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Correlation of Body Mass Index to Cardiothoracic Ratios of Hypertensive and Non-Hypertensive Berom Adults in Jos North Local Government Area

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ABSTRACT
Cardiothoracic ratio (CTR) is a radiographic measure widely used to estimate cardiac size and identify potential cardiomegaly. Body mass index (BMI), a proxy for body fatness, is a recognized cardiovascular risk factor. While both parameters are independently linked to cardiovascular health, their interrelationship, particularly within indigenous African populations, remains underexplored. To determine the relationship between BMI and CTR, and evaluate the potential sex-based differences in this relationship among hypertensive and non-hypertensive Berom adults in Jos North Local Government Area, Plateau State, Nigeria. A comparative cross-sectional study was conducted among 120 third-generation Berom adults (60 hypertensives and 60 non-hypertensives), equally divided by sex. Participants underwent standard posteroanterior chest radiography and anthropometric assessment. CTR was calculated as the ratio of the transverse cardiac diameter to the transverse thoracic diameter. BMI was computed as weight (kg)/height² (m²). Correlation between BMI and CTR was analyzed using Pearson correlation. A p-value < 0.05 was considered statistically significant. The hypertensive group exhibited higher mean BMI and CTR compared to the non-hypertensive group. A moderate positive correlation was found between BMI and CTR in hypertensive males ($r = 0.319$, $p = 0.086$), while hypertensive females had a weaker correlation ($r = 0.107$, $p = 0.572$). Non-hypertensive males showed a weak negative correlation ($r = –0.092$, $p = 0.628$) and non-hypertensive females a weak positive correlation ($r = 0.044$, $p = 0.817$). No correlation reached statistical significance. A trend toward a positive correlation between BMI and CTR was observed among hypertensive individuals, particularly males, suggesting that increased adiposity may contribute to cardiac enlargement in hypertensive states. CTR may be a useful, though limited, tool for cardiac risk assessment in resource-constrained settings. Further studies incorporating larger samples and advanced imaging modalities are warranted.
Keywords: Berom Adults, Body Mass Index, Cardiothoracic Ratio, Cardiovascular Risk, Hypertension, Jos North.

INTRODUCTION

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality globally, accounting for an estimated 17.9 million deaths annually, with hypertension and obesity representing two of the most prominent modifiable risk factors (World Health Organization [WHO], 2021; Mensah, Roth, & Fuster, 2020). The burden of these risk factors is rising in low- and middle-income countries, including those in sub-Saharan Africa, where epidemiological transitions driven by urbanization, lifestyle changes, and dietary shifts are contributing to increased cardiovascular risk (Ataklte et al., 2015; Agyemang & Owusu-Dabo, 2014).

In routine clinical practice, chest radiography remains a cost-effective and widely available imaging modality used for the preliminary assessment of cardiac size. The cardiothoracic ratio (CTR), defined as the ratio of the transverse cardiac diameter (TCD) to the transverse thoracic diameter (TTD), is commonly used to estimate cardiac silhouette dimensions. A CTR greater than 0.50 in adults is generally indicative of cardiomegaly and may reflect underlying pathological changes such as hypertensive heart disease, heart failure, or valvular dysfunction (Danias et al., 2001; Ellis & Schoenfeld, 1994). Although CTR has limitations in specificity, especially in obese individuals, it remains a practical tool in resource-constrained settings (Cuspidi et al., 2012).

Parallel to this, body mass index (BMI) is a widely utilized anthropometric index for assessing adiposity, classifying individuals into underweight, normal, overweight, or obese categories. Elevated BMI has been independently associated with structural and functional cardiac changes such as left ventricular hypertrophy, increased cardiac output, and elevated stroke volume, factors that could potentially influence CTR measurements (Lavie et al., 2009; Hall et al., 2015). Notably, obesity has been shown to contribute to subclinical cardiac remodeling even in the absence of overt hypertension (Ogunmola & Olamoyegun, 2014).

However, the relationship between BMI and CTR is not universally consistent. Ethnic, environmental, genetic, and sociocultural factors may modulate this relationship, making population-specific studies essential to improve the diagnostic utility of CTR in diverse populations (Zhou et al., 2021; Mensah et al., 2017). In sub-Saharan Africa, including Nigeria, there remains a paucity of research examining how obesity-related changes in cardiac structure manifest in traditional communities.

The Berom people of Jos North Local Government Area in Plateau State represent one such indigenous population with unique genetic and sociocultural characteristics. Yet, limited data exist on the cardiovascular profile of this ethnic group, particularly with respect to the interaction between BMI and CTR in the context of hypertension. Therefore, this study aims to evaluate the correlation between BMI and CTR among hypertensive and non-hypertensive Berom adults, with the goal of contributing to evidence-based, ethnically tailored cardiovascular risk assessment strategies.

MATERIALS AND METHODS

This was a comparative cross-sectional observational study carried out at the Radiology Unit of the University of Jos Health Services Centre. Ethical approval was obtained from the University of Jos Health Services Centre Ethical Research Committee, and written informed consent was also obtained from all participants.

The study population comprised third-generation Berom males and females aged between 22 and 70 years residing in Kabong District of Jos-North Local Government Area of Plateau State, Nigeria. Participants were categorized as either known hypertensives with well-controlled blood pressure or normotensives. Exclusion criteria included individuals who were non-Berom by ethnicity, hypertensive individuals with complications or significant comorbid conditions, and pregnant women.

Sample size was determined using Altman's formula for comparing two means: $N = (2 \times Cp_1power) / d^2$, where Cp_1power is a constant corresponding to a significance level of 0.05 and study power of 90%, yielding a value of 10.5 (Elise & Jonathan, 2002). An expected CTR difference of 0.06 with a standard deviation of 0.07 produced a standardized difference (d) of 0.857 (Halilu et al., 2017). This yielded a required sample size of approximately 30 participants per sex group. Thus, 60 hypertensive participants (30 males and 30 females) and 60 non-hypertensive participants (30 males and 30 females) were recruited, giving a total of 120 participants.

Consecutive sampling was employed to recruit study participants. Each subject underwent a standard posteroanterior (PA) chest radiograph using a Philips Practix mobile X-ray unit operated at 100 kV and 20 mA, with a focus-to-film distance of 150 cm. The transverse cardiac diameter (TCD) and transverse

thoracic diameter (TTD) were measured using a meter rule on radiographic films placed on a standard viewing box. CTR was calculated as the ratio of TCD to TTD (CTR = TCD/TTD).
Anthropometric data were collected using a calibrated RGZ-160 stadiometer. Weight was measured in kilograms and height in meters, and body mass index (BMI) was computed as weight divided by the square of height (kg/m²). Blood pressure measurements were taken using a mercury sphygmomanometer and Littmann stethoscope, with participants seated and rested for at least five minutes.
Each participant also completed a structured proforma capturing demographic data, social habits (such as alcohol and tobacco use), medical history (including diagnosis of hypertension, current medication), and frequency of follow-up.
Data analysis was performed using IBM SPSS Statistics version 25. Descriptive statistics (mean, standard deviation, frequency) summarized participant characteristics. Independent samples t-tests were used to compare CTR values across sex and hypertensive status. A p-value of less than 0.05 was considered statistically significant.

RESULTS
A total of 120 Berom adults participated in the study, comprising 60 hypertensives and 60 non-hypertensives, with equal distribution of males and females across groups. The mean age of the hypertensive group was of 53.50 ± 7.84 years while the non-hypertensive group had a mean age of 42.40 ± 10.74 years. Males in both groups were slightly older than females. The average height and weight did not differ significantly between the groups. Among males, hypertensive participants had a higher mean BMI (28.13 ± 2.90 kg/m²) compared to non-hypertensives (24.89 ± 2.96 kg/m²). Similarly, hypertensive females had a marginally higher BMI (29.76 ± 2.61 kg/m²) than their non-hypertensive counterparts (26.91 ± 4.05 kg/m²), though the differences were not statistically significant.
The correlation between BMI and cardiothoracic ratio (CTR) varied across subgroups. Among hypertensive males, a moderate positive correlation was observed (r = 0.319, p = 0.056), and hypertensive females had a weaker positive correlation (r = 0.107, p = 0.372). In non-hypertensive males, BMI showed a weak negative correlation with CTR (r = –0.092, p = 0.628), whereas non-hypertensive females exhibited a weak positive correlation (r = 0.044, p = 0.817). Figures 1 and 2 illustrate the relationship between BMI and CTR in non-hypertensive males and females, respectively, both showing scattered distributions with no significant trend. Figures 3 and 4 show the corresponding relationships in hypertensive males and females, with a clearer upward trend, especially among males.

Table 1 Demographic and Anthropometric Characteristics of Study Participants

Characteristics	Study Groups			
	Non-Hypertensives	Hypertensives	Statistics	p-value
Sex (Frequency/percent)			X^2	
Males	30(25.0)	30(25.0)	-	-
Females	30(25.0)	30(25.0)	-	-
Age (Mean±SD) Years			F test	
Male	42.40±10.74	55.30±7.84	1.370	0.247
Female	36.37±8.46	51.80±7.05	0.037	0.848
Height (Mean±SD) m				
Male	1.63±0.07	1.56±0.07	1.299	0.259
Female	1.53±0.06	1.51±0.06	0.013	0.909
Weight (Mean±SD) Kg				
Male	66.20±8.88	68.77±6.38	2.209	0.143
Female	63.07±10.58	65.38±14.72	0.409	0.525
BMI (Mean±SD) Kg/m^2				
Male	24.89±2.96	28.13±2.09	3.757	0.057
Female	26.91±3.60	29.76±2.61	0.282	0.597

Table 2 Correlation of BMI to CTR of Non-Hypertensive Berom Adult Males

Parameters	Values (Mean±SD)	Pearson Correlation Coefficient	p-value
BMI (Kg/m^2)	24.89±2.96	-0.092	0.628
CTR	0.48±0.03		

Table 3 Correlation of BMI to CTR of Non-Hypertensive Berom Adult Females

Parameters	Values (Mean±SD)	Pearson Correlation Coefficient	p-value
BMI (Kg/m^2)	26.91±3.60	0.044	0.817
CTR	0.45±0.04		

Table 4 Correlation of BMI to CTR of Hypertensive Berom Adult Males

Parameters	Values (Mean±SD)	Pearson Correlation Coefficient	p-value
BMI (Kg/m^2)	28.13±2.10	0.319	0.086
CTR	0.53±0.03		

Table 5 Correlation of BMI to CTR of Hypertensive Berom Adult Females

Parameters	Values (Mean±SD)	Pearson Correlation Coefficient	p-value
BMI (Kg/m^2)	29.76±2.61	0.107	0.572
CTR	0.52±0.02		

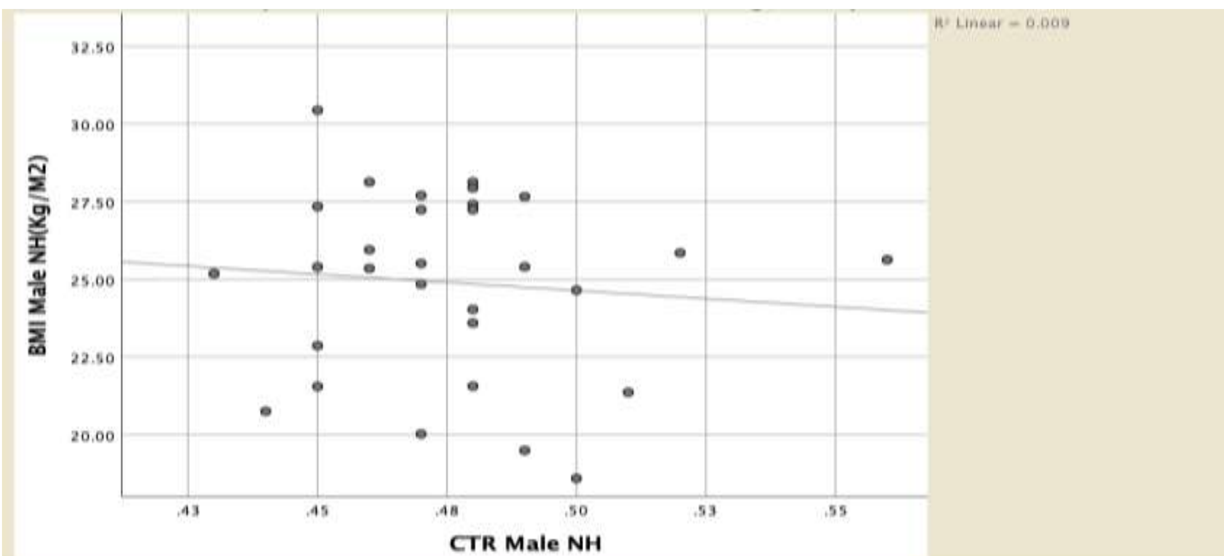

Figure 1 Correlation of BMI to CTR of Non-Hypertensive Berom Adult Males

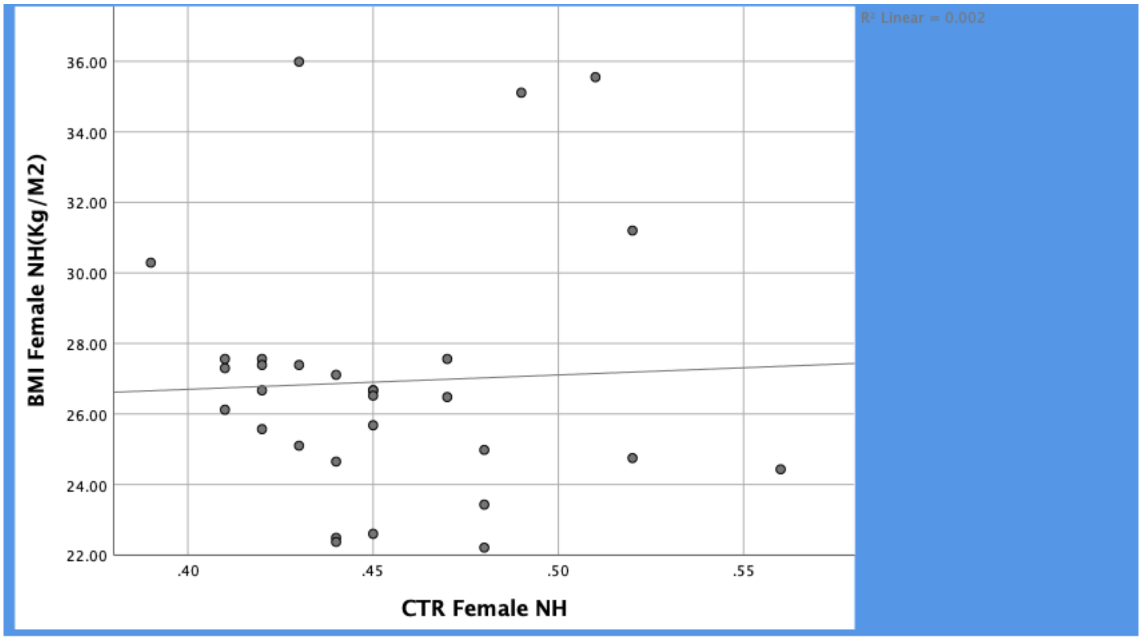

Figure 2 Correlation of BMI to CTR of Non-Hypertensive Berom Adult Females

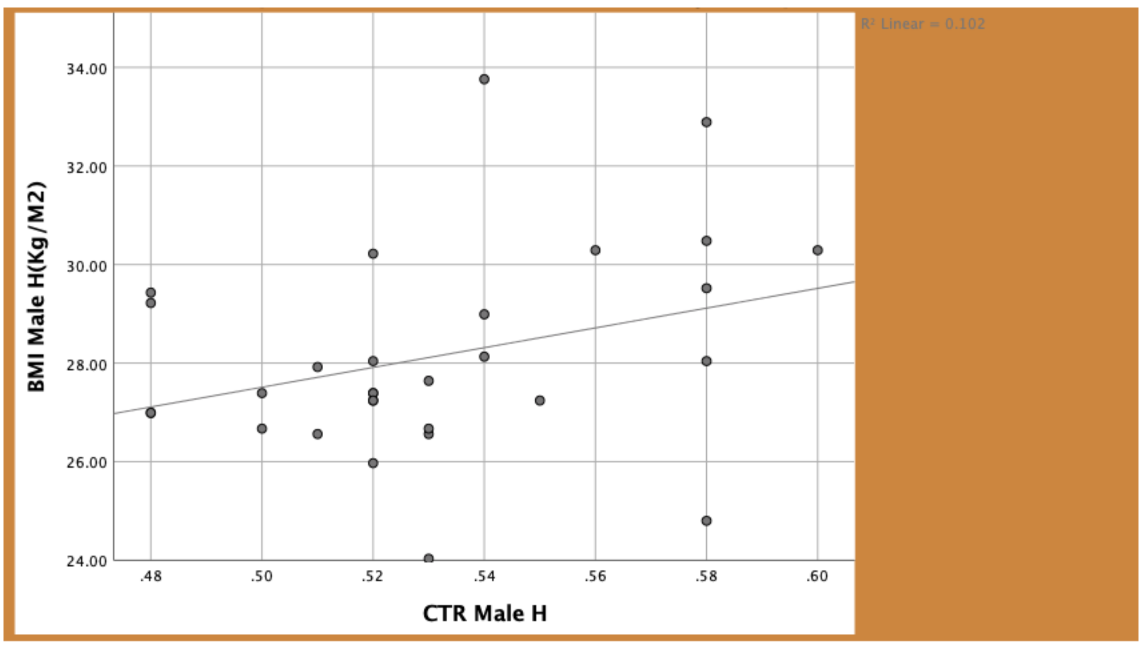

Figure 3 Correlation of BMI to CTR of Hypertensive Berom Adult Males

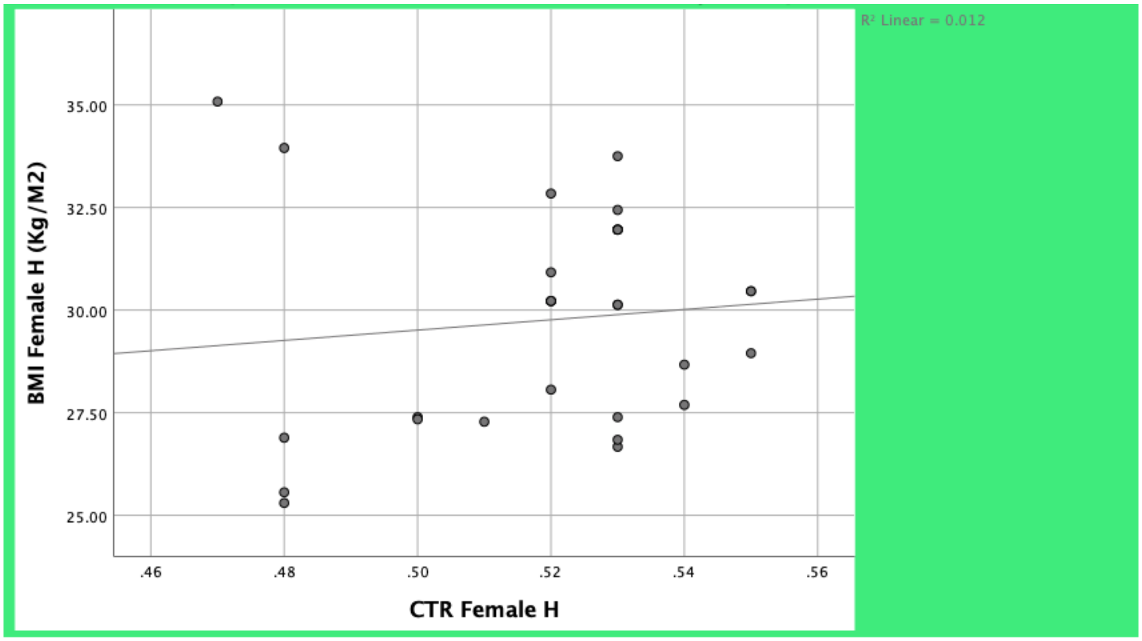

Figure 4 Correlation of BMI to CTR of Hypertensive Berom Adult Females

DISCUSSION

The present study explored the correlation between Body Mass Index (BMI) and Cardiothoracic Ratio (CTR) among hypertensive and non-hypertensive Berom adults in Jos North Local Government Area, with further stratification by sex. Our findings reveal nuanced relationship, suggesting that the relationship between body composition and cardiac morphology is both sex- and disease-status dependent.

Firstly, the anthropometric characteristics showed that hypertensive participants, on average, were older than non-hypertensives, aligning with epidemiological data that associates increasing age with hypertension prevalence (Chow et al., 2013). Though height and weight did not differ significantly between the groups, hypertensive individuals exhibited higher BMI values overall. This finding is consistent with earlier literature that identifies elevated BMI as a risk factor for hypertension and cardiovascular disease (Hall et al., 2015; Stevens et al., 2012).

When disaggregated by sex, hypertensive males and females demonstrated higher mean BMI compared to their non-hypertensive counterparts. While this difference was not statistically significant, the trend may still reflect an underlying pathophysiological process in which adiposity contributes to cardiovascular remodeling. Increased BMI has been implicated in promoting left ventricular hypertrophy and greater cardiac mass, which may be reflected in a higher CTR (Messerli et al., 1982; Lavie et al., 2009).

The analysis of correlations between BMI and CTR yielded varied results. Among non-hypertensive males, a weak negative correlation ($r = -0.092$) was observed, suggesting a minimal inverse relationship, while non-hypertensive females demonstrated a weak positive correlation ($r = 0.044$). These findings imply that in the absence of hypertension, BMI does not significantly impact CTR, supporting existing research indicating that early or mild increases in adiposity may not substantially affect cardiothoracic dimensions (Danias et al., 2001).

In contrast, hypertensive males exhibited a moderate positive correlation between BMI and CTR (r = 0.319), approaching statistical significance (p = 0.056). This trend indicates that increased BMI in hypertensive males may be associated with greater thoracic cavity occupation by the heart, possibly due to hypertensive cardiac remodeling and concentric hypertrophy (Kannel, 1996). Hypertensive females showed a weaker positive correlation (r = 0.107), suggesting a lesser influence of BMI on CTR in this subgroup. This sex disparity may be attributed to differences in fat distribution, hormonal influences, and cardiovascular response to obesity and hypertension (Regitz-Zagrosek et al., 2016).

Figures 1 and 2 depicted a random scatter of data points for non-hypertensive males and females, reaffirming the absence of a meaningful trend. Conversely, Figures 3 and 4 illustrated a subtle upward pattern among hypertensive males and females, respectively, which was more pronounced in males. This visual trend supports the numerical data and underlines the impact of both hypertension and increased body mass on cardiac silhouette.

Collectively, these findings reinforce the complex interplay between BMI and cardiothoracic morphology, especially under hypertensive conditions. They emphasize the need for routine cardiovascular imaging in overweight and hypertensive patients, even in the absence of overt symptoms. The CTR, while a crude marker, may offer preliminary insights into potential structural alterations warranting further echocardiographic assessment.

The relatively weak correlations and lack of statistical significance in some subgroups suggest that CTR alone may not be a robust indicator of cardiac changes in relation to BMI, especially in normotensive individuals. Nevertheless, CTR remains a useful screening tool in resource-limited settings such as Jos North, where advanced imaging may not be readily available.

Future studies with larger sample sizes and complementary imaging modalities such as echocardiography or cardiac MRI are recommended to better elucidate the relationship between adiposity and heart size. Furthermore, inclusion of other variables such as waist circumference, visceral fat indices, and metabolic markers could enhance the interpretative depth of such investigations.

CONCLUSION

This study has highlighted the varying relationships between Body Mass Index (BMI) and Cardiothoracic Ratio (CTR) among hypertensive and non-hypertensive Berom adults in Jos North, with notable sex-specific differences. While the overall correlation between BMI and CTR was generally weak in non-hypertensive individuals, a moderate positive correlation was observed among hypertensive males, suggesting that excess body mass may more significantly influence cardiac morphology in the presence of hypertension.

The findings underscore the potential value of CTR as a preliminary, cost-effective tool for assessing cardiomegaly, especially in hypertensive patients and settings with limited diagnostic resources. However, the weak correlations and lack of statistical significance in most subgroups indicate that CTR alone may not provide a comprehensive assessment of cardiac structural changes associated with increased BMI.

These results call for a more integrative diagnostic approach that includes detailed anthropometric measurements and advanced cardiac imaging techniques. Further studies involving larger and more diverse populations, alongside the evaluation of additional cardiovascular risk markers, are recommended to validate and expand upon these findings.

Ultimately, early identification and management of individuals at risk for cardiac structural changes, particularly among overweight and hypertensive populations, will be essential in mitigating long-term cardiovascular complications in the Berom community and similar populations in low-resource settings.

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