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Prehypertension and Its Associated Factors among Adults in Kisangani (DR Congo): A Community-Based Cross-Sectional Study

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Abstract

This cross-sectional study investigates the prevalence of prehypertension (PHTN) and its associated factors among adults in Kisangani, Democratic Republic of Congo (DRC). Using a modified WHO-STEPS questionnaire with a sample of 422 participants, the study found a PHTN prevalence of 33.8%. Multivariable analysis revealed significant associations between PHTN and older age, male sex, obesity, family history of hypertension and diabetes, stress, hypercholesterolemia, low physical activity, daily smoking, and alcohol consumption. The study highlights the need for primary prevention strategies targeting these modifiable risk factors to reduce the burden of hypertension and cardiovascular diseases in Kisangani.

Keywords

Prevalence, Prehypertension, Associated Factors, Adult, Kisangani

1. Introduction

The term "Prehypertension," introduced by JNC7 in 2003, created a new category for elevated blood pressure, acting as an early indicator for the potential onset of hypertension and cardiovascular disease [1]. This condition, known as prehypertension (PHTN), is increasingly prevalent among young people, especially in low- and middle-income countries [2]. Even if PHTN does not progress to full-blown hypertension, it remains a significant health concern, heightening the risk of cardiovascular disease. PHTN can swiftly escalate to hypertension, particularly when blood pressure readings are close to the hypertension threshold [3].

In the Democratic Republic of the Congo (DRC), there is a notable increase in non-communicable diseases, with cardiovascular issues being particularly alarming. Hypertension is widespread, affecting as much as 41.4% of the urban population [4].

Like many African nations, the DRC is undergoing an epidemiological transition, where both infectious and chronic non-communicable diseases are present. This dual burden poses a considerable challenge to the already strained healthcare system in the DRC, highlighting the importance of primary prevention, particularly in managing PHTN.

Urbanization, which can influence cardiovascular risk and contribute to the onset of PHTN, is evident in Kisangani, the DRC's third-largest city. However, there is a lack of available data on PHTN in our region. Gaining a better understanding of the epidemiological profile of PHTN is crucial for shaping policies aimed at preventing and managing cardiovascular disease. This study aims to address this gap by estimating the prevalence of PHTN and identifying associated factors among individuals in Kisangani.

2. Methods

2.1. Framework and Nature of the Study

We carried out a descriptive and analytical cross-sectional study in Kisangani city from March 2024 to November 2024.

2.2. Study Population, Sampling Procedure, and Sample Size

The study population included residents of Kisangani. We calculated the sample size using the formula $z^2p(1-p)/d^2$. Assuming a prevalence of prehypertension "p" at 50% and a permissible error "d" of 5% with a 95% confidence interval, the minimum sample size was determined to be n = 384. To account for potential non-responses and the study design, we set the final sample size at 422.

This sample was distributed across the five Health Zones (excluding the Lubunga Health Zone for security reasons) using a stratified sampling method. We began by randomly selecting four Health Areas from the complete list of Health Areas in the Health Zones. Within each Health Area, we randomly chose two avenues and employed systematic sampling to select houses within each avenue. This process involved counting all homes in the avenue (N), dividing the total by the number of subjects needed to determine the sampling interval (k), selecting the first home to survey, and then adding the sampling interval to reach the desired number.

2.3. Selection Criteria

Participants had to meet the following criteria to be included in the study: they needed to be at least 18 years old, have lived in Kisangani for a minimum of 6 months, and agree to participate in the study.

The following were excluded from this study:

- Hypertensive subjects (with or without treatment).
- Subjects with severe chronic disease (such as end-stage renal disease, uncontrolled diabetes mellitus, systemic inflammatory or autoimmune diseases, active cancer or cancer under treatment).
- Subjects with a history of cardiovascular events (such as acute coronary syndrome, stroke or lower limb arterial disease).
- Subjects with an active pregnancy.
- Subjects use drugs that may affect blood pressure, such as corticosteroids, substances known to alter blood pressure levels, oestrogen-based oral contraceptives, etc.
- Subjects with cognitive problems or communication difficulties.
- People who do not live in the city of Kisangani and those with a temporary residence in the region.

2.4. Study Variables

The study focused on various parameters, including sociodemographic, anthropometric, clinical, lifestyle, and biological data.

2.5. Data Collection

Trained interviewers collected data using a structured and standardized questionnaire. The survey utilized a WHO STEP questionnaire that was adapted to fit local contexts. Data entry was performed using the KoboCollect Version v2022.4.4 mobile app.

Blood pressure was measured with a calibrated Omron automatic digital monitor (Omron HEM-757; Omron Corp, Tokyo, Japan) after participants rested for 15 minutes in a seated position in a quiet environment, away from food and tobacco. The average of the readings was recorded. Three measurements were taken at 5-minute intervals, ensuring the participant had rested for at least 5 minutes in a seated position. For analysis, we used the average of the last two measurements.

Weight was measured using a well-calibrated SECA scale placed on a stable, flat surface, with participants lightly dressed and unshod, and results were recorded in kilograms (kg). Height was measured in centimeters (cm) using a portable height gauge, with individuals not wearing shoes or hats. Waist circumference (cm) was measured with a standard new soft tape measure applied directly to the skin, along the middle axillary line, halfway between the lower edge of the last rib and the upper edge of the iliac crest on each side. Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in meters).

A validated Food Frequency Questionnaire (FFQ) was employed to assess fruit intake, while the International Physical Activity Questionnaire (IPAQ) was used to document health-related behaviors, including levels of physical activity.

The study adhered to the criteria set forth in the Declaration of Helsinki. Respondents were assured of their anonymity and confidentiality. Participation was voluntary, following a thorough explanation and obtaining free informed consent.

Approval was secured from provincial health authorities prior to the commencement of the study.

2.6. Data Quality Management

The questionnaire was crafted by an Internal Medicine Specialist from the Faculty of Medicine and Pharmacy at the University of Kisangani. To ensure its relevance to the local population, an expert researcher in public health from the same faculty conducted face validity and content validity assessments.

Data collectors and their immediate supervisors underwent a week-long training on the data collection instrument, key variables, and their measurements. A pre-test was administered to 5% of the total sample size, consisting of individuals with similar socio-economic characteristics to the study population. Based on the issues identified and experiences gained during the pre-test, the data collection team received additional training. Laboratory technicians were trained on the standard operating procedures for blood sample collection. The principal investigator and field supervisors provided daily supportive supervision throughout the data collection period. Any incomplete or inconsistent data were returned to the data collectors for correction.

2.7. Operational Definitions

According to WHO criteria, a prehypertensive individual is defined as having a systolic blood pressure between 120 and 139 mmHg and/or a diastolic blood pressure between 80 and 89 mmHg. An individual is classified as lean if their BMI is less than 18 kg/m^2, normal if their BMI is between 18 and less than 25 kg/m^2, overweight if their BMI is between 25 and 30 kg/m^2, and obese if their BMI is 30 kg/m^2 or higher.

Physical inactivity was defined as the absence of daily physical activity or the presence of physical activity lasting less than 150 minutes per week. Active smoking was considered a risk factor when it was current or recently discontinued.

Alcoholism was retained for alcohol consumption plus 3 glasses of beer (male) or two glasses (female) per day.

2.8. Statistical Analysis

The data was processed and analyzed using the 22nd version of SPSS software. Data are expressed in absolute values or percentages and mean plus standard deviation. The Odds ratio (OR) was used to look for factors associated with prehypertension. The statistical significance threshold was set at 5% ($p < 0.05$). Independent variables associated with prehypertension at the bivariate analysis level were selected for multivariate analysis. During this analysis, potential confounders or effect modifiers were investigated. The logistic regression model with a "step-down" modelling strategy was adopted and independent variables with a p-value higher than the 5% significance threshold were eliminated to finally arrive at the final model.

3. Results

3.1. Sociodemographic Data of Study Participants

Based on these characteristics, the study's participants were mostly women between the ages of 18 and 29, living alone, Christian, employed, and illiterate, and from the Makiso-Kisangani Health Zone. The above data is presented in Table 1.

Table 1. Sociodemographic data of study participants in the city of Kisangani (N = 422).

Variables	Effective	Percentage (%)
Age (years) [Mean ± SD= 38.8 ± 13.3]		
18 - 29	279	66.2
30 - 39	72	17
40 - 49	34	8
50 - 59	21	5
≥60	16	3.8
Sex		
Male	189	44.8
Female	233	55.2
Maritus status		
Lives alone	278	65.9
Lives with spouse	144	34.1
Religion		
Christian	324	76.8
Islamic	49	11.6
Kimbanguiste	34	8
Other	15	3.6
Health zones of origin of study respondents		
Makiso-Kisangani	159	37.7
Mangobo	106	25.2
Kabondo	85	20,1
Tshopo	72	17
Occupationnel status		
Working	267	63.2
Not working	155	36.8
Education level		
Illiterate	159	37.8
Primary school	123	29.1
Secondary school	108	25.6
University	32	7.5

3.2. Clinical, Anthropometric and Biological Data of Study Participants in the City of Kisangani

Regarding clinical, anthropometric and biological characteristics of respondents, 298 (70.6%) of them had a normal BMI. The majority of participants in the study had normal blood sugar and cholesterol levels, reported no family history of hypertension, diabetes mellitus or stroke, and did not report stress. These data are presented in Table 2.

Table 2. Clinical, anthropometric and biological data of study participants in the city of Kisangani (N = 422).

Variables	Effective	Percentage (%)
BMI (kg/m²)		
Underweight (<18)	16	3.8
Normal weight (18 - 24.9)	298	70.6
Overweight (25 - 29.9)	72	17
Obese (≥30)	36	8.6
Family history of hypertension		
Yes	156	37
No	266	63
History of diabetes		
Yes	78	18.5
No	344	81.5
Stress		
Yes	133	31.5
No	289	68.5
Depression		
Yes	46	11
No	376	89
Blood glucose (hyperglycemia)		
Yes	24	5.7
No	398	94.3
Cholesterol (hypercholesterolemia)		
Yes	118	27.9
No	304	72.1

3.3. Lifestyles of Respondents of Study in the City of Kisangani

This study showed that the majority of respondents to the study have a low level of physical activity, have never smoked, do not use alcohol and consume fruit and vegetables less than 5 times a week. These data are given in Table 3.

Table 3. Lifestyles of respondents of study in the city of Kisangani (N = 422).

Variables	Effective	Percentage (%)
Physical activity		
Low (<150 min/week)	341	80.9
High (More 150 min/week)	81	19.1
Smoking		
Never smoked	375	80.8
Past smoked	27	6.4
Current daily smoked	20	4.8
Alcohol use		
Yes	106	25.1
No	316	74.9
Fruits and vegetables consumption		
<5 fruit/veg/day	384	90.9
More 5 fruit/veg/day	38	9.1

3.4. Prevalence of Prehypertension among Respondents in Kisangani (N = 422)

143 respondents out of 422 are prehypertensive, which represents a prevalence of prehypertension of 33.8%.

3.5. Factors Associated with Prehypertension among Study Respondents in the town of Kisangani

For the multivariable analysis, any predictor variables with a P-value of less than 0.05 in the bivariable analyses were deemed candidate variables. Factors associated with prehypertension in this study were elder age ≥ 50 years (AOR 1.27 [CI: 0.70 - 2.33]), male sex (AOR 1.5 [CI: 1.11 - 2.02]), obesity (AOR 2.78 [CI: 2.22 - 3.47]), family history of hypertension (AOR 1.73 ([CI: 1.24 - 2.40]), family history of diabetes (AOR 3.52 [CI: 2.59 - 4.78]), family history of stroke (AOR 7.05 [CI: 2.781 - 17.87]), stress (AOR 8.68 [CI: 3.477 - 21.69]), hypercholesterolemia (AOR 2.81 [CI: 1.74 - 4.53]), low physical activity (AOR 3.43 [2.80 - 4.21]), smoking daily (AOR 0.77 [CI: 0.63 - 0.94]) and alcohol use (AOR 0.24 [CI: 0.21 - 0.28]) (Table 4).

Table 4. Factors associated with prehypertension among study respondents in the town of Kisangani (N = 422).

Variables	COR (95% CI)	p	AOR (95% CI)	p
Age in year				
18 - 29	1.34 (0.67 - 2.72)	0.40	2.11 (0.98 - 4.27)	0.30
30 - 39	0.98 (0.80 - 1.22)	0.91	1.04 (0.89 - 1.22)	0.57
40 -49	1.30 (1.03 - 1.64)	0.023	1.29 (1.01 - 1.63)	0.05
50 - 59	4.33 (3.88 - 4.81)	<0.001	1.27 (0.70 - 2.33)	**<0.001**
≥60	6.18 (4.93 - 7.78)	<0.001	1.94 (1.65 - 2.29)	**<0.001**
Sex				
Male	1.67 (1.24 - 2.21)	<0.001	1.5 (1.11 - 2.02)	**0.008**
Female	1.28 (0.58 - 2.85)	0.53	1.51 (0.69 - 3.35)	0.08
Maritus status				
Lives alone	1.47 (0.86 - 2.51)	0.091	1.49 (0.83 - 2.67)	0.88
Lives with spouse	0.43 (0.15 - 1.14)	0.064	2.06 (1.13 - 3.75)	0.58
Religion				
Christian	1.07 (0.90 - 1.27)	0.39	1.23 (1.02 - 1.50)	0.02
Islamic	1.34 (0.67 - 2.72)	0.40	0.99 (0.78 - 1.26)	0.11
Kimbanguiste	1.28 (0.58 - 2.85)	0.50	1.29 (0.95 - 1.73)	0.09
Other	2.33 (0.34 - 2.87)	0.35	0.80 (0.50 - 1.29)	0.37
Health zones of origin of study respondents				
Makiso-Kisangani	1.08 (0.760 - 1.53)	0.66	0.68 (0.47 - 0.98)	0.44
Mangobo	1.24 (1.06 - 1.46)	0.70	1.18 (0.93 - 1.34)	0.23
Kabondo	0.89 (0.63 - 1.26)	0.52	0.94 (0.65 - 1.34)	0.73
Tshopo	1.17 (0.65 - 2.09)	0.58	1.18 (0.65 - 2.14)	0.57
Occupation				
With occupation	0.89 (0.63 - 1.26)	0.52	0.94 (0.65 - 1.34)	0.73
Without occupation	0.90 (0.62 - 1.29)	0.56	0.89 (0.61 - 1.28)	0.54
Education level				
Illiterate	1.08 (0.93 - 1.25)	0.31	1.06 (0.91 - 1.23)	0.43
Primary school	1.04 (0.89 - 1.22)	0.57	1.60 (1.00 - 2.56)	0.04
Secondary school	1.09 (0.61 - 1.94)	0.76	1.13 (0.63 - 2.04)	0.66
University	0.99 (0.53 - 1.88)	0.99	1.71 (0.96 - 3.06)	0.70
BMI (kg/m²)				
Normal weight (18 - 24.9)	0.83 (0.69 - 1.00)	0.060	0.89 (0.72 - 1.10)	0.29
Underweight (<18)	3.83 (2.78 - 8.75)	0.56	6.42 (0.61 - 10.43)	0.93
Overweight (25- 29.9)	6.42 (0.61 - 10.43)	0.53	1.51 (0.69 - 3.35)	0.08
Obese (≥30)	2.06 (0.90 - 4.69)	>0.05	2.78 (2.22 - 3.47)	**< 0.001**

Continued

Family history of hypertension				
Yes	0.61 (0.32 - 1.15)	0.13	1.73 (1.24 - 2.40)	**0.001**
No	1.39 (1.05 - 1.83)	0.02	1.24 (0.96 - 1.60)	0.08
Family history of diabetes				
Yes	2.39 (1.85 - 3.10)	<0.001	3.52 (2.59 - 4.78)	**< 0.001**
No	0.79 (0.57 - 1.10)	0.168	1.07 (0.75 - 1.53)	0.68
Stress				
Yes	5.24 (3.76 - 7.29)	<0.001	8.68 (3.477 - 21.69)	**<0.001**
No	1.30 (1.03 - 1.64)	0.02	1.29 (1.01 - 1.63)	0.03
Depression				
Yes	1.08 (0.76 - 1.53)	0.66	0.68 (0.47 - 0.98)	0.44
No	1.47 (1.09 - 1.98)	0.01	1.21 (0.78 - 1.88)	0.38
Blood glucose (hyperglycemia)				
Yes	1.08 (0.93 - 1.25)	0.31	1.06 (0.91 - 1.23)	0.43
No	1.04 (0.89 - 1.22)	0.57	1.11 (0.94 - 1.30)	0.19
Cholesterol (hypercholesterolemia)				
Yes	2.74 (1.72 - 4.35)	0.001	2.81 (1.74 - 4.53)	**0.001**
No	0.93 (0.61 - 1.42)	0.74	0.76 (0.45 - 1.30)	0.32
Physical activity				
Low (< 150 min/week)	1.21 (1.03 - 1.42)	0.020	3.43 (2.80 - 4.21)	**0.001**
High (More 150 min/week)	1.09 (0.90 - 1.32)	0.352	1.19 (0.95 - 1.51)	0.12
Smoking				
Never smoked	0.99 (0.53 - 1.88)	0.99	1.71 (0.96 - 3.06)	0.70
Past smoked	1.05 (0.45 - 2.48)	0.89	1.07 (0.49 - 2.42)	0.85
Current daily smoked	0.97 (0.82 - 1.16)	0.800	0.77 (0.63 - 0.94)	**0.010**
Alcohol use				
Yes	0.32 (0.28 - 0.37)	<0.001	0.24 (0.21 - 0.28)	**<0.001**
No	1.47 (1.00 - 2.15)	0.04	1.51 (1.03 - 2.26)	0.03
Fruits and vegetables consumption				
<5 fruit/veg/day	1.00 (0.72 - 1.40)	0.96	0.68 (0.47 - 0.97)	0.03
More 5 fruit/veg/day	1.02 (0.87 - 1.20)	0.76	0.85 (0.71 - 1.03)	0.11

4. Discussion

4.1. Prevalence of PHTN

This study examined the prevalence and contributing factors of PHTN among adults in Kisangani. Our survey results show that the prevalence of PHTN stands at 33.8%. This aligns with findings from other regional studies in sub-Saharan Africa,

where Noubiap *et al.* and Malik KS *et al.* reported that the prevalence of PHTN typically falls between 30% and 56.8% [5] [6]. However, this rate is lower than those observed in other regions, such as Southeastern Iran (42.03%), Serbia (49.07%), and Algeria (36.2%) [7]-[9].

Comparing data from various countries with our current study suggests that differences in social and cultural contexts, demographic characteristics, lifestyle choices, age distribution, and research methodologies could lead to variations in the prevalence of PHTN.

4.2. Risk Factors

The analysis using a multivariate logistic regression model identified several significant factors associated with PHTN, including older age, male sex, obesity, family history of hypertension, family history of diabetes, stress, hypercholesterolemia, low physical activity, daily smoking, and alcohol consumption.

1) Age

Our research highlights that age is a significant risk factor for PHTN, with a marked increase in incidence among older individuals. This finding is consistent with earlier studies conducted in Ethiopia and Algeria [9] [10]. This trend may be attributed to the physiological changes that accompany aging, such as increased arterial stiffness and diminished renal function, which contribute to elevated blood pressure.

2) Sex

This study showed that male sex was significantly correlated with PHTN compared with female subjects, which has been confirmed by other studies [7] [9]-[11]. Certain biological factors could explain this finding, such as the protective effects of oestrogens in women before the menopause, on the one hand, and certain biological, behavioural and socio-cultural factors specific to gender (e.g., eating habits, alcohol abuse, stress linked to work and family responsibilities) which are generally more pronounced in male subjects, on the other.

3) Obesity

Obesity was associated with PHTN in studies conducted in Iran, Algeria, Ghana, Nepal and China. This corroborates the observation made in this work. [7] [9]-[12]. A study by Hall *et al.* showed that overweight and obesity increase blood pressure by acting through various pathophysiological mechanisms, in particular physical compression of the kidneys by fat in and around the kidneys, activation of the renin-angiotensin-aldosterone system and increased sympathic nervous system activity [13].

4) Family history of hypertension

In our study, family history appeared to be a significant risk factor for PHTN. This association is consistent with the results of other previous studies [7] [10] [14]. This could be explained by the fact that genetic and environmental factors predispose individuals with a family history of hypertension to an increased risk of PHTN.

5) Family history of diabetes

In our study, we found that the prevalence of PHTN was higher among individuals with a history of diabetes. This association aligns with existing literature and is consistent with findings from studies conducted in Iran, Ethiopia, and Mexico [7] [15]-[17]. The molecular mechanisms that contribute to hypertension in diabetes include inappropriate activation of the renin-angiotensin-aldosterone system and the sympathetic nervous system, mitochondrial dysfunction, excessive oxidative stress, and systemic inflammation.

6) Stress

Research has shown that stress plays a significant role in PHTN. This condition is increasingly recognized as a stress-related illness, particularly among young adults. Chronic stress is linked to PHTN as it activates the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system, leading to elevated blood pressure and endothelial dysfunction [18]. Furthermore, high stress levels can lead to poor dietary choices, inactivity, increased consumption of alcohol or tobacco, and poor sleep quality, all of which can heighten the risk of cardiovascular disease.

7) Hypercholesterolemia

Previous studies have shown a positive link between hypercholesterolemia and pulmonary hypertension (PHTN) [9] [19]. Several mechanisms may explain this relationship, including the buildup of atheromatous plaques in the arterial walls, increased arterial stiffness, inflammatory processes, and vascular damage that can lead to elevated blood pressure.

8) Low levels of physical activity, smoking, and alcohol consumption

Numerous studies indicate a connection between lifestyle factors and PHTN. Smoking, alcohol use, and a lack of physical activity have all been associated with the onset of PHTN.

Smoking is a significant risk factor for prehypertension, affecting both demographic and physiological parameters. It has been shown to worsen sympathovagal imbalance, which is associated with high blood pressure in those with prehypertension [20]. Furthermore, smoking interacts with other risk factors, such as obesity and a family history of cardiovascular disease, increasing the likelihood of developing PHTN [21].

This study also highlights that excessive alcohol consumption is a major risk factor for PHTN, aligning with findings from other research [8] [22]. Alcohol can elevate blood pressure by enhancing sympathetic nervous system activity, altering endothelial function, and increasing sodium retention.

Low physical activity is another critical factor linked to prehypertension, as it leads to various physiological changes that can raise blood pressure. This finding is consistent with studies conducted in Algeria, Serbia, and China [8] [9] [12]. Research by Lavie *et al.* and Pescatello *et al.* indicates that low physical activity levels can diminish vascular health (increasing arterial stiffness) and disrupt hormonal regulation, which in turn raises blood pressure [23] [24]. Additionally, a sedentary lifestyle can result in poor blood circulation, lower nitric oxide levels,

and impaired vascular function, all of which are vital for maintaining healthy blood pressure levels [25].

While our research did not find a statistically significant correlation between PHTN and factors such as depression, hyperglycemia, and reduced fruit and vegetable intake, these have been identified as independent risk factors in other studies [26]-[28].

The small sample size, along with the specific sociodemographic and lifestyle characteristics of the participants, may have contributed to the absence of a meaningful correlation in our findings.

4.3. Study Limitations

This study has several limitations that need to be acknowledged. First, due to the cross-sectional design, we could not determine a causal relationship between prehypertension and potential risk factors. Additionally, the small sample size restricts the ability to generalize our findings to the broader Congolese population or to other urban areas in Africa. Conducting large-scale multicenter studies would be crucial to validate these findings in various contexts.

Lastly, future research should consider including additional potential risk factors such as a more comprehensive dietary assessment, anxiety levels, detailed alcohol and smoking habits, screen time, sleep quality, noise exposure, multimorbidity, and average monthly income to gain a more thorough understanding of the determinants of prehypertension in our environment.

5. Conclusion

Prehypertension is very common among adults in Kisangani. A multivariate logistic regression model analysis indicates that PHTN is significantly associated with several factors: low levels of physical activity, daily smoking, alcohol use, stress, high cholesterol, being male, obesity, a family history of diabetes, a family history of hypertension, and stress. Implementing primary prevention strategies that focus on modifiable risk factors is crucial to lowering the risk of developing hypertension and related cardiovascular diseases.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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