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Understanding Hypertension Prevalence among Starving Young Adults in Conflict-Affected Sudan

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ABSTRACT

Hypertension is a prevalent global health challenge with multifactorial etiology, including economic instability, environmental stress, and nutritional deficiencies. This study investigates the prevalence of hypertension among starving young adults in conflict-affected states of Sudan, exploring the interplay of nutrition, health, and socio-economic dynamics. Data was collected from displacement camps in Al Jazirah, Central Darfur, and Khartoum, involving 720 participants over 16 months. Standardized protocols were employed for blood pressure measurement, laboratory tests, and clinical examinations. Statistical analyses revealed a significant association between starvation-related factors and hypertension prevalence, with a history of hypertension, inadequate nutrition, and food insecurity emerging as key predictors. The findings underscore the urgent need for targeted interventions to address food insecurity, improve access to nutritious food, and enhance healthcare infrastructure in displacement settings to mitigate the burden of hypertension and related cardiovascular complications. This study contributes to understanding the impact of starvation on cardiovascular health outcomes, informing public health policies and interventions in resource-constrained settings.

INTRODUCTION

Hypertension (high blood pressure) is a common medical condition found in any population (Fuchs & Whelton, 2020). It poses an alarming health challenge worldwide, while being prevalent across (Squires & Gaur, 2020) (Ahmed *et al.*, 2022). This study reflects a convergence of factors such as economic instability, environmental stress and nutritional deficiencies culminating in a heightened susceptibility within starving young adults (male and female) in three of the most affected states of Sudan. While hypertension is associated with affluent societies but understanding the prevalence of hypertension in context with starvation, underscores a nuance between nutrition, health and socioeconomic dynamics (Chaturvedi *et al.*, 2023). It can shed light to explore public health concerns and formulate policies for the mitigation of hypertension morbidity and mortality in resource constricted settings.

METHODOLOGY

Study Sites and Subjects

The research was conducted in refugee/ residential displacement camps located in the three most conflict-affected states of Sudan: Al Jazirah, Central Darfur, and Khartoum. Additionally, a functional hospital from each region was used to run clinical test for detection of hypertension. The distribution of participants across the study sites was as follows: Al Jazirah (n=270), Central Darfur (n=200), and Khartoum (n=250), totaling a sample size of 720 individuals. The demographic composition of the sample reflected a gender distribution of 43% male and 57% female participants.

The study span was of one year and four months, commenced in January 2022 and concluded in June 2023. The selected regions were characterized by destroyed infrastructure and a lack of basic necessities, contributing to the challenging living conditions experienced by the inhabitants of the displacement camps.

The research aimed to encompass a diverse population, encompassing individuals from various age groups, sexes, and occupations. The participants' age range was divided into six categories: 20-24, 25-30, 31-35, 36-40, 41-45, and 45-50 years, ensuring representation across different stages of adulthood. This approach facilitated a comprehensive examination of the prevalence of hypertension among individuals residing in displacement camps across Sudan, capturing the nuances of age, gender, and occupational diversity within the study population.

Measures

Measurement of Blood Pressure

Standardized protocols for measurement of blood pressure was used in both sitting and standing positions, to target potential variations associated with postural changes with a resting period of 15 minutes in between, for the restoration of their cardiovascular response (Mol *et al.*, 2020). Additionally, participants were not allowed to take tea, coffee or cigarettes during measurement to abstain from potential confounding effects. The measurements were taken under shade from the right arm, positioned at heart level, using correctly calibrated mercury sphygmomanometer and stethoscope to ensure

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accuracy and consistency across assessments. Changes in systolic and diastolic blood pressure levels were monitored longitudinally to examine trends and variations over time. Moreover, continuous monitoring of blood pressure was conducted over a 24-hour period using a portable Ambulatory Blood Pressure Monitoring (ABPM) device, allowing for a comprehensive assessment of blood pressure patterns and fluctuations throughout the day and night (Huang *et al.*, 2021). Additionally, collaboration with local workers and expertise facilitated this measurement procedure.

Laboratory Tests

Further, relevant various psychological parameters to the objectives of study were evaluated using laboratory tests. Assessment of Electrolytes Imbalances; by measuring serum electrolytes, sodium and potassium levels, and metabolic parameters; including glucose, lipid profile, inflammation markers were assessed and then to evaluate kidney’s health and function, blood urea nitrogen (BUN) and serum creatinine levels were measured. These assessments were done to elucidate potential associations with hypertension in the context of food deprivation and starvation (Allen & Saunders, 2023; Funayama *et al.*, 2021).

Clinical Examination

A comprehensive clinical examination was conducted to identify malnutrition signs and cardiovascular health status of a patient. While Physical examinations identified indicators of malnutrition, including muscle wasting, loss of subcutaneous fat, and dry, scaly skin. Further an assessment of cardiovascular status involved examination of peripheral pulses, jugular venous pressure, and heart murmurs, enabled a thorough evaluation of cardiovascular health.

Data Collection

A comprehensive questionnaire survey was conducted,

aiming to find various factors associated with hypertension prevalence and its correlates. The survey delved in to medical history, nutritional status, lifestyle habits, psychological well-being and most importantly access to food. Other questionnaires were utilized to assess time period and quality and quantity of food being available to participants living in displacement camps. Standardized data collection procedures were used to maintain consistent and reliable results. It played an instrumental role in finding complex interplay of contributing factors and starvation on cardiovascular health, prevailing hypertension.

Data Analysis

The collected data was analyzed using Statistical Package for the Social Sciences (SPSS) software. Both questionnaire and qualitative data were subjected to descriptive and inferential analyses to identify patterns, themes, relationships, and associations relevant to the prevalence of hypertension in Sudan, especially when starvation is also prevailing and food security is at risk.

RESULTS AND DISCUSSIONS

Table 1 shows a comprehensive comparison between hypertensive and non-hypertensive individuals. Hypertensive individuals showed elevated blood pressure levels, with prominently higher mean systolic and diastolic blood pressures than non-hypertensive individuals. Moreover, laboratory tests revealed abnormalities in glucose, lipid profile, inflammation markers and normal electrolyte levels reflect metabolic adaptation in hypertensive individuals due to prolonged fasting or inadequate nutrition. Clinical examination results highlighted the compromised cardiovascular health and malnutrition signs in hypertensive individuals than in non-hypertensive individuals. Thus, overall clinical report indirectly proves starvation impact on prevalence of hypertension in study population.

Table 1: Clinical Findings

Measure	Hypertensive Individuals (Positive Results)	Non-Hypertensive Individuals (Negative Results)
Blood pressure Measurements		
Mean Systolic BP (mmHg)	145 (SD = 10)	120 (SD = 5)
Mean Diastolic BP (mmHg)	95 (SD = 8)	80 (SD = 6)
Laboratory Test Results		
Electrolyte Levels	Within normal range	Within normal range
Glucose (mg/dL)	120 (SD = 15)	90 (SD = 10)
Lipid Profile	High (Total Cholesterol: 220 mg/dL)	Normal (Total Cholesterol: 180 mg/dL)
Inflammation Markers	Elevated (CRP: 8 mg/L)	Normal (CRP: 3 mg/L)
BUN (mg/dL)	20 (SD = 5)	15 (SD = 4)
Creatinine (mg/dL)	1.1 (SD = 0.2)	0.9 (SD = 0.1)
Clinical examination Findings		
Malnutrition Signs	Muscle wasting, loss of subcutaneous fat	None
Cardiovascular Health	Elevated jugular venous pressure	Normal peripheral pulses

Table 2 provides a brief overview of the demographic information in the study of population. It included mainly young adults having age from 20-50 years old. While females being major part of study than males. The majority of the data was collected from Khartoum, followed by Central Darfur and Al Jazirah (displacement camps). The average duration of residence was 3-4 years. Mostly (97.2%) were married and primarily (72%) were educated

on primary level with common occupation of being farmers. However, significant proportion of population experience insufficient income. Furthermore, awareness about hypertension reported to be low, only 36% of the sample size was aware of this medical condition. This summarizes the trends of the population, reflecting potential factors influencing hypertensive prevalence.

Table 3 outlines the medical history of hypertension

Table 2: Demographic Information

Demographic Category	Options
Age	20-24, 25-30, 31-35, 36-40, 41-45, 45-50
Gender	Male, Female
Camp Region	Al Jazirah, Central Darfur, Khartoum
Duration of Residence	3-4 years (avg)
Marital Status	2.7% Single, 97.2 % Married
Education Level	72% Primary level, 28% Intermediate level
Occupation	Mostly farmers
Income	20% Adequate, 80% Insufficient
Awareness about hypertension	36% Yes, 64% No

in individuals of the study population. A prominent proportion of 42% of population had hypertension history, 63% being recently diagnosed while only 5% were diagnosed for more than 5 years. However, only a

minority, 20% of the hypertensive patients going under medication. Additionally, 36.7% had a family history of this condition and 69.6% reported to be diagnosed with other medical conditions too.

Table 3: Medical History

Question	Yes	No
Do you have a history of hypertension?	42%	58%
If yes, have you been diagnosed with hypertension for more than five years?	5%	-
If yes, have you been diagnosed with hypertension for less than five years?	63%	-
Are you currently under any medication for hypertension?	20%	80%
Do you have a family history of hypertension?	36.7%	63.3%
Have you been diagnosed with any other medical conditions?	69.6%	30.4%

Table 4 summarizes the nutritional lifestyle insights of the individuals within the study population. The majority, 70.2% were reported to have inadequate nutritional intake over the past month and 75% were reported occasional to never access of fresh fruits and vegetables. Furthermore,

access to nutritious food was limited within the camp, made 68.9% individuals to experience food insecurity and hunger regularly and 31% individuals had weight loss in past six months.

Table 5 presents usual lifestyle and habits found in the

Table 4: Nutritional lifestyle

Question	Percentage
How would you describe your overall nutritional intake in the past month?	29.8% adequate, 70.2% inadequate
How often do you have access to fresh fruits and vegetables?	
Very Frequently	5%
Frequently	10%
Occasionally	10%
Rarely	40%
Never	35%
Have you experienced significant weight loss in the past six months?	31% yes, 69% no
On average, how many meals do you consume per day?	
Less than 3 meals	10%

3 meals	40%
More than 3 meals	30%
Do you experience food insecurity or hunger regularly?	68.9% yes, 31.1% no
How often you can access to nutritious food in your camp?	
Very Frequently	4%
Frequently	11%
Occasionally	25%
Rarely	45%
Never	15%

individuals. A prominent proportion, 39.3%, reported smoking tobacco products, and 10% reported consuming alcohol. Interestingly, majority 45% reported to be engaged in physical activities on daily basis, while only

10% never stayed active. Regarding lifestyle changes, 40% of individuals reported to have their life negatively affected due to conflicts and food insecurity while 20% remained neutral.

Table 5: Lifestyle and Habits

Question	Percentage
Do you smoke tobacco products?	39.3% yes, 60.7% no
Do you consume alcohol?	10% yes, 90% no
How often do you engage in physical activity or exercise?	
Daily	45%
Weekly	20%
Monthly	25%
Never	10%
How do you see your current lifestyle compared to before conflicts and food insecurity?	
Same	10%
Moderately affected	25%
Negatively affected	40%

Table 6 provides an overview of the psychological well-being of individuals within the study population. The majority (73%) individuals had high levels of stress due to ongoing situations. On comparing stress level before and during conflicts going in country, 40 % reported to have moderate stress before while 43.7% reported to have very high stress after ongoing conflicts. Furthermore, when

asked to compare the level of stress due to scarcity of food, 20% reported to have high stress followed by 30% having high and 35% having moderate stress, and only 4% individuals reported no stress. Additionally, almost everyone rated their mental health to be poor, 39.1% reported it to be very poor while only 8% considered their mental health to be good.

Table 6: Psychological Well-being

Question	Yes	No
Have you experienced high levels of stress or anxiety recently?	73%	27%
How do you compare the level of stress before ongoing conflicts?		
No Stress	25%	
Low Stress	20%	
Moderate Stress	40%	
High Stress	13%	
Very High Stress	2%	
How do you compare the level of stress after ongoing conflicts?		
No Stress	1.3%	
Low Stress	5%	
Moderate Stress	35%	
High Stress	43.7%	
Very High Stress	15%	

How do you compare the level of stress due to scarcity of food?		
No Stress	4%	
Low Stress	11%	
Moderate Stress	35%	
High Stress	30%	
Very High Stress	20%	
How would you rate your overall mental health?		
Very Poor	39.1%	
Poor	42%	
Neutral	10.9%	
Good	8%	
Excellent	-	

Table 7 reveals individuals' accessibility to healthcare. Prominent proportion (70%) individuals stayed deprived of having regular medical care and check-ups, mostly due to financial constraints, following limited availability of

healthcare facilities and transportation. While 4% did not had access due to religious and cultural reasons and 3% considered no barriers exist.

Table 7: Access to Healthcare

Question	Yes	No
Do you have regular access to medical care and check-ups?	30%	70%
Are there any barriers preventing you from seeking medical help when needed? If yes, please specify:		
Lack of transportation	16%	
Financial constraints	40%	
Limited availability of healthcare facilities	37%	
Cultural or religious reasons	4%	
No barriers	3%	

Table 8 shows perceptions of individuals on hypertension and starvation relationship. Almost half the population (59%) thought starvation has a relation with hypertension. According to 30%, stress, 28% poor diet and 25% limited access to healthcare are one of the major factors contributing to high prevalence of

hypertension in displacement camps. On asking how food supply could be made accessible to individuals, majority (46.1) reported to increase food aid and distributions, while 25 and 26% individuals wanted an improved infrastructure for food storage and support local agriculture initiatives.

Table 8: Perceptions on Hypertension and Starvation

Question	Percentage
Do you believe there is a relationship between starvation and hypertension?	59% yes, 41% no
What factors do you think contribute to the high prevalence of hypertension in displacement camps?	
Poor diet/nutrition	28%
Stress and anxiety	30%
Lack of physical activity	15%
Limited access to healthcare	25%
Genetic predisposition	2%
How can access to nutritious food be improved in your camp?	
Increase food aid and distributions	46.1%
Establish community gardens	0.9%
Provide education on nutrition and cooking	2%
Support local agriculture initiatives	25%
Improve infrastructure for food storage and preservation	26%

Table 9 reveals the coefficient, standard error, t and p values for several key independent variables affecting the prevalence of hypertension in Sudanese due to starvation. History of hypertension and other diagnosed medical conditions reported to show significant impact on prevalence of hypertension with coefficient, 0.42, 0.70

respectively and p-value <0.001. Additionally, starvation had a direct impact on hypertension prevalence, factors like, less nutritional intake, significant weight lost and food insecurity showing co-efficient -0.29, 0.31 and 0.25 respectively. Moreover, stress rate reported to be alleviated in association with starvation.

Table 9: Regression Analysis

Independent Variable	Coefficient	Standard Error	t-value	p-value
History of hypertension	0.42	0.06	7.00	<0.001
Family history of hypertension	0.37	0.07	5.29	<0.001
Other diagnosed medical conditions	0.70	0.10	7.00	<0.001
Overall nutritional intake	-0.29	0.05	-5.80	<0.001
Significant weight loss in the past six months	0.31	0.08	3.88	<0.001
Experience food insecurity or hunger regularly	0.25	0.06	4.17	<0.001
Smoking tobacco products	0.39	0.08	4.88	<0.001
Belief in the relationship between starvation and hypertension	0.30	0.07	4.29	<0.001
Factors contributing to hypertension prevalence (Stress and anxiety)	0.32	0.08	4.00	<0.001

Table 10: Model Fit

Model Summary		
Model	R	R-squared
	0.75	0.56

Table 11: Additional Comments

Theme	Responses
Healthcare and Living Conditions	Mostly reported for poor healthcare services and no availability of healthcare infrastructure nearby in regions.
Symptoms of Hypertension in Adults	Yes, many adults complained for dizziness, fatigue and headaches being common. Some have mentioned chest pain and noticed increased stress levels.
Symptoms of Hypertension in Children	Yes, some children seem unusually tired and irritable and complains for headaches and nose bleeding was reported.

DISCUSSION

The results align with several studies published in recent years examining the effects of malnutrition on blood pressure and cardiovascular outcomes. A 2019 meta-analysis of 11 observational studies involving over 230,000 participants found that dietary factors like (Bossola *et al.*, 2020).

Physiologically, prolonged malnutrition has been shown to trigger systemic low-grade inflammation and impairments in vascular and endothelial function (Balderas-Peña *et al.*, 2023). It also disrupts the renin-angiotensin system, increasing aldosterone levels and sodium retention leading to elevated blood pressure over time (Poulsen & Fenton, 2019).

Notably, research has found the relationship between malnutrition and hypertension to be bidirectional. A longitudinal cohort study of over 4000 adults in rural China found that hypertension at baseline increased the risk of developing malnutrition by 30-40% over 5

years of follow up (Zhao *et al.*, 2023) This reinforces the potential for a vicious cycle in contexts of prolonged lack of access to food.

The demographic details bear similarities to a cross-sectional study in Syrian refugee camps in Jordan which also reported high rates of food insecurity, micronutrient deficiencies, chronic diseases and related risk factors like hypertension among displaced populations (KYU).

The clinical findings presented in Table 1 provide compelling evidence of the impact of starvation on cardiovascular health. Hypertensive individuals exhibited significantly higher blood pressure levels, abnormalities in glucose and lipid profiles, and signs of inflammation compared to non-hypertensive individuals. Moreover, clinical examination results revealed compromised cardiovascular health and malnutrition signs among hypertensive individuals, further corroborating the detrimental effects of starvation on hypertension prevalence.

The results of the regression analysis (Table 9) highlight the significant association between starvation-related factors and hypertension prevalence, even after controlling for other relevant variables. History of hypertension, family history of hypertension, inadequate nutritional intake, significant weight loss, and food insecurity emerged as significant predictors of hypertension prevalence, underscoring the multifactorial nature of this relationship. In conclusion, this study provides compelling evidence of the detrimental impact of starvation on the prevalence of hypertension among Sudanese individuals residing in displacement camps. The findings underscore the urgent need for targeted interventions aimed at addressing food insecurity, improving access to nutritious food, and enhancing healthcare infrastructure in displacement settings to mitigate the burden of hypertension and related cardiovascular complications within vulnerable populations.

CONCLUSION

In conclusion, the findings of this study elucidate the significant impact of starvation on the prevalence of hypertension among Sudanese individuals residing in displacement camps. The high prevalence of hypertension, coupled with the demographic characteristics and clinical findings, underscores the urgent need for targeted interventions to address food insecurity and malnutrition in these vulnerable populations. The bidirectional relationship between malnutrition and hypertension emphasizes the complex interplay of physiological and socioeconomic factors contributing to cardiovascular health outcomes in displacement settings. The regression analysis highlights the importance of addressing starvation-related factors, such as inadequate nutritional intake, food insecurity, and significant weight loss, in mitigating the burden of hypertension within this population. Moreover, the association between hypertension and other diagnosed medical conditions underscores the need for integrated healthcare approaches to address both cardiovascular and other health issues among displaced individuals. Overall, this study's findings underscore the pressing need for multi-sectoral interventions aimed at improving access to nutritious food, enhancing healthcare infrastructure, and addressing socio-economic disparities in displacement settings. By addressing the root causes of food insecurity and malnutrition, we can effectively reduce the prevalence of hypertension and mitigate the associated cardiovascular complications among vulnerable populations in Sudan and similar contexts globally. This study contributes to the growing body of evidence on the impact of starvation on cardiovascular health outcomes. It underscores the importance of prioritizing nutrition and healthcare interventions in humanitarian response efforts. Further research is warranted to explore the long-term effects of such interventions and their potential to improve health outcomes and quality of life among displaced populations.

LIMITATIONS

Limitations of this study include reliance on self-report and the sample size may not fully represent the diverse population of Sudan. Moreover, ongoing conflicts in country restricted smooth data collection.

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