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RESEARCH ARTICLE

# Prevalence and associated factors of hypertension in adults in Lubumbashi, Democratic Republic of the Congo: A hospital cross-sectional study

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**Abstract:** Introduction: Hypertension is the leading cause of morbidity and mortality from cardiovascular disease worldwide. Knowledge of its prevalence and associated factors helps to prevent its complications. The objectives of this study were to determine the prevalence and associated factors of hypertension in hospitals in Lubumbashi, Democratic Republic of the Congo. Methods: A cross-sectional analytic study was conducted among 520 adults from February 6 to November 30, 2023 in 2 health facilities in the city of Lubumbashi (Afia Polyclinic – Don Bosco and Jason Sendwe Provincial General Reference Hospital). Participants were selected by systematic random sampling. Hypertension was defined when the subject had a blood pressure (BP) $\geq$ 135/85 mmHg on diurnal Ambulatory Blood Pressure Monitoring (ABPM) or $\geq$ 180/110 mmHg on clinic oscillometric BP measurement (OBPM), or when he/she had self-reported hypertension and/or was taking antihypertensive medication even if diurnal ABPM was normal. Factors associated with hypertension were determined using a logistic regression model at the 5% significance level. Results: The prevalence of hypertension was 32.8% (95% CI: 28.9%-37.0%). Factors significantly associated with hypertension included age $\geq$ 50 years (AOR = 4.0 [1.2-12.7]), dyslipidemia (AOR = 18.6 [3.2-107.4]), hypercalcemia (AOR = 171.6 [32.5-905.9]), hyperkalemia (AOR = 27.6 [7.1-107.8]), and hypernatremia (AOR = 948.1 [160.0-5619.3]). Conclusion: This study reveals the high hospital prevalence of hypertension and the factors associated with it, emphasizing the necessity for targeted interventions for at-risk populations, especially the elderly and those with electrolyte imbalances.

**Keywords:** arterial hypertension, associated factors, hospital environment, Lubumbashi

## 1 Introduction

Hypertension is recognized as the primary risk factor for cardiovascular disease (CVD) [1], leading to conditions such as stroke, heart attack, heart failure, and chronic kidney disease. It is estimated that 1.28 billion individuals aged 30 to 79 worldwide are affected by hypertension, with a significant portion in low- and middle-income countries. Africa exhibits the highest prevalence of hypertension, with a rising incidence in sub-Saharan Africa (SSA) [2]. In the Democratic Republic of the Congo (DRC), the prevalence ranges from 9.9% to 49.3% [3]. Various factors contribute to an increased risk of hypertension, including obesity, excessive alcohol and salt intake, lack of physical activity [4], an aging population [5], air pollution [6], ambient noise [7, 8], and the impact of the COVID-19 pandemic [9]. In Lubumbashi, the prevalence of hypertension is influenced by multiple factors, such as age over 50, female gender, diabetes, inadequate intake of fruits and vegetables, and a history of stroke, as reported by Musung et al. in 2021 [3]. According to Umba et al. in 2020, hypertension accounts for approximately 50% of cardiovascular consultations in the DRC [10]. The scarcity of data on the prevalence of hypertension and its associated factors in Lubumbashi hospitals justifies the interest of this study.

## 2 Materials and methods

### 2.1 Study design, sample and duration

Participants were selected through systematic random sampling at two health care facilities in Lubumbashi (Afia Polyclinic - Don Bosco and Jason Sendwe Provincial General Reference

Hospital), between February 6 and November 30, 2023. Consequently, 520 individuals deemed potentially eligible were retained to constitute our sample size.

## 2.2 Eligibility and exclusion criteria

Eligible participants were males and females aged 18 and older who provided their consent and willingly signed the informed consent form. Excluded from this study were pregnant individuals and those unable to undergo blood pressure (BP) measurement due to arm impairment.

## 2.3 Studied variables

The variables in our study were as follows:

(1) Dependent variable: Hypertension;
(2) Independent variables: Sociodemographic data (gender, age, weight, height, waist circumference, Body Mass Index (BMI)), ionic levels (Sodium ($Na^+$), Potassium ($K^+$), Calcium ($Ca^{2+}$), lipids (Total Cholesterol, HDL-C, LDL-C, Triglycerides), renal function assessment (Creatinine with calculation of estimated Glomerular Filtration Rate (eGFR)), and history of alcohol and tobacco consumption.

Measurements of clinical oscillometric BP and heart rate (HR) (3 readings) were conducted in the doctor's office [11] with the presence of medical staff (Physician or Nurse) [24] and then in their absence (Patient alone) [12]. Any participant with oscillometric BP values falling in the categories of high normal (130-139/85-89 mmHg), grade 1 (140-159/90-99 mmHg), and grade 2 and 3 i.e. BP$\geq$ 160/100mmHg [12, 13] underwent 24-hour Ambulatory blood pressure monitoring (ABPM) for confirmation of the hypertension [14–16].

Anthropometric parameters (weight and height) were measured as follows:

(1) Weight was measured on a lightly clothed, unshod subject standing on a medical scale and recorded in kilograms (kg).
(2) Height was measured using a vertical measuring tape, with the subject standing unshod, shoulders and hips perpendicular to the central axis, heels against the footboard, knees together, arms relaxed at the sides of the body, and head erect. It was recorded in centimeters (cm).

Peripheral venous blood samples (from the elbow or jugular vein) were taken the morning after the patient returned to the doctor's office (24 hours later), without tourniqueting, in an EDTA tube with anticoagulant, by the survey site's experienced biologist. The blood sample tubes were delivered to the laboratory within 4 hours of collection and labeled with the necessary code according to identity vigilance standards [17] for the determination of ion levels ($K^+$, $Ca^{2+}$, $Na^+$), urea, creatinine, cholesterol, and triglycerides.

Urine was collected early in the morning by the participant in a sterile bottle provided to them the day before during the clinical examination. The urine samples deposited in the morning at the on-site laboratory were used to quantify albumin and Na+ and expressed as the albumin/sodium ratio (Alb/$Na^+$).

The operational definitions of the variables were as follows:

(1) Hypertension: a participant was classified as hypertensive if they self-reported hypertension and/or were taking antihypertensive medication, regardless of their daytime ABPM results. Additionally, hypertension was defined as having a daytime ABPM reading of $\geq$ 135/85 mmHg or MPA-OC values $\geq$ 180/110 mmHg, indicating grade 3 hypertension [12].
(2) Overweight and obesity: calculated using the formula BMI = weight (in kilograms) divided by height (in meters) squared and expressed in kg/$m^2$. Overweight was defined by a BMI $\geq$ 25 kg/$m^2$ and obesity by a BMI $\geq$ 30 kg/$m^2$ [18].
(3) Abdominal obesity: a waist circumference $\geq$ 88 cm in women and $\geq$ 102 cm in men defined abdominal obesity [18].
(4) Diabetes mellitus: a fasting blood glucose level $\geq$ 126 mg/dl (7 mmol/L) or the use of antidiabetic drugs (oral or injectable) defined diabetes mellitus [19].
(5) Dyslipidemia: was defined by total cholesterol >200 mg/dl, LDL-C >160 mg/dl, HDL-C <40 mg/dl, TG >150 mg/dl, or hypolipemiants [20].
(6) Hypernatremia: was defined as a serum sodium concentration greater than 145 mEq/dl (normal value 135-145 mEq/dl).
(7) Hyperkalemia: was defined as a serum potassium concentration above 5.0 mEq/dl (normal value 3.5-5.0 mEq/dl).
(8) Hypercalcemia: calcemia greater than 10.4 mg/dl (normal value 8.8-10.4 mg/dl) defines hypercalcemia.

## 2.4 Statistical analysis

The statistical analysis was conducted using Stata version 16.0. Quantitative variables were reported as means with their corresponding standard deviations, while qualitative variables were presented as frequencies and percentages. Proportions were compared using Pearson's chi-square test, and means were compared between genders using Student's t-test. To assess the likelihood of hypertension based on associated factors, a bivariate analysis was initially performed, followed by multiple logistic regression analysis. Statistical significance was set at a p-value $< 0.05$.

## 2.5 Ethical considerations

Ethical approval for the study was obtained from the University of Lubumbashi Medical Ethics Committee (UNILU/CEM/108/2022). Permission to conduct the study in the facilities was granted by the facility managers. Written free and informed consent was obtained from volunteers before their participation in the survey.

# 3 Results

## 3.1 Basic characteristics of study subjects

Five hundred and twenty individuals participated in the study, with 269 men, accounting for 52% of the sample. The results indicated that women had higher mean values for various measures, which were statistically significant ($p < 0.001$). Specifically, the mean weight was 65.83 kg, waist circumference 86.11 cm, heart rate 80.26 beats per minute (bpm), total cholesterol 128.62 mg/dl, HDL-C 58.28 mg/dl, LDL-C 98.80 mg/dl, and creatinine 1.20 mg/dl. Conversely, in men, the mean height was 168.71 cm, and blood urea was 32.22 mg/dl, with values higher than those in women, and the differences were also statistically significant ($p < 0.05$). (Table 1)

**Table 1** Baseline characteristics of study subjects (n = 520)

| Variables | Gender | | |
|---|---|---|---|
| | Female (52%) (n = 269) | Male (48%) (n = 251) | *p*-value |
| Age (years), mean | 52.6 | 52.4 | 0.44 |
| Weight (kg), mean | 65.8 | 63.0 | <0.001 |
| Height (cm), mean | 168.7 | 170.0 | <0.001 |
| Waist circumference (cm), mean | 86.1 | 85.4 | <0.001 |
| BMI (kg/m$^2$), mean | 23.2 | 23.7 | 0.06 |
| SBP (mmHg), mean | 136.8 | 134.9 | 0.59 |
| DBP (mmHg), mean | 85.0 | 84.6 | 0.18 |
| HR (bpm), mean | 80.3 | 76.9 | <0.001 |
| Blood glucose (mg/dl), mean | 107.1 | 106.5 | 0.50 |
| Total cholesterol (mg/dl), mean | 128.6 | 114.7 | 0.01 |
| HDL-C (mg/dl), mean | 58.3 | 55.0 | 0.26 |
| LDL-C (mg/dl), mean | 98.8 | 95.2 | <0.001 |
| Triglycerides (mg/dl), mean | 92.5 | 92.5 | <0.001 |
| Blood urea (mg/dl), mean | 31.9 | 32.2 | 0.02 |
| Creatinemia (mg/dl), mean | 1.2 | 1.1 | <0.001 |
| eGFR (ml/min/m$^2$), mean | 96.7 | 98.1 | 0.10 |
| Hematocrit (%), mean | 40.8 | 43.0 | 0.16 |
| Natraemia (mEq/dl), mean | 140.4 | 138.8 | 0.54 |
| Kalemia (mEq/dl), mean | 5.0 | 5.0 | 0.21 |
| Calcemia (mg/dl), mean | 9.9 | 9.6 | 0.09 |
| Alcohol consumption, n (%) | 32 (11.9) | 63 (25.1) | 0.09 |
| Tobacco consumption, n (%) | 1 (0.4) | 7 (2.8) | 1.00 |

**Note**: mEq/dl, milliequivalents per deciliter. mg/dl, milligrams per deciliter. BMI, body mass index. mg/dl, milligram per deciliter. HDL, High Density Liprotein. LDL, Low Density Lipoprotein. mg/dl, milligram per deciliter. eGFR, estimated glomerular filtration rate per milliliter per minute for 1.73 square meters of body surface area. HR, heart rate. Bpm, beats per minute. SBP, systolic blood pressure. DBP, diastolic blood pressure.

## 3.2 Prevalence and factors associated with hypertension

Table 2 shows that the prevalence of hypertension in hospitals in Lubumbashi is 32.8%, with a 95% confidence interval (95% CI) of 28.9% to 37.0%. After logistic regression, the factors that were significantly associated with hypertension were age $\geq$ 50 years (Adjusted

odds ratio [AOR] = 4.0 [1.2-12.7]), dyslipidemia (AOR = 18.6 [3.2-107.4]), hypercalcemia (AOR = 171.6 [32.5-905.9]), hyperkalemia (AOR = 27.6 [7.1-107.8]) and hypernatremia (AOR = 948.1 [160.0-5619.3]).

**Table 2** Bivariate and multivariate analyses of factors associated with hypertension among 520 adults in hospital in Lubumbashi

| Variables | Total (n = 520) n (%) | Hypertension | | AOR [95% CI] | *p*-value |
|---|---|---|---|---|---|
| | | Yes (n = 170) n (%) | No (n = 350) n (%) | | |
| Age (years) | | | | | |
| $< 50$ | 220 (42.3) | 42 (19.1) | 178 (80.9) | 1 | |
| $\geq 50$ | 300 (57.7) | 128 (42.7) | 172 (57.3) | 4.0 [1.2-12.7] | 0.02 |
| Gender | | | | | |
| Male | 251 (48.3) | 74 (29.5) | 177 (70.5) | 1 | |
| Female | 269 (51.7) | 96 (35.7) | 173 (64.3) | 2.3 [0.8-6.9] | 0.139 |
| Alcohol consumption | | | | | |
| No | 425 (81.7) | 133 (31.3) | 292 (68.7) | 1 | |
| Yes | 95 (18.3) | 37 (38.9) | 58 (61.1) | 1.0 [0.2-3.6] | 0.942 |
| Tobacco | | | | | |
| No | 512 (98.5) | 168 (32.8) | 344 (67.2) | 1 | |
| Yes | 8 (1.5) | 2 (25.0) | 6 (75.0) | 0.7 [0.1-3.9] | 1 |
| Obesity | | | | | |
| No | 494 (95.0) | 156 (31.6) | 338 (68.4) | 1 | |
| Yes | 26 (5.0) | 14 (53.8) | 12 (46.2) | 4.3 [0.3-57.8] | 0.269 |
| Diabetes mellitus | | | | | |
| No | 426 (81.9) | 126 (29.6) | 300 (70.4) | | |
| Yes | 94 (18.1) | 44 (46.8) | 50 (53.2) | 1.8 [0.5-7.0] | 0.409 |
| Dyslipidemia | | | | | |
| No | 492 (94.6) | 153 (31.1) | 339 (68.9) | 1 | |
| Yes | 28 (5.4) | 17 (60.7) | 11 (39.3) | 18.6 [3.2-107.4] | 0.001 |
| eGFR (ml/min/$m^2$) | | | | | |
| $\geq 60$ | 425 (81.7) | 134 (31.5) | 291 (68.5) | 1 | |
| $< 60$ | 95 (18.3) | 36 (37.9) | 59 (62.1) | 0.4 [0.1-1.8] | 0.209 |
| Hypercalcemia | | | | | |
| No | 414 (79.6) | 70 (16.9) | 344 (83.1) | 1 | |
| Yes | 106 (20.4) | 100 (94.3) | 6 (5.7) | 171.6 [32.5-905.9] | $< 0.0001$ |
| Hyperkalemia | | | | | |
| No | 335 (64.4) | 45 (13.4) | 290 (86.6) | 1 | |
| Yes | 185 (35.6) | 125 (67.6) | 60 (32.4) | 27.6 [7.1-107.8] | $< 0.0001$ |
| Hypernatremia | | | | | |
| No | 375 (72.1) | 29 (7.7) | 346 (92.3) | 1 | |
| Yes | 145 (27.9) | 141 (97.2) | 4 (2.8) | 948.1 [160.0-5619.3] | $< 0.0001$ |

**Note**: eGFR, estimated glomerular filtration rate

# 4 Discussion

The prevalence of hypertension was 32.8% (95% CI: 28.9% to 37.0%), i.e. around one-third of patients examined. This rate is in line with prevalences recorded in SSA, which vary between 20% and 58% [21]. However, there are significant regional inequalities. For example, relatively low rates of 6.25% and 6.99% were reported in Burkina Faso in hospital studies in Bobodioulasso and in a regional hospital [22, 23]. In Côte d'Ivoire, a rate of 8.27% was reported [24]. By contrast, in Togo, one study showed a much higher prevalence of 66.8%, reflecting increased morbidity and mortality associated with cardiovascular disease [25]. These differences may reflect variations in risk factors, access to care, diagnostic methods and prevention efforts, dietary habits, lifestyle, genetics and demographic differences.

In our study, 56.5% of hypertension cases involved women. This female predominance is consistent with findings from other studies [21, 26–28]. Studies in Brazzaville and Bamako reported prevalences of 61.6% and 65%, respectively [21, 26]. Research in Kpalimé, Togo, indicated that 56.3% of hypertensive individuals were women [27], and at the Lubumbashi Cardiology Centre, 53.3% of cases of hypertensive heart disease involved women [28]. The higher prevalence of hypertension in women may be influenced by factors such as hormonal changes associated with oral contraceptive use and menopause, pregnancy-related risks like gestational hypertension, lifestyle factors including sedentary behavior and stress, as well as genetic predisposition [29]. Our study revealed that individuals over 50 years old were independently associated with hypertension (ORa=4.0 [1.2-12.7], p = 0.020). This finding

aligns with the results reported by Musung et al. in the Lushese population. [9], as well as in studies of risk factors for non-communicable diseases in Kinshasa [30], Kisangani [31], and South Kivu in urban and rural areas [32] and in urban communities [33], as well as the 2017 May Measurement Month (MMM 17) survey [34] and the 2019 survey [35], studies in Ethiopia by Abebe et al. [36] and Roba et al. [37] and in Jordan [38]. The development of hypertension with age can be attributed to several factors. Firstly, arterial walls become stiffer with age, particularly the large arterial trunks, increasing systolic blood pressure. Secondly, arteriosclerotic structural changes, such as the accumulation of fatty deposits, calcium, and fibrosis, reduce arterial diameter and increase resistance to blood flow, thereby raising blood pressure. Finally, small peripheral arteries can also undergo changes, resulting in increased resistance to blood flow and thus contributing to elevated blood pressure [39, 40].

Measuring blood levels of various lipids, such as total cholesterol, LDL, HDL, and triglycerides, as well as electrolytes such as potassium, sodium, and calcium, is essential for assessing patients with or suspected of having hypertension. These analyses can be performed according to the patient's specific clinical context, in line with the 2018 ESC/ESH guidelines on the management of hypertension [41]. Our study indicated significant associations between hypertension and several biochemical factors.

With regard to dyslipidemia, it is widely documented and accepted internationally that this condition is frequently associated with hypertension [42], both of which can intensify endothelial dysfunction when they coexist [43]. This correlation has been observed both globally and in various African regions, where targeted research has been carried out to assess the epidemiological and clinical consequences of this interaction on the health of local communities [44,45]. These studies highlight the need for joint management of hypertension and dyslipidemia to reduce the risk of cardiac complications.

Research indicates that hypernatremia is associated with increased salt sensitivity, especially in the elderly, those of African descent or those with hypertension. This link with the immune system, affecting macrophages and T lymphocytes, may contribute to both hypertension and cardiovascular disease. These interactions can lead to sodium retention in the kidneys, inhibition of nitric oxide production in blood vessels, activation of the orthosympathetic system in the brain and sodium release in the skin. Sodium-rich diets are linked to increased risk of hypertension, particularly in black subjects. This may be attributed to genetic mutations affecting the ENaC channel in the collecting tubule, leading to sodium retention and salt sensitivity [46]. In addition, intestinal microbial dysbiosis, an imbalance in gut flora, may increase sodium sensitivity and blood pressure [47]. These findings may suggest that managing salt intake and balancing gut flora are key strategies for treating hypertension.

The study showed a statistically significant association between hypertension and hyperkalemia. However, this result requires cautious interpretation, considering other factors that may influence these conditions. For instance, certain treatments for hypertension, like inhibitors of the renin-angiotensin system, are known to increase the risk of hyperkalemia [48]. Furthermore, underlying pathologies such as hyperaldosteronism may also impact potassium levels in hypertensive patients [49]. Therefore, it is crucial to continue research to comprehend the mechanisms of this correlation and develop tailored therapeutic approaches for patients with both hypertension and hyperkalemia. Effectively managing hypertension could aid in regulating potassium levels and decreasing the risk of hyperkalemia.

The significant association between hypercalcemia and hypertension suggests an increased risk of hypertension in individuals with hypercalcemia. For comparison with other studies, it is essential to take several factors into account. Firstly, sample size influences the precision of odds ratio estimates. Secondly, adjustment methods for confounding variables must be similar to ensure comparability of results. In addition, the characteristics of the study population, such as age, gender and comorbidities, may influence the odds ratio. Finally, the context of the study, including environmental and geographical conditions, may affect the prevalence of hypercalcemia and the strength of the association. However, the mechanism of action of calcium on blood pressure is still under investigation. Several hypotheses have been put forward, including that a decrease in intracellular calcium concentration could lead to vasodilation, thereby helping to lower blood pressure. In addition, calcium could affect cholesterol levels, raising HDL and lowering LDL, thereby protecting the cardiovascular system. It has also been suggested that calcium may influence sodium excretion and nitric oxide sensitivity, modulating its vasodilatory action [50].

The limitations of this study could include several aspects. Firstly, its cross-sectional nature limits its ability to establish causality, providing data at a specific point in time instead. In

addition, the sample size, comprising 520 adults, may not be representative of the entire Lubumbashi population. Another limitation is the variability of BP measurements, as these may fluctuate according to various factors such as stress or physical activity, which may not have been fully controlled for in the study. Moreover, certain confounding factors not measured or included in the study, such as diet, physical activity, or access to healthcare, could influence the results. Lastly, participants in the hospital-based study could have higher rates of hypertension due to their presence in the hospital for health reasons, potentially leading to selection bias.

# 5 Conclusion

The present study offers valuable insights into the prevalence and associated factors of hypertension in Lubumbashi. Our findings underscore a notable prevalence of hypertension in this area, along with correlations with diverse demographic and biochemical factors. Nonetheless, it emphasizes the significance of enhancing awareness about hypertension and enacting efficient prevention and management measures in the Lubumbashi region. This study lays a robust foundation for forthcoming research and programs aimed at enhancing cardiovascular health in Lubumbashi and comparable regions. Through a comprehensive and cooperative strategy, we aspire to achieve substantial advancements in combating hypertension and its related complications.

# Conflicts of interest

The authors declare that they have no conflict of interest.

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