participants compared to diabetics ($p < 0.05$). When we look at the individual dietary diversity score, it emerges that high dietary diversity was significantly more accentuated in normal with high blood pressure than in hypertensives ($p < 0.05$).

Table 3. Distribution of food group consumption frequency, food consumption score and dietary diversity score in participants with and without hypertension and diabetes.

Food groups		Hypertension			Diabetes		
		Controls % (N)	Cases % (N)	P value	Controls % (N)	Cases % (N)	P value
Protective foods							
Vegetables (zoom, folon, cabbage etc…)	Low	55.70 (112)	56.90 (87)	0.83	62.20 (84)	54.50 (73)	0.19
	High	44.30 (89)	43.10 (66)		37.80 (51)	45.50 (61)	
Fruits (orange, pineapple etc…)	Low	60.30 (114)	48.90 (65)	0.04	46.80 (52)	61.70 (79)	0.02
	High	39.70 (75)	51.10 (68)		53.20 (59)	38.30 (49)	
Pulse (beans, peanuts etc…)	Low	22.90 (46)	22.20 (34)	0.88	11.90 (16)	32.10 (43)	<0.00
	High	77.10 (155)	77.80 (119)		88.10 (119)	67.90 (91)	
Deleterious foods							
Cereals (maize, millet, wheat flour etc …)	Low	14.90 (30)	15.00 (23)	0.97	16.30 (22)	14.20 (19)	0.62
	High	85.10 (171)	85.00 (130)		83.70 (113)	85.80 (115)	
Tubers (potato, yam, etc…)	Low	47.80 (96)	50.00 (77)	0.67	42.20 (57)	54.80 (74)	0.03
	High	52.20 (105)	50.00 (77)		57.80 (78)	45.20 (61)	
Oils & fats (red oil, butter, peanut oil etc…)	Low	22.90 (46)	22.20 (26)	0.17	8.10 (11)	26.90(36)	<0.00
	High	77.10 (155)	77.80 (127)		91.90 (124)	73.10 (98)	
Food consumption							
Food consumption score	Poor	84.60 (170)	77.90 (120)	0.10	86.70 (117)	80.70 (109)	0.18
	Acceptable	15.40 (31)	22.10 (34)		13.30 (18)	19.30 (26)	
Individual dietary diversity score	Low diversity	72.30 (107)	88.40 (175)	<0.00	82.00 (109)	82.30 (107)	0.94
	High diversity	27.70 (41)	11.60 (23)		18.00 (24)	17.70 (23)	

3.4. Association between Biological Factors and Hypertension and Diabetes in the Study Population

Table 4 shows the association between biological factors and hypertension and diabetes in the study population. Abdominal obesity increased the risk of participants developing hypertension (OR = 1.89, CI 95% 1.20 - 2.97). In contrast, hypertriglyceridaemia (OR = 2.24, CI 95% 1.13 - 4.40) increased the risk of diabetes in the study population.

3.5. Association between Socio-Demographic and Lifestyle Factors and Hypertension and Diabetes in the Study Population

Table 5 presents the risk of developing hypertension and diabetes in relation to the socio-demographic and lifestyle factors in the study population. The risk of developing hypertension was elevated in men (OR = 1.97; 95% CI: 1.25 - 3.08) and in participants with regular alcohol consumption (OR = 2.01; 95% CI: 1.29 - 3.13). No significant association was observed between the socio-demographic factors and diabetes.

Table 4. Association between biological factors, and hypertension and diabetes in the study population.

Risk factor		Hypertension		Diabetes	
		Odds ratio (OR) (95% CI)	P value	Odds ratio (OR) (95% CI)	P value
Abdominal obesity	No	1		1	
	Yes	1.89 (1.20 - 2.97)	0.00	0.74 (0.44 - 1.24)	0.25
Hypertriglyceridemia	No	1		1	
	Yes	0.55 (0.30 - 1.00)	0.05	2.24 (1.13 - 4.40)	0.01
Total hypercholesterolemia	No	1		1	
	Yes	0.60 (0.37 - 0.98)	0.04	1.69 (0.97 - 2.96)	0.06
High CRP	No	1		1	
	Yes	0.38 (0.20 - 0.73)	0.00	1.08 (0.55 - 2.13)	0.80

Table 5. Association between socio-demographic factors, lifestyle, and hypertension and diabetes in the study population.

Risk factor		Hypertension		Diabetes	
		Odds ratio (OR) (95% CI)	P value	Odds ratio (OR) (95% CI)	P value
Sexe	Women	1		1	
	Male	1.97 (1.25 - 3.08)	0.00	0.98 (0.59 - 1.64)	0.96
Age group	20 - 39 years	1		1	
	40 - 59 years	0.88 (0.55 - 1.40)	0.59	0.62 (0.36 - 1.05)	0.07
	≥60 years	1.23 (0.65 - 2.31)	0.51	0.49 (0.22 - 1.05)	0.06
Level of education	University	1		1	
	Illiterate/primary	1.29 (0.50 - 3.33)	0.58	3.77 (0.99 - 14.37)	0.05
	Secondary	1.04 (0.40 - 2.68)	0.93	3.17 (0.83 - 12.09)	0.09

Continued

Marital status	Single	1		1	
	Married	1.52 (0.86 - 2.69)	0.14	0.62 (0.31 - 1.23)	0.17
	Widowed/Divorced	0.85 (0.40 - 1.79)	0.67	0.62 (0.26 - 1.45)	0.27
Socioeconomic level	Low	1		1	
	Medium	0.79 (0.47 - 1.33)	0.38	2.10 (0.92 - 4.80)	0.07
	High	1.05 (0.52 - 2.12)	0.87	0.78 (0.39 - 1.55)	0.48
Physical activity	High	1		1	
	Low	1.19 (0.66 - 2.15)	0.55	1.96 (1.00 - 3.84)	0.05
	Medium	0.99 (0.57 - 1.17)	0.98	1.34 (0.72 - 2.48)	0.35
Alcohool	Irregular	1		1	
	Regular	2.01 (1.29 - 3.13)	0.00	0.79 (0.48 - 1.31)	0.37
Tabacco	Non-smoker	1		1	
	Smoker	1.33 (0.38 - 4.70)	0.65	1.52 (0.42 - 5.52)	0.52

3.6. Association between Food Group Consumption Frequency, Food Consumption Score and Food Diversity Score and Hypertension and Diabetes in the Study Population

Table 6 shows the risk of developing hypertension and diabetes in relation to the frequency of consumption of food groups, the food consumption score and the dietary diversity score in the study population. Low fruit consumption (≤3 times/week) increased the risk of hypertension (OR = 1.59; 95% CI: 1.01 - 2.48). Similarly, the risk of diabetes (OR = 1.82; 95% CI: 1.09 - 3.06) was increased by low fruit consumption (≤3 times/week). Low dietary diversity (OR = 2.91; 95% CI: 1.65 - 5.12) increased the risk of arterial hypertension. Low consumption (≤3 times/week) of legumes (OR = 3.51; 95% CI: 1.86 - 6.63) was associated with an increased risk of diabetes in our study population.

4. Discussion

This case-control study aimed to assess how food insecurity affects the metabolic profile of individuals with diabetes or hypertension. Our results showed that the prevalence of hypertension and diabetes was 43.4% and 50%, respectively, in the food-insecure population. The prevalence of HTN and diabetes obtained in this study was higher than that obtained in studies conducted in the Cameroonian population by Biyegue *et al.* [36], and Bigna *et al.* [37]. This high prevalence can be explained in part by the food insecurity status of study participants included in this study opposite to those reported by these authors. Indeed, studies have shown that food insecurity is associated with a 33% increase in the risk of hypertension [38] and an increase in the risk of diabetes and its complications [23] [39]. Clinically, these participants who are diabetic and hypertensive could be at risk of arthrosclerosis, retinopathy, nephropathy and neuropathy which are major causes of morbidity and mortality in diabetic and hypertensive patients [40].

Table 6. Association between food group consumption frequency, food consumption score and dietary diversity score, and hypertension and diabetes in the study population.

		Hypertension		Diabetes	
		Odds ratio (or) (95% CI)	P value	Odds ratio (or) (95% CI)	P value
Protective food					
vegetables	High	1		1	
	Low	1.04 (0.68 - 1.60)	0.83	0.72 (0.44 - 1.18)	0.19
Fruits	High	1		1	
	Low	1.59 (1.01 - 2.48)	0.04	1.82 (1.09 - 3.06)	0.02
Pulse	High	1		1	
	Low	0.96 (0.58 - 1.59)	0.88	3.51 (1.86 - 6.63)	0.000
Deleterious food					
Cereals	Low	1		1	
	High	0.99 (0.55 - 1.78)	0.97	1.178 (0.60 - 2.29)	0.62
Tubers	Low	1		1	
	High	0.97 (0.60 - 1.39)	0.67	0.60 (0.37 - 0.97)	0.03
Oils & fats	Low	1		1	
	High	1.45 (0.84 - 2.47)	0.17	0.24 (0.11 - 0.49)	0.00
Food consumption					
Food consumption score	Acceptable	1		1	
	Poor	0.66 (0.37 - 1.10)	0.11	0.64 (0.33 - 1.24)	0.19
Individual dietary diversity score	High diversity	1		1	
	Low diversity	2.91 (1.65 - 5.12)	0.00	1.02 (0.54 - 1.92)	0.94

The high prevalence of both HTN and diabetes can be explained by the interconnected pathophysiological mechanisms of these two pathologies. Indeed, hypertension is more common in diabetic patients and diabetes is also more prevalent in hypertensive patients than in the general [41]. Thus, there is a close association between hypertension and diabetes. Activation of the systemic and tissue renin angiotensin aldosterone system (RAAS) in insulin-resistant states plays an important role in the development of hypertension. Studies have shown that insulin resistance and hyperglycemia induce systemic RAAS activation, associated with increased vascular resistance and blood pressure [42].

Our study revealed that low fruit consumption was significantly associated with high blood pressure and diabetes in the study population. Fruit is an agricultural commodity that contributes significantly to dietary diversity and nutritional adequacy in terms of vitamins, minerals such as potassium and magnesium, antioxidants and dietary fiber [43] [44]. These compounds, notably potassium and magnesium, are known to have protective effects on endothelial function [45]. More specifically, potassium improves the bioavailability of NO (a potent vasodilator) by promoting endothelial NO synthase (eNOS) activity [46]. Increased potassium intake inhibits renin secretion and angiotensin II production via the renin angiotensin aldosterone system (RAAS), thus reducing vasoconstriction and sodium retention effects that increase blood pressure [47]. Similarly, the minerals, and antioxidants contained in fruit can improve insulin sensitivity, potentially by decreasing apoptosis, promoting pancreatic β-cell proliferation, and reducing muscle inflammation and oxidative stress [48]. In addition, fruit consumption may indirectly influence T2D risk by preventing excess adiposity, via dietary fiber, thereby contributing to satiety [49]. These dietary fibers (insoluble and soluble) may also improve glycemic control. Recent data suggest that the fermentation of soluble fibers by the gut microbiome may provide further benefits by increasing the production of short-chain fatty acids, which have been shown to modulate glucose metabolism [50]. However, considering the availability and accessibility of the types of fruits farmed and consumed in the different study areas could bring more insides on the relationship denoted in the present study.

This study identified the specific factors for each cardiovascular risk factor. For example, in the case of hypertension, we observed that high blood pressure was strongly associated with low dietary diversity, which is a characteristic of food insecurity. This state of food insecurity could be exacerbated if no measures are taken to improve dietary diversity. The clinical consequence could be the onset of several other diseases. Food insecurity is associated with poor diet and nutritional deficiencies. Diets lacking important minerals such as potassium are linked to higher blood pressure [51]. Low dietary diversity has been associated with diets low in protective nutrients, making individuals more vulnerable to chronic diseases such as hypertension [52].

This study showed that low consumption of legumes predisposed the study population to diabetes. The beneficial effects of legume consumption on the regulation of glucose metabolism might be linked to several mechanisms. The bioavailability of legume carbohydrates may be reduced by resistant starch factors [53]. In addition, legumes possess natural amylase inhibitors that can reduce amylase activity and thus slow the process of carbohydrate digestion in the small intestine, thereby reducing glucose index values, which may contribute to the dietary prevention of diabetes [54].

The results of this study also showed that alcoholism is a risk factor for hypertension in food-insecure individuals. Food insecurity increases the risk of excessive alcohol consumption as a coping strategy for stress and poverty [55]. This link may be particularly relevant in sub-Saharan Africa, where alcoholism is widespread [56]. Studies of food-insecure populations have found positive associations between alcohol dependence and hypertension after controlling for socio-economic factors [57]. Several studies have shown that alcoholism is a well-established risk factor for hypertension [58] [59]. Some studies have highlighted the role of cortisol in alcohol-induced increases in blood pressure [60]. Alcohol stimulates the secretion of corticotropin-releasing hormones, which in turn stimulates cortisol secretion [61], sympathetic stimulation and hypertension. The hormonal profile of these participants could provide a clearer picture of the above-mentioned mechanism.

In addition, this study showed that males were predisposed to hypertension in the study population. This finding is in line with numerous studies that have indicated that men are more affected by hypertension than women worldwide [62], and more specifically in Cameroon [63]. This observed difference is thought to stem from sex hormones that protect women against hypertension [64]. Indeed, estrogen secreted by women has the capacity to protect the cardiovascular system and endothelial function in women. Estrogen is thought to affect the vascular wall, both smooth muscle and endothelium, by stimulating the release of vasoactive mediators such as nitric oxide, which promotes arterial vasodilation, modulates inflammatory processes and regulates the balance of oxidative stress [65]. To deeply understanding of the relationship between the gender and hypertension, some parameters such as food intake, physical activity and alcohol consumption could be considered.

Among the various biological factors studied, abdominal obesity was the only predisposing factor for hypertension in food insecure individuals. In sub-Saharan Africa in nutritional transition, food insecurity has been shown to exacerbate the risk of obesity [66]. A cross-sectional study in Cameroon found that food insecurity was associated with a higher prevalence of abdominal obesity, confirming its role in obesity-related comorbidities such as hypertension [67]. Visceral fat promotes hypertension through the secretion of pro inflammatory adipokines that impair insulin sensitivity and promote endothelial dysfunction [68]. On the other hand, hypertriglyceridemia is, the only condition that predisposed to diabetes. Indeed, the literature shows that hypertriglyceridemia affects more than half of diabetic participants. This association may be explained by the etiology of diabetes. Indeed, in patients with diabetes, insulin resistance is at the root of the inefficiency of lipoprotein lipase, an enzyme essential for breaking down triglycerides in the circulation. Our results are in line with those of Charoensri *et al*. [69], who showed that hypertriglyceridemia is an independent risk factor for future diabetes, probably due to the aggravation of insulin resistance and the acceleration of islet beta cell dysfunction. Our results are in line with those of Peng *et al*. [66], who showed that the risk of type 2 diabetes was elevated in participants with hypertriglyceridemia (OR = 1.92, CI 95% 1.49 - 2.46).

5. Conclusion

In conclusion, the results of this study showed that food insecure participants were at risk for diabetes and hypertension. These observations suggest that food insecurity should be considered when establishing nutritional policies for the management and prevention of diabetes and hypertension in our country.

Limitations of the Study

Limitations include participant self-reported data, which made dietary assessment difficult to appreciate.

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Availability of Data and Material

Data and material of this study are available request from the corresponding authors.

Authors' Contribution

BRTT and JLN conceived and designed the study. BRTT, PVH, OM, JAFY, JLNM collected the data and conducted the laboratory analyses. BRTT, FRN, BGKA carried out the statistical analysis. BRTT, RGNT, HTM wrote the paper. JLN revised the manuscript. JLN and JEO supervised the work. All authors read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest related to the publication of this article.

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