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Prevalence of arterial hypertension and evaluation of its associated risk factors among the adult population at Shendi Teaching Hospital, Sudan, 2026

A Final Thesis submitted In partial fulfillment of the academic requirement for the degree of MBBS

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Dedication

We dedicate this academic research to our beloved parents,

who supported us every step of the way on this long journey.

They were the cornerstone of our path and the source of our strength and determination. They made countless sacrifices for us, patiently enduring and supporting us throughout. They provided unwavering support throughout our years with their unconditional love, endless sacrifices, patience, and constant encouragement.

They believed in us even when we were uncertain, encouraging us to persevere and affirming our ability to succeed. They wanted us to remain confident and to keep trying, regardless of the circumstances, and this helped us move forward with confidence and determination.

With deepest gratitude and respect, we dedicate this work to them.

Acknowledgment

All praise and sincere gratitude are due to Allah, the Almighty, for granting us the strength, patience, and guidance to accomplish this work.

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Our heartfelt thanks go to everyone who supported and believed in us along this journey. This work would not have been possible without their support

List of Abbreviations:

Abbreviation	Full Term
AOR	Adjusted Odds Ratio
BMI	Body Mass Index
BP	Blood Pressure
CI	Confidence Interval
DBP	Diastolic Blood Pressure
HTN	Hypertension
LMICs	Low- and Middle-Income Countries
MBBS	Bachelor of Medicine, Bachelor of Surgery
SBP	Systolic Blood Pressure
SD	Standard Deviation
SDG	Sudanese Pound
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
WHO	World Health Organization

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Abstract

Background: Arterial hypertension remains a critical global health challenge and a primary driver of cardiovascular morbidity and mortality. In sub-Saharan Africa, and specifically Sudan, an ongoing epidemiological transition is increasing the burden of high blood pressure. However, localized data regarding the situation in the Shendi locality—a unique agricultural and tribal hub—is lacking. Establishing local prevalence and identifying risk factors is essential for developing personalized clinical approaches and effective public health interventions.

Objective: To estimate the point prevalence of hypertension and evaluate the association between non-modifiable, modifiable, and psychosocial risk factors among the adult population in Shendi Teaching Hospital, River Nile State, Sudan.

Methods: A descriptive cross-sectional study was conducted at the internal medicine outpatient clinic of Shendi Teaching Hospital between February and April 2026. A sample of 230 adult patients was recruited using convenience sampling. Data were collected via face-to-face interviews using a structured questionnaire addressing sociodemographics, lifestyle behaviors, and stress levels. Clinical measurements of blood pressure (BP) and Body Mass Index (BMI) were performed. Statistical analysis was conducted using SPSS Version 28, employing Chi-square tests, independent samples T-tests, and Pearson correlation.

Results: The point prevalence of hypertension was 14.8% (95% CI: 10.2%–19.4%). While 11.3% were previously aware of their condition, 3.5% were newly identified during screening. Among those previously diagnosed, only 50% were adherent to antihypertensive medications. Significant associations were found between hypertension and advanced age ($p<0.001$) and a positive family history (27.8% prevalence vs. 3.3% in those without; $p<0.001$). Obesity emerged as a critical modifiable factor; hypertensive participants had a significantly higher mean BMI (29.3±6.2) compared to normotensives (24.6±7.6 ,$p=0.002$). Alcohol consumption ($p=0.002$) and high perceived stress ($p=0.017$) were also strongly associated with elevated BP.

Conclusion: The study reveals a significant "silent" burden of hypertension in Shendi, characterized by a substantial proportion of newly identified cases and high rates of medication non-adherence. The primary drivers are aging, hereditary factors, obesity, and psychosocial

stress. Targeted screening programs and adherence counseling are urgently required to prevent long-term complications like stroke and heart failure.
Keywords: Sudan, Shendi, Arterial Hypertension, Prevalence, Risk Factors, Obesity, Psychosocial Stress, Medication Adherence.

الملخص

الخلفية: لا يزال ارتفاع ضغط الدم الشرياني يُعد تحديًا صحيًا عالميًا رئيسيًا ومحركًا أساسيًا للمراضة والوفيات القلبية الوعائية. في أفريقيا جنوب الصحراء، وبشكل خاص في السودان، يؤدي التحول الوبائي المستمر إلى زيادة عبء ارتفاع ضغط الدم. ومع ذلك، لا تزال البيانات المحلية حول الوضع في محلية شندي—التي تُعد مركزًا زراعيًا وقبليًا مميزًا—محدودة. إن تحديد معدل الانتشار المحلي والتعرف على عوامل الخطر يُعد أمرًا ضروريًا لتطوير نهج سريرية موجهة وتدخلات صحية عامة فعّالة.

الهدف: تقدير معدل الانتشار النقطي لارتفاع ضغط الدم وتقييم الارتباط بين عوامل الخطر غير القابلة للتعديل، والقابلة للتعديل، والعوامل النفسية الاجتماعية بين السكان البالغين في شندي، ولاية نهر النيل، السودان.

المنهجية: أُجريت دراسة وصفية مقطعية في العيادة الخارجية للطب الباطني بمستشفى شندي التعليمي خلال الفترة من فبراير إلى أبريل 2026. تم تجنيد عينة مكونة من 230 مريضًا بالغًا باستخدام أسلوب العينة الميسّرة. جُمعت البيانات من خلال مقابلات مباشرة باستخدام استبيان منظم تناول الخصائص الديموغرافية الاجتماعية، والسلوكيات الحياتية، ومستويات التوتر. كما تم إجراء قياسات سريرية لضغط الدم (BP) ومؤشر كتلة الجسم (BMI). أُجري التحليل الإحصائي باستخدام برنامج SPSS الإصدار 28، مع استخدام اختبار كاي-تربيع، واختبار (T) للعينات المستقلة، ومعامل ارتباط بيرسون.

النتائج: بلغ معدل الانتشار النقطي لارتفاع ضغط الدم 14.8% (فاصل الثقة 95%: 10.2%–19.4%). وبينما كان 11.3% على علم مسبق بحالتهم، تم تشخيص 3.5% حديثًا أثناء الفحص. ومن بين الذين تم تشخيصهم سابقًا، كان 50% فقط ملتزمين بتناول الأدوية الخافضة للضغط. وُجدت علاقات ذات دلالة إحصائية بين ارتفاع ضغط الدم وكل من التقدم في العمر ($p<0.001$) ووجود تاريخ عائلي إيجابي (نسبة انتشار 27.8% مقابل 3.3% لدى من ليس لديهم تاريخ عائلي؛ $p<0.001$). كما برزت السمنة كعامل قابل للتعديل مهم؛ حيث كان متوسط مؤشر كتلة الجسم لدى المصابين بارتفاع ضغط الدم أعلى بشكل ملحوظ (29.3±6.2) مقارنة بغير المصابين (24.6±7.6، $p=0.002$). كذلك، ارتبط كل من استهلاك الكحول ($p=0.002$) وارتفاع مستويات التوتر المُدرَك ($p=0.017$) بشكل قوي بارتفاع ضغط الدم.

الخلاصة: تكشف الدراسة عن عبء "صامت" ملحوظ لارتفاع ضغط الدم في شندي، يتمثل في نسبة كبيرة من الحالات غير المشخصة سابقًا وارتفاع معدلات عدم الالتزام بالعلاج. وتتمثل العوامل الرئيسية المؤثرة في التقدم في العمر، والعوامل الوراثية، والسمنة، والتوتر النفسي الاجتماعي. هناك حاجة ملحّة لتنفيذ برامج فحص مستهدفة وتقديم إرشاد لتعزيز الالتزام بالعلاج للحد من المضاعفات طويلة الأمد مثل السكتة الدماغية وفشل القلب.

الكلمات المفتاحية: السودان، شندي، ارتفاع ضغط الدم الشرياني، معدل الانتشار، عوامل الخطر، السمنة، التوتر النفسي الاجتماعي، الالتزام بالعلاج.

Chapter One

Introduction

1.1 Introduction:

Hypertension, clinically defined as a persistent systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg, remains a primary driver of global cardiovascular morbidity and mortality [1, 3]. Often labeled the "silent killer," its asymptomatic nature leads to severe complications such as stroke, coronary artery disease, and renal failure if not identified and treated early [1, 6]. While historically viewed as a disease of high-income nations, nearly three-quarters of hypertension-related deaths now occur in low- and middle-income countries [2]. In sub-Saharan Africa (SSA), the condition coexists with a high burden of infectious diseases, creating a complex public health landscape that strains limited resources [1, 5]. Recent data indicates that the region faces a rising epidemic, with pooled prevalence estimated at 30% and an alarmingly low awareness rate among the affected population [5].

Hypertension has become a persistent problem in LMICs, which account for over 75% of all hypertensive mortality cases worldwide [2]. The cause behind this phenomenon can be traced back to a process known as epidemiological transition, which is marked by accelerated urbanization, alongside changes in lifestyle and diet practices [4]. With the development of such countries, it is noted that people consume more processed food products and engage in less physical activity, thus increasing their susceptibility to metabolic problems [6]. However, while the prevalence of hypertension continues to rise, these areas lag behind developed countries when it comes to knowledge and management of the condition [2]. This leads to a situation where patients in developing countries are unaware and unmanaged, making them vulnerable to potentially avoidable heart diseases [5].

Hypertension is now a major public health emergency in Sudan with an estimated national prevalence rate of around 35.7% [6]. There has been a marked rise in the number of patients suffering from this condition, especially in urban settings where the prevalence rate has more than doubled in the last two decades [4]. This rising trend is worsened by a widespread phenomenon of under-diagnosis since many people in Sudan are usually unaware of their hypertension till other complications develop [3, 4]. Existing health care interventions have had to contend with inadequate screening services and sub-optimal treatment of patients diagnosed with hypertension [4, 5]. The existence of such shortcomings in the health sector necessitates the gathering of data on the disease in Sudan [3].

Hypertension occurs as a result of different factors, both non-modifiable and modifiable, acting together inside the body. These factors are aging, male gender, and strong familial background for the illness, all of which increase vulnerability to developing the disease [1, 4, 6]. In terms of modifiable risk factors, diet plays a vital role, especially high sodium intake, but other factors like lack of exercise, smoking cigarettes, and drinking dangerous amounts of alcohol also contribute [3, 4]. Metabolic factors play an equally significant role in the onset of high blood pressure through being overweight, having central obesity, and suffering from diabetes mellitus [1, 3]. Moreover, high levels of stress in both social and occupational settings play a vital role in contributing to high blood pressure among the Sudanese population [3].

1.2 Problem Statement:

Although the incidence of hypertension has been on the rise in Sudan, it must be noted that no updated data is available about the situation regarding Shendi, which lies in the River Nile State [6]. The existing literature provides information about regional trends but lacks detailed data on how the risk factors correlate with disease prevalence in such an agricultural area of Sudan with strong tribal connections [6]. Without local information on the issue at hand, it will not be possible for doctors to develop a personalized approach towards the problem at the state level [1]. Lacking updated data means that it is hard to identify the populations at risk [1].

1.3 Justification:

It is imperative that we conduct this research so that we can plan our interventions well and come up with strategies to minimize stroke and heart failure in this community [1, 6]. Through this study, local data will be generated that will help health planners to deploy the available funds to areas where the condition is prevalent and to risk factors that predispose communities to stroke and heart failure [1, 2]. This research will form the basis for further research that will help to track the trends in cardiovascular diseases in this state [6]. It is possible that the results of this research will influence behavior change and adherence to anti-hypertensive drugs [6].

1.4 Objectives

1.4.1 General Objective

- To assess the prevalence of arterial hypertension and evaluate its associated risk factors among the adult population at Shendi Teaching Hospital, Sudan.

1.4.2 Specific Objectives

- To estimate the point prevalence of hypertension among adults residing in the Shendi locality.
- To identify the association between non-modifiable factors—including age, gender, and family history—and the prevalence of hypertension.
- To determine the relationship between modifiable lifestyle factors—specifically dietary habits (salt and sugar intake), physical inactivity, and tobacco use—and blood pressure status.
- To investigate the impact of psychosocial stress levels on the development of high blood pressure.

Chapter Two

Literature Review

Literature review:

The epidemiology of hypertension and its associated risk factors represents a complex interaction between biological predisposition and environmental influences. This review provides an extensive synthesis of global, regional, and localized data, with a specific focus on the Sudanese context and the multifaceted determinants of the disease.

1. Global and Regional Prevalence of Hypertension

Hypertension is characterized by sustained high BP, which is specifically considered to be a systolic BP of ≥140 mmHg or diastolic BP of ≥90 mmHg [1, 11, 18]. World-wide, about 1.3 billion individuals suffer from hypertension, which is identified as the most significant modifiable risk factor for early mortality and morbidity [2, 9]. The disease is also regarded as a public health crisis in sub-Saharan Africa (SSA). According to a meta-analysis comprising 33 studies conducted on more than 110,000 participants, a prevalence rate of 30% was reported in SSA [5]. Other regional meta-analyses have indicated greater prevalence rates, particularly in West Africa, where a rate of 33.8% has been identified [17]. However, Ethiopia's prevalence remains lower at 20.63% [16].

The situation in Sudan is particularly serious and on the increase. According to national figures, the incidence rate of about 35.7% is noted in Sudan but differs across various demographic populations [4, 6]. An explosive increase in cases of hypertension has been observed in urban populations of North Sudan over the past two decades; the prevalence rate increased from 7.5% in 1990 to more than 18% in the early 2000s up to the present [4]. Among occupations in the River Nile State, some industries have an extremely high incidence rate; e.g., 45.9% of bank workers suffer from the disorder [3]. High-risk groups reveal particularly disturbing statistics; for example, Sudanese people suffering from diabetes mellitus show a prevalence rate of 47.6%, and it becomes even higher, 79.3%, among patients with pre-existing overweight/obesity problems [6]. Moreover, specific ethnic groups demonstrate unique prevalence rates; thus, the Nuba tribal population in Atbara suffers from a disease in 49.4% of cases [8].

2. Modifiable Risk Factors

2.1 Aging

Age is considered the greatest predictor of hypertension worldwide. This is because there is an increase in arterial resistance and stiffness of the central arteries, which happens with age [1, 12, 16]. Prevalence statistics obtained from various parts of Africa indicate that whereas the prevalence of hypertension is 16% for people aged 30, this rises to around 44% for people aged

60 [5]. People who have passed 40 years of age in Sudan are more prone to having high blood pressure compared to other age groups, and the likelihoods increase even further for individuals who are ≥ 60 years [3, 4, 13].

2.2 Gender and Predisposition Biology

The connection between gender and hypertension is complex. Despite the findings from various studies conducted in Burundi and Mayotte, where there was no apparent difference in the prevalence of high BP between men and women [1, 2], other research studies conducted in Sudan and Ethiopia have shown that men have an increased chance of having high BP levels [8, 9, 16]. In contrast, elderly women have a higher prevalence of hypertension compared to men in the same age group [15]. One reason for this could be the loss of estrogen after menopause, as this hormone regulates the sympathetic nervous system through nitric oxide.

2.3 Family History and Genetics

Family history is a known and established significant risk factor in the case of hypertension, increasing the chances of developing hypertension by two to three times in an individual [1, 16]. Models have established that family history is among the top four predictive factors for hypertension [14]. The link can be attributed to genetics as well as the shared domestic environment, such as diet and lack of physical activity [1, 3].

3. Modifiable Lifestyle and Metabolic Risk Factors

3.1 Obesity and Body Composition

Being overweight and obesity play major roles in causing the current hypertension epidemic in developing countries. Central obesity (measured by waist circumference > 90 cm) and BMI (≥30 kg/mm2) have been identified as factors highly correlated with hypertension in the River Nile State through various studies [3, 4]. Scientifically, visceral fat tissue serves as an endocrine organ producing substances such as leptin and pro-inflammatory cytokines, TNF-α and IL-6, resulting in impaired endothelium function and vascular resistance [15, 17]. Obstructive studies conducted in Indonesia reveal that being obese is the main risk factor in urban regions, and in Sudan 92.6% of hypertensive cases have been found to be centrally obese [6, 15].

3.2 Food Consumption Pattern: Sodium and Potassium

The food sodium content is another important risk factor that can be modified. High intake of sodium causes volume expansion and reduces nitric oxide production, thereby contributing to high BP [17]. On the other hand, an increased potassium intake is linked with low BP and is regarded as a risk-reducing factor [15]. In Sudan, a "salty diet" and addition of salt while eating correlate with increased BP [3].

3.3 Physical Inactivity and Sedentary Lifestyle

Epidemiological transition in West Africa and Sudan has caused a prevalence of sedentary jobs. Sedentary lifestyle and low levels of physical activity are associated with a 46% greater risk of hypertension [3, 17]. This trend has been observed in Sudan's financial industry, where the nature of work and long working hours have resulted in high disease prevalence [3].

3.4 Use of Tobacco and Alcohol

The use of tobacco still contributes significantly to the burden on the heart in terms of causing acute vasoconstriction, thus increasing the load on the heart [11, 12]. While there are few associations that have been reported in the literature among selected populations, the overall agreement is that it increases risks [3, 17]. The use of alcohol has shown significant associations with the development of hypertension [8, 16, 17, 18].

4. Psychological and Economic Factors

Stress's role in developing hypertension among patients in Sudan is now extensively reported in literature. It was found that severe work stress is associated with an increased probability of being hypertensive, with certain reports finding patients working in stressful occupations at several times greater odds for hypertension than others [3]. Chronic stress causes the activation of pathways that contribute to maintaining high blood pressure [11]. In addition, other economic factors such as low levels of education (literacy), in combination with unemployment, are identified as contributing factors to hypertension in Sudan and Burundi, probably due to mental stress caused by lack of financial stability [1, 4, 6, 8]. Marriage in Sudan is also associated with an increase in BP, possibly due to changes in diet and lifestyle resulting from marriage [6].

5. Clinical Issues: Awareness, Treatment, and Control

Notwithstanding its high prevalence, very few patients are managed for hypertension on the continent. From studies conducted in sub-Saharan Africa, it was found that only 27% of all cases of hypertension have been made aware of their condition, 18% were under treatment, and only 7% had managed to control their BP [5]. While there are more patients made aware of their hypertension in Mayotte (48%), only 30.2% managed to maintain controlled levels despite being under pharmacological treatment [2].

Chapter Three

Methodology

3.1 Study Design

A descriptive cross-sectional study design was utilized to assess the prevalence of hypertension and its associated risk factors among the target population. This design allowed for the simultaneous evaluation of exposures and outcomes at a single point in time.

3.2 Study Setting

The study was conducted at the internal medicine outpatient clinic of Shendi Teaching Hospital, which serves as the principal tertiary referral center for the Shendi locality. As a central hub for managing complex cardiovascular cases and chronic comorbidities, the hospital provided a comprehensive environment to assess patient demographics, clinical presentations, and treatment patterns. The hospital's diverse patient population offered a robust sample base representing both the local urban community and the surrounding rural areas.

3.3 Study Duration

The research was carried out over a period of approximately three months. Data collection commenced on the 13th of February 2026 and concluded on the 3rd of April 2026.

3.4 Study Population

The study population consisted of adult patients presented to the internal medicine outpatient clinic in Shendi Teaching Hospital who were diagnosed with or being evaluated for hypertension during the study period.

3.4.1 Inclusion Criteria

- Adult patients (aged 18 years and above) attending the Shendi Teaching Hospital internal medicine outpatient clinic.

3.4.2 Exclusion Criteria

- Patients who declined to participate or were unable to provide informed consent.
- Patients with diagnosed severe mental illness or significant cognitive impairment that hindered their ability to provide reliable information.

3.5 Sampling Technique and Sample Size

3.5.1 Sample Size Calculation

The sample size was determined to ensure adequate statistical power and representativeness. The following formula was applied:

$$n=[z2\times p\times(1-p)]e2$$

Where:

- z = 1.96 (reflecting a 95% confidence level).
- p= 0.5 (assumed prevalence of 50% to ensure the maximum possible sample size).
- e= 0.065: A margin of error of approximately 6.5% was accepted.

Based on these parameters, a final sample size of 230 patients was identified and utilized for this research. This sample size was deemed sufficient to provide the necessary statistical power to represent the target population and analyze the associated risk factors effectively.

3.5.2 Sampling Technique

A convenience sampling technique was employed to recruit participants who met the inclusion criteria during the clinic hours. Efforts were made to ensure that a proportional number of patients were represented from various demographic strata.

3.6 Variables

3.6.1 Independent Variables

These variables included the risk factors hypothesized to influence blood pressure status, categorized as follows:

- **Non-Modifiable Factors:** Age, gender, and family history of hypertension or related chronic conditions (such as diabetes, kidney disease, or cardiovascular disease).

- **Modifiable Lifestyle Factors:** Dietary habits (specifically salt and sugar intake), physical activity levels, tobacco use (smoking), and alcohol consumption.
- **Anthropometric Factors:** Body Mass Index (BMI), derived from the participants' recorded weight and height.
- **Psychosocial Factors:** Perceived stress levels.

3.6.2 Dependent Variable

- **Arterial Hypertension Status:** Defined by clinical diagnosis or blood pressure measurements.

3.6.3 Confounding Variables

Extraneous factors that were accounted for to prevent distortion of the results included:

- **Socio-economic Status:** Income and education levels, which influence dietary choices and healthcare access.
- **Co-morbidities:** Pre-existing conditions like Diabetes Mellitus or Chronic Kidney Disease.
- **Conflict-related Factors:** Displacement status or specific stress resulting from the regional instability and socio-political crisis in Sudan.
- **Medication Adherence:** Whether previously diagnosed individuals were consistent with their prescribed treatment.

3.7 Data Collection Techniques and Tools

Data was collected through face-to-face interviews using a structured, written questionnaire. The tool was divided into three sections:

1. **Socio-demographic and Non-modifiable factors:** Age, gender, and family history.
2. **Modifiable Lifestyle Behaviors:** Diet, physical activity, smoking, and stress levels.
3. **Clinical Measurements:** Focused on blood pressure readings and BMI.

3.8 Data Management and Analysis

All collected data were checked for completeness and consistency before being coded and entered into the Statistical Package for the Social Sciences (SPSS) software, Version 28.

Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize the variables. Inferential statistics, such as correlation and regression analysis, were conducted to assess the relationships between the identified risk factors and hypertension status. Statistical significance was set at a p-value of less than 0.05 with a 95% confidence level.

3.9 Ethical Considerations

Ethical clearance was obtained, and informed consent was physically secured from each participant before they engaged with the study. Participants were informed that the data would be used strictly for research purposes and that participation was entirely voluntary.

No coercion was used, and participants maintained the right to withdraw from the study at any point. The confidentiality and anonymity of the data were strictly observed, ensuring that no identifying information was linked to the final research results.

Chapter Four

Results

4. Results:

Table 1. Sociodemographic characteristics of study participants (n=230).

Variable		Frequency (n)	%
Age Group (years)	18–30	197	85.7
	31–40	18	7.8
	41–50	8	3.5
	51–60	4	1.7
	> 60	3	1.3
Sex	Male	117	50.9
	Female	113	49.1
Marital Status	Single	181	78.7
	Married	45	19.6
	Divorced	2	0.9
	Widowed	2	0.9
Educational Level	University / Higher	199	86.5
	Secondary	26	11.3
	Primary	2	0.9
	No formal education	3	1.3
Monthly Income (SDG)	< 200,000	69	30
	200,000 – 500,000	81	35.2
	> 500,000	80	34.8

The study population was predominantly young (85.7% aged 18–30), with an approximately equal sex distribution (50.9% male, 49.1% female). The majority were single (78.7%) and had attained university-level education (86.5%), which likely reflects the setting of the outpatient clinic. Income was relatively evenly distributed across the three categories, suggesting a heterogeneous socioeconomic profile.

Table 2. Prevalence of Hypertension and Blood Pressure Profile of the study participants (N=230).

Indicator	n	%
Hypertensive (HTN)	34	14.8
Normotensive	196	85.2
Previously diagnosed with HTN	26	11.3
Newly identified HTN (by BP measurement)	8	3.5
Diagnosed & on antihypertensive medications	13	5.7
Mean SBP (valid readings, n=126) ± SD	122.4 ± 12.4 mmHg	
Mean DBP ± SD	80.7 ± 6.6 mmHg	

The point prevalence of hypertension was 14.8% (95% CI: 10.2%–19.4%), meaning approximately 1 in 7 adults screened was hypertensive. Notably, 3.5% of participants were newly identified through blood pressure measurements during this study, underscoring the role of screening in detecting undiagnosed cases. Of the 26 previously diagnosed individuals, only 13 (50%) were on regular antihypertensive medication, indicating a significant gap in treatment adherence. The mean SBP of 122.4 mmHg and DBP of 80.7 mmHg were within the normal range overall, reflecting that the majority of participants were normotensive.

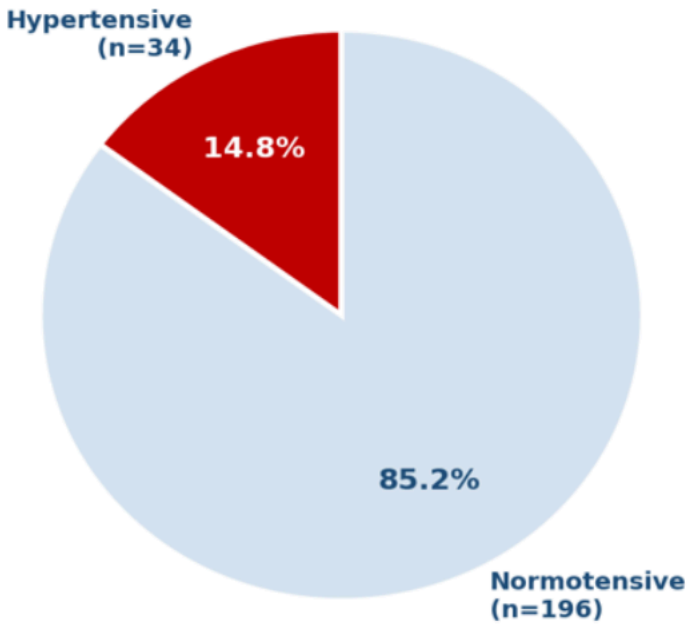


Figure I. Prevalence of Hypertension Among Study Participants, Shendi 2026 (N=230)

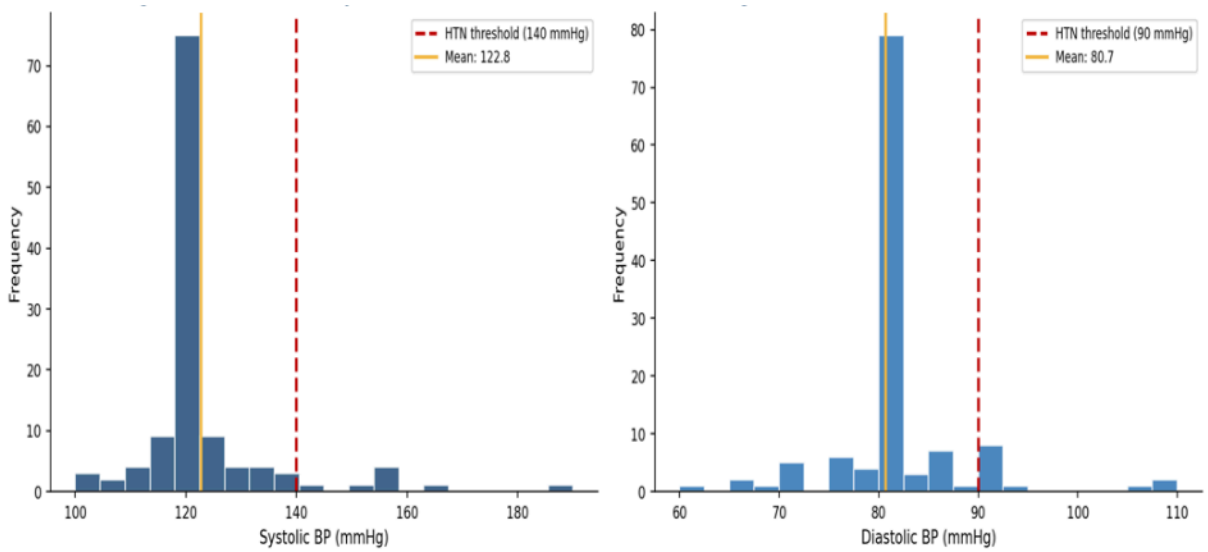


Figure II. Distribution of Systolic and Diastolic Blood Pressure Readings Among Study Participants, Shendi 2026

Table 3. Association between non-modifiable factors — including age, sex, and family history of hypertension — and the prevalence of hypertension (n=230).

Variable		Total n	HTN n	HTN %	χ^2	p-value
Age (years)	**18–30**	197	25	12.70%	31.37	< 0.001*
	31–40	18	1	5.60%		
	41–50	8	2	25.00%		
	51–60	4	3	75.00%		
	> 60	3	3	100.00%		
Sex	**Male**	117	15	12.80%	0.445	0.505
	Female	113	19	16.80%		
Family History	**No family history**	122	4	3.30%	25.38	< 0.001*
	Positive family history	108	30	27.80%		

There is a statistically significant association between both age groups, family history, and hypertension prevalence. HTN prevalence rises markedly with advancing age: from 12.7% in the youngest group (18–30 years) to 75.0% in those aged 51–60, and 100% in those over 60. This gradient is consistent with established epidemiological evidence linking aging to vascular stiffness and endothelial dysfunction as primary drivers of hypertension.

Participants with a positive family history had a prevalence of 27.8%, compared to only 3.3% in those without — an 8.5-fold absolute difference.

No statistically significant association was found between sex and hypertension (χ^2=0.445, p=0.505, OR=0.73). While females had a slightly higher prevalence (16.8% vs. 12.8%), this difference did not reach statistical significance.

Table 4. Relationship between modifiable lifestyle factors — specifically dietary habits (salt and sugar intake), physical inactivity, tobacco use, toombak use, and alcohol consumption — with blood pressure status.

Variable / Category	n (Total)	HTN n	HTN %	χ^2 / OR	p-value
Tobacco (Cigarettes)				χ^2=1.99	0.37
Non-smoker	200	29	14.50%		
Current smoker	14	1	7.10%		
Former smoker	16	4	25.00%		
Toombak (Oral Tobacco)				χ^2=5.06	0.08
No	208	28	13.50%		
Yes (current)	19	6	31.60%		
Formerly	3	0	0.00%		
Salt Intake (added to food)				χ^2=0.42	0.936
Never	33	6	18.20%		
Rarely	80	11	13.80%		
Sometimes	80	12	15.00%		
Always	37	5	13.50%		
Physical Activity (≥30 min, 3x/week)				χ^2=0.09	0.763
Active (Yes)	144	20	13.90%		
Inactive (No)	86	14	16.30%		
Alcohol Consumption				χ^2=9.16	**0.002***
No	220	29	13.20%		
Yes	9	5	55.60%		

Among the modifiable lifestyle factors, alcohol consumption showed the strongest and only statistically significant association with hypertension (χ^2=9.16, p=0.002, OR=8.23, 95% CI: 2.09–32.45). Alcohol consumers had a prevalence of 55.6% versus 13.2% among non-consumers. Toombak (oral tobacco) use showed a trend toward significance (p=0.080), with current users having a prevalence of 31.6%. Neither cigarette smoking, salt intake, sugar intake, nor physical activity showed a statistically significant association with HTN in this sample (all p>0.05). The lack of significance for salt intake may reflect social desirability bias in self-reporting, the relatively young sample, or insufficient variation in salt use patterns. Physical inactivity was associated with a slightly higher HTN rate (16.3% vs 13.9%), but this difference did not reach statistical significance.

Table 5. The relationship between body mass index (BMI) and hypertension prevalence.

BMI Category	WHO Range	n	%	HTN n (%)	χ^2	p
Underweight	< 18.5	28	13.7	2 (7.1%)	31.22	< 0.001*
Normal weight	18.5–24.9	89	43.4	4 (4.5%)		
Overweight	25.0–29.9	56	27.3	9 (16.1%)		
Obese	≥ 30.0	32	15.6	14 (43.8%)		
Overall (valid BMI, n=205)	—	205	—	Mean BMI: 25.2 ± 7.6		
HTN group: BMI 29.3 ± 6.2 | Norm: 24.6 ± 7.6 | t=3.19, p=0.002	**Pearson r (BMI vs SBP) = 0.225, p=0.015**					

BMI category was significantly associated with hypertension (χ^2=31.22, p<0.001). The HTN prevalence rose from 4.5% in the normal weight group to 16.1% among the overweight and 43.8% among obese participants — a nearly 10-fold difference between normal and obese categories. The independent samples t-test confirmed that hypertensive participants had a significantly higher mean BMI (29.3 ± 6.2) compared to normotensive participants (24.6 ± 7.6; t=3.19, p=0.002). Furthermore, Pearson correlation revealed a positive, statistically significant correlation between BMI and SBP (r=0.225, p=0.015), confirming that higher BMI predicts higher systolic blood pressure. These findings align with global evidence identifying obesity as one of the most powerful modifiable risk factors for hypertension.

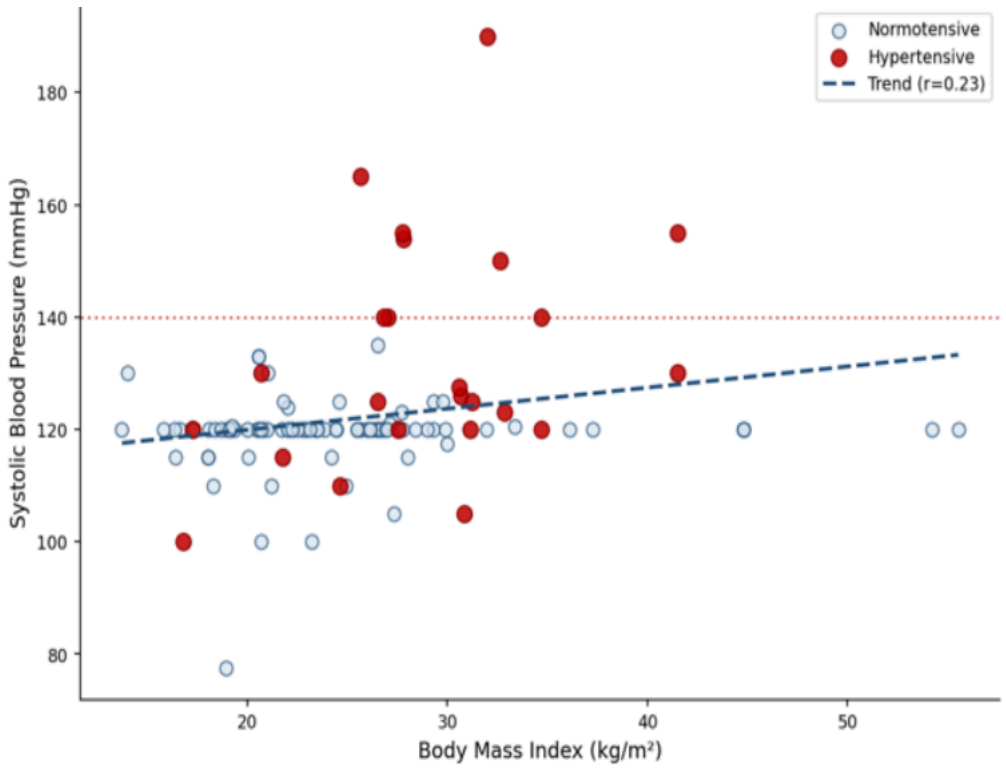


Figure III. Scatter Plot of BMI versus Systolic Blood Pressure with Linear Trend, Shendi 2026

Table 6. Hypertension Prevalence by Perceived Stress Level and Crisis-Related Stress.

Variable / Category	Total n	HTN n	HTN %	χ^2	p-value
Perceived Stress Level (past month)				8.165	**0.017***
Low (No)	36	2	5.60%		

Moderate (To some extent)	107	12	11.20%		
High (Yes, significantly)	87	20	23.00%		
Crisis-Related Stress (current national conflict)				2.174	0.337
No	30	3	10.00%		
To some extent	104	13	12.50%		
Yes, significantly	96	18	18.80%		

Perceived stress level was significantly associated with hypertension (χ^2=8.165, p=0.017), with a clear dose-response pattern: HTN prevalence was 5.6% in the low-stress group, 11.2% in the moderate group, and 23.0% in the high-stress group. This 4-fold gradient supports a causal pathway through sympathetic nervous system activation, cortisol elevation, and vascular inflammation. Crisis-related stress (related to the national conflict) showed a similar trend (10.0% → 12.5% → 18.8%), but did not reach statistical significance (p=0.337).The trend nonetheless carries clinical significance in the context of Sudan's ongoing socio-political crisis.

Chapter Five
Discussion

5.1 Discussion

The point prevalence of hypertension (HTN) in this study was 14.8% (95% CI: 10.2% – 19.4%), indicating that approximately 1 in 7 adults in the Shendi outpatient population is hypertensive. While this figure is lower than the 32.8% reported in Gadarif (10) or the 20.1% found among banking sector employees in River Nile State (4), it is crucial to note that our study population was significantly younger, with 85.7% of participants aged 18–30. Despite the younger demographic, the prevalence remains clinically significant and mirrors the "silent" burden of undiagnosed hypertension identified in systemic reviews across Sub-Saharan Africa (3).

Non-Modifiable Determinants: The Impact of Aging and Genetics

The strongest statistical association with hypertension was age ($p < 0.001$), with prevalence rising from 12.7% in the youngest cohort to 100% in those over 60. This linear progression is a hallmark of epidemiological findings in Africa, as documented by Bosu et al. (8), who identified age as the most consistent predictor of high blood pressure. This is largely due to biological processes such as arterial stiffening and endothelial dysfunction that accumulate over time (7).

Furthermore, the study revealed a powerful genetic component; participants with a positive family history had a prevalence of 27.8%, representing an 8.5-fold difference** compared to those without (3.3%). This is consistent with research by Noor et al. (12) regarding specific ethnic groups in Sudan, suggesting that hereditary factors may be particularly potent in this region, necessitating targeted family-based screening interventions.

Modifiable Risk Factors: Obesity and Alcohol

Body Mass Index (BMI) emerged as the most critical modifiable risk factor ($p < 0.001$). The prevalence of HTN among obese participants (43.8%) was nearly ten times higher than among those with a normal weight (4.5%). This aligns perfectly with previous local data from Noor et al. (6), which highlighted the rising tide of obesity-related hypertension in Northern Sudan. The significant positive correlation between BMI and SBP ($r = 0.225$, $p = 0.015$) reinforces the physiological link between adipose tissue and increased vascular resistance.

Interestingly, alcohol consumption showed a very strong association ($p = 0.002$), with over half of consumers identified as hypertensive. While alcohol use is often underreported in Sudan due

to cultural and religious sensitivities, these results mirror meta-analyses of West African populations (9) where alcohol is a primary driver of blood pressure elevation.

Conversely, factors like salt intake and tobacco use did not reach statistical significance ($p > 0.05$). This contrast with broader literature (7, 11) may be due to the "homogeneity" of the sample—where most participants reported similar salt habits—or the relatively low number of active smokers, which limited the statistical power to detect an association.

Psychological Stress and the National Crisis

A notable finding was the significant role of perceived stress ($p = 0.017$). Participants reporting high stress levels had a 23.0% HTN prevalence, a four-fold increase over the low-stress group. While stress related specifically to the current national conflict showed a visible upward trend (10.0% to 18.8%), it did not reach the threshold for statistical significance ($p = 0.337$). This suggests that while acute crisis stress is a concern, chronic, daily perceived stress may have a more immediate physiological impact on the autonomic nervous system and blood pressure regulation in this population.

The Awareness and Treatment Gap

Perhaps the most striking finding is the medication adherence gap. Of the 26 participants previously diagnosed with hypertension, only 50% (n=13) were on regular antihypertensive medication. This critical gap is a common theme in Sub-Saharan African studies, including research in Burundi (1) and Mayotte (2), and points toward systemic barriers such as the cost of medication, lack of symptomatic awareness, and disrupted healthcare access during the ongoing national crisis. The 3.5% of participants newly identified during the study further emphasizes that routine screening remains the most effective tool for capturing undiagnosed cases before they progress to complications like stroke or heart failure.

5.2 Conclusion

The findings of this study in Shendi (2026) indicate a hypertension prevalence of 14.8%, a figure that is particularly concerning given the young average age of the participants. The research highlights a significant "silent" burden of the disease, with several cases newly identified during screening and a troubling 50% non-adherence rate among those previously diagnosed.

The primary drivers of hypertension in this population are a combination of non-modifiable factors—specifically advancing age and family history and modifiable lifestyle factors, most notably obesity (high BMI), alcohol consumption, and high perceived stress. The clear "dose-response" relationship between stress levels and blood pressure suggests that the psychological toll of the current socio-political environment in Sudan may be a contributing factor to cardiovascular risk.

5.3 Recommendations

1. Clinical & Public Health Interventions

Routine Screening Programs: Implement mandatory blood pressure checks in outpatient clinics, workplaces, and universities to capture "newly identified" cases early.

Adherence Counseling: Develop patient education programs specifically aimed at the 50% of hypertensive patients not taking medication, focusing on the dangers of "silent" complications like stroke and renal failure.

Weight Management Initiatives: Since obesity increased the risk of HTN nearly 10-fold, community-based nutritional counseling and physical activity programs are essential.

2. Psychosocial Support

Stress Mitigation: Integrate mental health screenings and stress-management workshops into primary care, especially given the significant association between high perceived stress and hypertension.

3. Policy and Future Research

Targeted Screening: Prioritize individuals with a positive family history of hypertension for regular monitoring.

Longitudinal Studies: Further research is needed to track the long-term impact of the national crisis on cardiovascular health trends in Sudan.

5.4 Study Limitations

While this study provides valuable insights, several limitations must be acknowledged:

1. Sample Size and Setting: The sample size (n=230) was relatively small and recruited from an outpatient clinic setting. This may lead to selection bias, as the population was predominantly young and highly educated, and thus may not be fully representative of the general population of Sudan.

2. Self-Reporting Bias: Data regarding lifestyle factors such as salt intake, alcohol consumption, and tobacco use were self-reported. This introduces the possibility of social desirability bias, where participants may underreport perceived "unhealthy" behaviors.

3. Cross-Sectional Design: As a cross-sectional study, it captures a single point in time. This prevents the establishment of a definitive causal relationship between risk factors (like stress or BMI) and the onset of hypertension.

4. Blood Pressure Measurement: While valid readings were taken, clinical diagnosis typically requires multiple measurements over several visits to account for "white coat hypertension" or temporary fluctuations.

5. Data Gaps: Certain variables, such as specific salt measurements or lipid profiles, were not measured, which might have provided a more comprehensive overview of cardiovascular risk.

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استبيان دراسة معدل انتشار ضغط الدم وعوامل الخطورة المرتبطة به - شندي 2026

مقدمة:

نحن طلاب السنة النهائية بكلية الطب - كلية نبتة، نقوم بإجراء بحث تكميلي لنيل درجة البكالوريوس في الطب والجراحة (MBBS) بعنوان: "معدل انتشار ارتفاع ضغط الدم الشرياني وتقييم عوامل الخطورة المرتبطة به بين البالغين في محلية شندي، ولاية نهر النيل، 2026".

هدف الدراسة: تهدف هذه الدراسة إلى معرفة مدى انتشار ضغط الدم المرتفع في المنطقة وتحديد العوامل المؤثرة عليه (مثل النمط الغذائي، النشاط البدني، والضغوط النفسية).

السرية: نؤكد لكم أن جميع المعلومات التي سيتم جمعها ستعامل بسرية تامة وتستخدم لأغراض البحث العلمي فقط. المشاركة تطوعية تماماً ولكم الحق في الانسحاب في أي وقت.

القسم الأول: الموافقة

1. هل توافق على المشاركة في هذه الدراسة؟

( ) نعم

( ) لا

القسم الثاني: البيانات الديموغرافية

2. العمر (بالسنوات):

( ) 18-30

( ) 31-40

( ) 41-50

( ) 51-60

( ) أكثر من 60

3. النوع (الجنس):

( ) ذكر

( ) أنثى

4. الحالة الاجتماعية:

( ) غير متزوج

( ) متزوج

( ) مطلق

( ) أرمل

5. المستوى التعليمي:

( ) بدون تعليم رسمي

( ) أساس

( ) ثانوي

( ) جامعي فما فوق

6. المهنة:

.....

7. الدخل الشهري للأسرة (بالجنيه):

( ) أقل من 200,000

( ) 200,000 - 500,000

( ) أكثر من 500,000

8. هل يعاني أحد الوالدين أو الإخوة من ضغط الدم المرتفع؟

( ) نعم

( ) لا

القسم الثالث: نمط الحياة

9. هل تستخدم التبغ (سجائر)؟

( ) لا

( ) مدخن سابق

( ) مدخن حالي

10. هل تستخدم "التمباك"؟

( ) نعم

( ) لا

( ) سابقاً

11. استهلاك الملح: كم مرة تضيف ملحاً إضافياً للطعام بعد تقديمه؟

( ) دائماً

( ) أحياناً

( ) نادراً

( ) أبداً

12. استهلاك السكر: كم ملعقة سكر تضع عادة في الكوب الواحد؟

( ) 0-1 ملعقة

( ) 2 ملعقة

( ) 3 ملاعق

( ) 4 ملاعق أو أكثر

13. النشاط البدني: هل تمارس نشاطاً (مشي سريع/عمل شاق) لـ 30 دقيقة 3 مرات أسبوعياً؟

( ) نعم

( ) لا

14. هل تتناول الكحول؟

( ) نعم

( ) لا

القسم الرابع: الضغوط النفسية

15. كم مرة شعرت بالتوتر أو عدم القدرة على السيطرة على أمور حياتك مؤخراً؟

( ) نعم بشكل كبير

( ) إلى حد ما

( ) لا

16. هل أدت الظروف والأزمات الحالية في البلاد لزيادة شعورك بالتوتر؟

( ) نعم بشكل كبير

( ) إلى حد ما

( ) لا

القسم الخامس: القياسات الإكلينيكية

(يملأها الباحث)

17. الوزن (كيلوجرام): .....

18. الطول (سنتيمتر): .....

19. قياس ضغط الدم الأول: .....

20. قياس ضغط الدم الثاني: .....

21. هل تم تشخيصك مسبقاً بالضغط؟

( ) نعم

( ) لا

22. إذا كانت الإجابة "نعم"، هل تتناول الأدوية بانتظام؟

( ) نعم

( ) لا

23. هل تعاني من أمراض مزمنة أخرى؟

( ) نعم

( ) لا

24. اذكر المرض (في حال الإجابة بنعم):

.....