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Residential Housing Quality and Metabolic Syndrome among adults in Osogbo, Nigeria: a cross-sectional study

Hajarat Ajoke MUSIBAU[1], Oluwapelumi Peter ARINOLA[1], Amos Akindele AJAYI[2], Linda Rose OLAYINKA[3], Ridwan Ekundayo ADEDOYIN[1], Favour Lydia BALOGUN[1], Ezinne Sylvia MELIKAM[4], Bakoshi Emmanuel ISREAL[5], Akinkunmi Paul OKEKUNLE[6†], Adekunle Gregory FAKUNLE[1,7†]*

[1]*Department of Public Health, College of Health Sciences, Osun State University, Osogbo, Osun State, Nigeria*
[2]*Department of Family Medicine, Osun State University, Osogbo, Osun State, Nigeria*
[3]*Alli Ehotc University College Hospital, Ibadan, Nigeria*
[4]*Department of Public Health Sciences, College of Behavioural, Social and Health Sciences, Clemson University, USA*
[5]*Federal Polytechnic Kaduna, Kaduna, Nigeria*
[6]*Seoul National University, 08826 Seoul Republic of Korea*
[7]*Modupe and Folorunsho Alakija Research and Medical Teaching Hospital*

Abstract

Context: Previous explorations on the health implications of housing have employed subjective measures.
Objective: This study aims to investigate the association between residential housing quality (RHQ) measured using the housing quality index (HQI) and metabolic syndrome (METS) among adults in Osogbo, Nigeria.
Method: Households of 700 adults aged ≥18 years, selected through multi-stage sampling in Osogbo, Nigeria, were assessed using a housing standard checklist to determine the housing quality index (HQI). A summation of the HQI was performed and dichotomized into "poor RHQ" and "good RHQ" using the 50th percentile. METS was defined according to the Adult Treatment Panel III guidelines. Multivariable-adjusted logistic regression models were used to estimate the odds ratio (OR) and 95% confidence intervals (CIs) for the odds of METS at a two-sided P<0.05.
Results: Overall, 70/700(10%) had METS with a female preponderance, 60(85.7%). The proportion of homes with poor RHQ was higher among participants with METS, 60(85.7%), than those without METS, 380(60.3%), p<0.001. In the final model, poor RHQ was associated with higher odds of METS (OR 2.74, 95% CI 1.31-5.76) after adjusting for relevant covariates.
Conclusions: Environmental health interventions targeted at improving RHQ might significantly contribute to reducing the burden of metabolic syndrome in LMICs.

Keywords: Housing quality, Cardiometabolic health, Hypertension, Diabetes Mellitus, Osogbo, Nigeria.

Introduction

Africa has long been recognized for its public health challenges stemming from infectious diseases and nutritional deficiencies. However, due to nutritional transition and lifestyle modifications associated with urbanization and industrialization, there has been a significant rise in chronic non-communicable diseases.[1] Health conditions such as hypertension, dyslipidemia, hyperglycemia, hypertriglyceridemia, insulin resistance and low-level HDL are among the leading global causes of morbidity and mortality.[2]

Corresponding Author:
Adekunle Gregory Fakunle
Department of Public Health, Osun State University, Osogbo, Osun State, Nigeria.

adekunle.fakunle@uniosun.edu.ng

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The coexistence of three or more of these conditions in an individual has led to the identification of metabolic syndrome (METS).[3,4]

Although METS was thought to be uncommon in Africa,[5] numerous studies have revealed higher prevalence in various sub-Saharan countries, including Nigeria.[6-8] A systematic review and meta-analysis reported a 32.4% and 31.6% prevalence of METS in Africa using the World Health Organization (WHO) criteria and the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III),[9] respectively. A recent investigation carried out in Southwest Nigeria indicated prevalence rates of 4.9%, 3.9% and 4.9% according to the harmonized, International Diabetes Federation (IDF) and NCEP-ATP III criteria, respectively.[8,10] Additionally, Bowo-Ngandji et al.,[9] reported a higher prevalence of 28.2%, 30.8% and 33.3% using the NCEP-ATP III, IDF and Harmonized definitions in their systematic review. Considering the increasing prevalence of METS, several risk factors, such as sedentary behaviour,[11] poor diet,[11] and abdominal obesity,[6] have been documented, particularly in low-income settings like Nigeria, to enable policymakers and public health experts to develop appropriate community-based prevention programs. Despite these efforts, little is known about the significance of housing and living environment in the pathophysiology of METS manifestations in this population.

Environmental factors such as urbanization and adopting western lifestyles play a major role in determining the prevalence of METS across various populations. The occurrence of METS is affected by socioeconomic factors, including education and income levels, alongside lifestyle choices like dietary habits, smoking, alcohol intake and physical activities.[12,13] Economic advancement is thought to contribute to a rise in unhealthy dietary patterns, reduced physical activity and increased rates of smoking and alcohol consumption, which collectively lead to a higher incidence of overweight and obesity, thereby increasing the prevalence of METS. The effect of urbanization, economic development and western lifestyle influences are increasingly being felt in rural communities, impacting the rate of METS. However, available epidemiological studies do not consistently show a greater METS prevalence in rural or urban settings. Research conducted in countries such as India,[14] China,[15] Malaysia[16] and regions of sub-Saharan Africa[17] indicates that METS is more prevalent in urban areas than in rural areas. This suggests that as rural communities experience urbanization, the associated lifestyle changes and health issues become more evident. Conversely, studies in the United States[18] and Korea[19] reported a higher prevalence of METS among rural populations. Therefore, the variation in METS prevalence between rural and urban populations can be linked to differing demographic and socio-cultural factors in which the living environment, such as housing, plays a significant role.

Housing has been identified as a major determinant of health.[20,21] Poor housing quality has been identified as a major risk factor for several communicable and non-communicable diseases.[22-24] Despite the importance of housing quality in the epidemiology of diseases, it remained a neglected site for public health intervention, especially in Nigeria, where information on this subject is relatively scarce.[24] Whether housing quality is associated with METS is yet to be clearly understood. The importance of exploring the significance of housing and living environment in the manifestation of cardiometabolic diseases cannot be underestimated, not only to extend the scope of understanding on this subject but also vital in bridging the gap between clinicians and housing experts for unique engagement on housing design in managing the increasing burden of METS in this population. Although features of substandard housing, such as an unsafe water supply, poor sanitation, indoor air pollution, and overcrowding, have long been recognized as risk factors for communicable diseases such as acute respiratory infection (ARI), diarrhoea, malaria, and tuberculosis,[25] its impact on the development of non-communicable diseases such as METS has not been extensively explored.

In addition, compared to the range of evidence on the contribution of housing on communicable disease outcomes, little research exists in Nigeria on the impact of housing on the development of METS among occupants. Therefore, this study assessed the association of residential housing quality (RHQ) with METS among adults (≥18 years) in Osogbo, Nigeria.

Methods:

Ethical approval and consent to participate

The research received approval from the Ethics Committees of the College of Health Sciences, Osun State University (UNIOSUNHREC Ref No: 2023/PBH/054). The authorities of the selected communities provided consent to engage with the participating communities.

Study area

This study took place in Osogbo, the administrative capital of Osun State, which spans an area of 47 square kilometres. Osogbo is located between latitudes 7º42'N and 7º51'N and longitudes 4º28'E and 4º40'E, with an average elevation of about 300 meters above sea level.[26] The average annual temperature is 26.1ºC, with an average annual rainfall of 1241mm. Osogbo has two local government areas (LGAs): Osogbo and Olorunda LGAs.

Study design and sampling strategy

A cross-sectional study design was employed to investigate the link between RHQ and metabolic syndrome among adults in Osogbo. A multi-stage sampling technique was used to identify and select eligible households. In the first instance, Osogbo LGA was randomly chosen from the two LGAs in Osogbo. This was followed by a random selection of six wards from the 15 geo-political wards in Osogbo LGA. Afterwards, a purposive technique was used to select a polling unit (a politically approved centre where individuals visit to cast their votes during political elections) in each ward. Lastly, using a house numbering system, the first building in each polling unit was selected, followed by every 10th building as assigned by the researcher. In cases where there were multiple households in a building, convenient sampling was used to select one. Also, in situations where the 10th building is a school or town hall, the next building was selected. In each household, individuals at least 18 years of age who had lived in the neighbourhood for at least 12 months before the study were selected. Participants with a history of cardiovascular diseases were excluded from the study. Data collection involved in-person interviews conducted by trained interviewers, with all participants providing written informed consent before their interviews.

Definition of Metabolic Syndrome (METS)

Metabolic syndrome (METS) was defined, according to the Adult Treatment Panel (ATP) III guidelines, as the coexistence of impaired fasting glucose, high blood pressure, and abnormal waist circumference. Fasting glucose was assessed from a drop of blood sample using the Accu-Chek glucometer following the manufacturer's instructions.[27] All measurements were performed by trained personnel. Blood pressure was measured according to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) guideline using the mercury sphygmomanometer and the auscultatory method.[28] Waist circumference was determined according to the World Health Organization (WHO) protocol[29] using a stretch-resistant tape measure at the midpoint between the iliac crest and the lowest palpable rib while the participant stands with feet hip-width apart and weight evenly distributed. All measurements were done in triplicates and the mean of the three values was recorded.

Housing quality index (HQI) and Residential Housing Quality (RHQ) assessment

Selected households were visited by a trained environmentalist and assessed using a validated observational checklist[30] to document observed housing and household characteristics. The characteristics screened for included building type, ownership status (owned or rented), occupant density (total floor area divided by the number of occupants), number of rooms, and roofing materials, among others. A housing quality standard by the United States Department of Housing and Urban Development (HUD)[31] was used to determine the quality of housing inhabited by participants. The HUD housing standard consisted of 12 essential housing facilities such as sanitary facilities, food preparation and refuse disposal, space and security, thermal environment, illumination and electricity, water supply, accessibility, structure and materials, interior air quality, ventilation, lead-based paints and neighbourhood smoke detectors. The presence or absence of these essential facilities were scored 1 or 0, respectively and summed to determine the housing quality index (HQI). Participants' homes that achieved an HQI $\leq 50^{th}$ percentile score were grouped as having "poor RHQ" while those that scored $> 50^{th}$

percentile score were grouped as having "good RHQ".

Sociodemographic and anthropometric characteristics (covariates)

Sociodemographic variables assessed included age (in years), sex (male or female), level of education categorized as none, primary, junior and senior secondary, or tertiary, and average monthly income grouped as less than US$ 100 and at least US$ 100. Anthropometric indices such as body mass index (BMI in kg/m^2) derived as a function of weight (in kg) divided by the square of height (m^2), waist-to-hip ratio (WHR) derived from waist and hip circumferences (cm), general obesity as BMI ≥ 25 kg/m^2 and abnormal obesity as WHR ≥0.90 for men and 0.85 for women. Smoking was defined as self-reported use of any tobacco product in the 12 months before the study or a lifetime. Alcohol use was defined as self-reported use of alcoholic drinks 12 months before the study. Physical inactivity was defined as a lack of engagement in moderate or vigorous exercise for at least 4 hours per week.[32] The assessment measures for stress and depression measures were adapted from the INTERSTROKE study.[33]

Statistical analysis

Data were analyzed using SPSS (version 25) and R statistical program (version 4.0.0). Participants' sociodemographic and housing characteristics were compared by METS status using the Chi-square test for categorical variables and the t-test for continuous variables. Independent associations of RHQ with METS were assessed using stepwise logistic regression to determine the odds ratio (OR) and 95% confidence interval (CI), adjusting for relevant covariates. Covariates were included in the regression models based on empirical evidence from our bivariate analyses and knowledge of factors related to METS. In model 1, we adjusted for sociodemographic characteristics, including age (≤50 vs >50 years), sex (male vs female), average monthly income (<$100 vs ≥ $100) and educational level (no education vs educated). Model 2 was adjusted for household characteristics such as housing tenure (rented vs owned) and occupancy (≤5 vs >5) in addition to all the covariates in model 1. Model 3 was adjusted for physical activity (inactive vs active), stress (no vs yes) and depression (no vs yes) in addition to covariates in model 2. The final model was adjusted for smoking (no vs yes), alcohol consumption (no vs yes) and BMI (< 25kg/m^2 vs ≥25kg/m^2) in addition to covariates in model[3]. Furthermore, a restricted cubic spline with 3 knots was used to model the exposure-response relationship between HQI and METS while adjusting for the same covariates to determine the linear relationship between HQI and METS. All statistical analyses were carried out at a two-sided P<0.05.

Results:

Table 1: Sociodemographic, Anthropometry and clinical characteristics of participants

	All participa N = 700	Participants wit METS; N = 63	Participants v METS; N = 7	p-value
Age; mean ± (years)		47.37 ± 16.38	48.89 ± 16.9	0.94
<3	105(15.0%)	97(15.4%)	8(11.4%)	
3039	108(15.4%)	99(15.7%)	9(12.9%)	
4049	196(28.0%)	171(27.1%)	25(35.7%)	0.58
5059	108(15.4%)	98(15.6%)	10(14.3%)	
6069	86(12.3%)	80(12.7%)	6(8.6%)	
7079	65(9.3%)	58(9.2%)	7(10.0%)	
>79	32(4.6%)	27(4.3%)	5(7.1%)	
Sex				
Mal	105(15.0%)	95(15.1%)	10(14.3%)	0.86
Fema	595(85.0%)	535(84.9%)	60(85.7%)	
Marital Statu				
Singl	76(10.9%)	71(11.3%)	5(7.1%)	0.70
Marrie	514(73.4%)	462(73.3%)	52(74.3%)	
Divorc	24(3.4%)	21(3.3%)	3(4.3%)	
Widow	86(12.3%)	76(12.1%)	10(14.3%)	
Education				
No Educa	166(23.7%)	140(22.2%)	26(37.1%)	0.002*
Prima	162(23.1%)	149(23.7%)	13(18.6%)	
Junio	133(19.0%)	122(19.4%)	11(15.7%)	
Seconda Senio	142(20.3%)	137(21.7%)	5(7.1%)	
Seconda Tertia	97(13.9%)	82(13.0%)	15(21.4%)	
Average mon income				
< US$ 1	652(95.9%)	590(96.7%)	62(88.6%)	0.001*
≥ US$ 1	28(4.1%)	20(3.3%)	8(11.4%)	
Ethnicity				
Yorub	691(98.7%)	621(98.6%)	70(100.0%)	0.60
Haus	5(0.7%)	5(0.8%)	0(0.0%)	
Igbo	4(0.6%)	4(0.6%)	0(0.0%)	
Religion				
Musli	614(87.7%)	551(87.5%)	63(90.0%)	0.54
Christian	86(12.3%)	79(12.5%)	7(10.0%)	
Occupation				
Trade	541(77.3%)	480(76.2%)	61(87.1%)	0.28
Civil Serv	5(0.7%)	5(0.8%)	0(0.0%)	
Farme	6(0.9%)	6(1.0%)	0(0.0%)	
Professio	71(10.1%)	68(10.8%)	3(4.3%)	
Artisa	47(6.7%)	42(6.7%)	5(7.1%)	
Not Emplo	30(4.3%)	29(4.6%)	1(1.4%)	
Physical activ				
Physica inactivi	581(83.0%)	516(81.9%)	65(92.9%)	0.02*
Physically a	119(17.0%)	114(18.1%)	5(7.1%)	
Alcohol				
Neve	446(63.7%)	423(67.1%)	23(32.9%)	<0.001
Former drin	139(19.9%)	114(18.1%)	25(35.7%)	p-value
Current drin	115(16.4%)	93(14.8%)	22(31.4%)	0.94

METS=Metabolic Syndrome, BMI=mass index, HT=Hypertension
**=significant p value*

Table 1 (continued): Sociodemographic, Anthropometry and clinical characteristics of participants

Variables	All participant N = 700	Participants witho METS; N = 630	Participants wi METS; N = 70	p-value
Ever smoked				
No	621(88.7%)	567(90.0%)	54(77.1%)	0.001*
Yes	79(11.3%)	63(10.0%)	16(22.9%)	
Stress				
No	188(26.9%)	173(27.5%)	15(21.4%)	0.28
Yes	512(73.1%)	457(72.5%)	55(78.6%)	
Depression				
No	459(65.6%)	427(67.8%)	32(45.7%)	<0.001*
Yes	241(34.4%)	203(32.2%)	38(54.3%)	
Family Hx of HTN				
Yes	208(29.7%)	178(28.3%)	30(42.9%)	0.01*
No	492(70.3%)	452(71.7%)	40(57.1%)	
BMI; mean ± SD (kg/m^2)		26.43 ± 6.27	29.61 ± 7.56	0.02*
<25	286(43.2%)	267(44.7%)	19(29.2%)	
≥25	376(56.8%)	330(55.3%)	46(70.8%)	0.02*
Waist-Hip ratio mean ± SD		0.85 ± 0.07	0.88 ± 0.06	0.24
<0.85	365(52.1%)	344(54.6%)	21(30.0%)	
≥0.85	335(47.9%)	286(45.4%)	49(70.0%)	<0.001*

METS– Metabolic Syndrome; BMI– Body mass index; HTN– Hypertension
**=significant p value*

Table 2: Housing and household characteristics of participants

Variables	Overall, N = 700	Participants withou METS; N = 630	Participants with METS; N = 70	p-value
Type of building				
Single room	231(33.0%	218(34.6%)	13(18.6%)	0.02*
Self-contain apartmer	83(11.9%)	73(11.6%)	10(14.3%)	
Flat	359(51.2%	319(50.6%)	40(57.1%)	
Duplex	27(3.9%)	20(3.2%)	7(10.0%)	
House ownership				
Owned	409(58.4%	376(59.7%)	33(47.1%)	0.04*
Rented	291(41.6%	254(40.3%)	37(52.9%)	
Occupancy; mean ± S		3.32 ± 1.59	4.34 ± 1.58	0.01*
≤5	614(87.7%	562(89.2%)	52(74.3%)	
>5	86(12.3%)	68(10.8%)	18(25.7%)	<0.001*
Number of rooms				
>2	387(55.3%	339(53.8%)	48(68.6%)	0.02*
≤2	313(44.7%	291(46.2%)	22(31.4%)	
Material used in building				
Cement	491(77.9%	52(74.3%)	543(77.6%)	0.08
Wood	83(13.2%)	8(11.4%)	91(13.0%)	
Mud	14(2.2%)	0(0.0%)	14(2.0%)	
Brick	42(6.7%)	10(14.3%)	52(7.4%)	
Material used in roofing				
Aluminium shee	141(20.1%	124(19.7%)	17(24.3%)	0.35
Asbestos	450(64.3%	405(64.3%)	45(64.3%)	
Bamboo shee	47(6.7%)	41(6.5%)	6(8.6%)	
PVC shee	49(7.0%)	47(7.5%)	2(2.9%)	
Stone coated tile	13(1.9%)	13(2.1%)	0(0.0%)	
Housing Quality Index mean ± SD		4.06 ± 2.07	3.31 ± 1.62	<0.001*
Poor RHQ	440(62.9%	380(60.3%)	60(85.7%)	
Good RHQ	260(37.1%	250(39.7%)	10(14.3%)	<0.001*

METS– Metabolic Syndrome; RHQ– Residential housing quality

The characteristics of participants by METS status are presented in table 1. Participants' overall mean (SD) age was 47.52 (16.44) years, with a majority, 595 (85%), being females. The prevalence of METS was 70/700 (10%). The proportion of those with a monthly income earning at least $100 was higher among participants with METS, 8 (11.4%), than those without METS, 20 (3.3%), p = 0.001. Similarly, current alcohol use (31.4% vs 14.8%), smoking rates (22.9% vs 10%), stress (78.6% vs 72.5%) and depression (54.3% vs 32.2%) were more prevalent among participants with METS than those without METS, respectively. In addition, mean BMI (29.61 ± 7.56 kg/m^2 vs 26.43 ± 6.27 kg/m^2) was significantly higher among participants with METS than those without METS.

Housing characteristics by METS status are presented in table 2. In terms of housing tenure, majority 37 (52.9%) of participants with METS than those without METS, 254 (40.3%) live in a rented apartment. The mean ± SD occupant density among participants with METS, 4.43 ± 1.58, was significantly higher than among participants without METS, 3.32 ± 1.59; p=0.01. In addition, HQI differs significantly between participants with and without METS: 3.31 ± 1.62 vs 4.06 ± 2.07; p<0.001. The prevalence of poor housing quality was significantly higher among participants with METS than those without METS: 60 (85.7%) vs 380 (60.3%); p<0.001.

Table 3 presents a stepwise multivariable-adjusted regression analysis for the association between housing quality and METS. The unadjusted model shows that poor housing quality was significantly associated with higher odds of METS (OR 3.95; 95% CI: 1.98 – 7.86). In model 1, (adjusted for age, sex, monthly income, and family history of hypertension), the odds of the association though slightly attenuated, remained; METS (aOR = 3.62, 95% CI: 1.81 – 7.28). When the final model was adjusted for housing tenure, occupancy, physical inactivity, stress, depression, BMI and WHR in addition to covariates in model 1, the association of poor housing quality was further attenuated, but the independent association with METS remained, OR = 2.74, 95% CI: 1.31 – 5.76.

Table 3: Stepwise multivariable-adjusted multinominal regression for the association of residential housing quality with Metabolic Syndrome

Model/Covariates	**Unadjusted, OR (95% CI)**	**Model 1**		**Model 2**		**Model 3**		**Model 4** [1]	
		aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
RHQ; *poor*	**3.95(1.98-7.86)**	**3.62**	**1.81-7.28**	**3.14**	**1.55-6.38**	**2.96**	**1.45-6.04**	**2.74**	**1.31-5.76**
Age; *>50 yrs*	0.97(0.58-1.63)	0.65	0.34-1.25	0.72	0.37-1.41	0.77	0.39-1.52	0.64	0.30-1.36
Sex; *female*	1.07(0.53-2.15)	1.00	0.48-2.11	0.97	0.46-2.08	1.01	0.47-2.20	1.43	0.58-3.50
Av. monthly income; *<US$100*	0.26(0.11-0.62)	0.27	0.10-0.71	0.29	0.11-0.77	0.29	0.10-0.80	0.50	0.16-1.55
Primary education; *educated*	**0.47(0.23-0.95)**	**0.36**	**0.10-0.71**	**0.40**	**0.18-0.88**	**0.44**	**0.20-0.98**	**0.46**	**0.20-1.07**
Housing tenure; *rented*	**1.66(1.01-2.72)**			**1.41**	**0.82-2.42**	**1.48**	**0.85-2.57**	**1.07**	**0.58-1.95**
Occupancy; *>5*	**2.86(1.58-5.17)**			**2.16**	**1.14-4.10**	**2.11**	**1.10-4.05**	**1.91**	**0.95-3.85**
Physical activity; *inactive*	**2.87(1.13-7.29)**					**2.24**	**0.84-5.98**	**2.11**	**0.76-5.85**
Depression; *yes*	**2.50(1.52-4.11)**					**1.90**	**1.11-3.28**	**1.63**	**0.89-2.98**
Stress; *yes*	**1.39(0.76-2.52)**					**1.17**	**0.61-2.25**	**0.99**	**0.48-2.04**
Smoking; *Yes*	**2.67(1.44-4.94)**							**1.93**	**0.93-4.01**
Alcohol intake; *Yes*	**4.18(2.47-7.06)**							**3.82**	**2.05-7.10**
BMI; *≥25kg/m²*	**1.96(1.12-3.42)**							**2.53**	**1.33-4.80**

RHQ – Residential housing quality; BMI – Body mass index. Model 1 was adjusted for age (≤50 vs >50 years), sex (male vs female), average monthly income (<$100 vs. $100) and primary education (not educated vs. educated). Model 2 was adjusted for house owner ship (owned vs rented) and occupancy (≤5 vs >5) in addition to covariates in model 1. Model 3 was adjusted for physical inactivity (active vs. inactive), stress (no vs yes), and depression (no vs yes) in addition to covariates in model 2. Model 4 was adjus ted for smoking (no vs. yes), alcohol intake (no vs. yes) and BMI (<25 vs. ≥25 kg/m²) in addition to covariates in model 3.

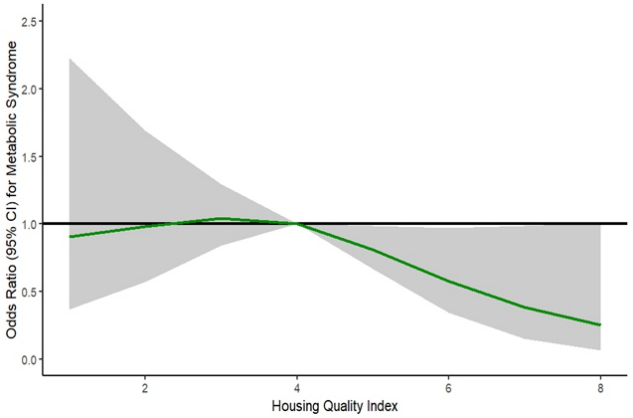

Figure 1: Restricted cubic splines for the association between housing quality index (HQI) and the odds of METS among participants. Green lines denote the odds ratio (OR), and grey shades represent the 95% confidence intervals. The model was adjusted for age (≤50 vs >50 years), sex (male vs female), education (not educated vs. educated), monthly income (<$100 vs. $100), house ownership (owned vs rented), occupancy (≤5 vs >5), physical inactivity (no vs. yes), stress (no vs yes), depression (no vs yes), BMI (<25 vs ≥25 kg/m^2), alcohol intake (no vs. yes) and smoking (no vs. yes).

The dose-response relationship in Figure 1 revealed no significant relationship between HQI and METS until an HQI value of 4 and above (i.e., a minimum of 4 essential housing facilities), when the linear trend suddenly became significantly protective.

Discussion:

This study investigated the association between residential housing quality and metabolic syndrome among adults residing in Osogbo, Nigeria. The prevalence of METS in our population was 10% and the magnitude of poor residential housing quality among participants with METS was higher than those without METS. Residential housing quality was found to be independently associated with METS, reinforcing the critical role of living conditions in the primordial prevention and management of cardiovascular diseases. Our findings demonstrated that poor residential housing quality remains a major determinant of METS even after adjusting for a comprehensive set of confounders. This relationship emphasizes the varied impact of environmental stressors on human health, especially in low- and middle-income countries (LMICs) where housing conditions are below acceptable standards.

Although prior studies have confirmed that METS can markedly increase the risk of cardiovascular diseases (CVDs),[5,7] only a few studies have explored its prevalence and associated factors in LMICs.[5,6,34] The prevalence of METS assessed using the Adult Treatment Panel (ATP) III in our study was 10%, a figure higher than the prevalences reported in similar studies in Southwest Nigeria.[8,10] Even though advanced age and sex have been reported to be associated with high blood pressure,[35,36] impaired fasting glucose,[37-39] and abnormal waist circumference,[40,41] our report revealed no significant relationship with METS. However, housing characteristics such as house ownership and occupancy were notable determinants of METS in our population. A recent study reported that people facing poor home conditions have higher levels of cardiometabolic risk (CMR), even when accounting for socioeconomic advantage.[24]

Our finding on the association between RHQ and METS aligns with the work of Mawhorter et al.[42], who demonstrated that poor housing conditions are

linked to increased cardiometabolic risk, particularly among older adults. In light of the broader health implications of exposure to poor housing quality, Fakunle et al.[20] reported a strong association between poor housing quality and acute respiratory infections among children in Nigeria, further illustrating the broad spectrum of health risks associated with substandard living conditions. While our study focuses on adults and the coexistence of high blood pressure, impaired fasting glucose and abnormal waist circumference, the current findings contribute to the growing recognition of housing quality as a key social determinant of health. It is plausible that poor RHQ impacts METS due to the lack of essential housing facilities required to maintain healthy living. The absence of these housing facilities could lead to psychosocial stress, impaired mental health and poor dietary habits associated with METS.[43] The persistence of poor housing quality as an independent predictor of METS suggests that housing interventions could be crucial in mitigating the burden of chronic diseases in LMICs. Haines et al. (2013)[25] emphasized the potential of improved housing to promote health and development in low-income settings, a perspective that our findings support. The high prevalence of poor housing quality in our study (85.7% among participants with METS) underscores the urgency of addressing housing disparities as part of broader public health strategies.

Furthermore, the exposure-response relationship between HQI and METS exhibited a non-significant trend until reaching an HQI of 4, at this point, the trend experienced a significant inverse relationship. This suggests that at a minimum of 4 housing facilities, the odds of developing METS reduced significantly which complements our previous explanation of lack of essential housing facilities as a major determinant of METS. This finding is undoubtedly significant for public health intervention strategies, highlighting the need for culturally sensitive approaches to ensuring high HQI in Nigeria. The implications for policy formulation in Nigeria are substantial, as ensuring a high standard of living through improved housing quality status could contribute to mitigating the rising prevalence of METS and other cardiovascular diseases in Nigeria.

Our study is one of the few to objectively quantify residential housing quality using HQI and examine its association with METS in a Nigerian context. Previous research has often relied on subjective assessments of housing conditions,[44,45] which may be prone to bias. By contrast, our study employed direct observations and measurements, thereby reducing the risk of misclassification and enhancing the reliability of our findings. This methodological strength allows us to draw more robust conclusions about the relationship between RHQ and METS. However, there are limitations to our study that should be acknowledged. The cross-sectional design precludes causal inferences, and the relatively small sample size may limit the generalizability of our findings. Also, there are no relevant studies to explain the underlying mechanism of the association as a result of the complexities associated with housing. Again, it is difficult to judge which of the essential housing facilities is most important in the association between RHQ and METS. Additionally, while we adjusted for a wide range of covariates, residual confounding factors may not be accounted for. Future longitudinal studies are needed to elucidate the causal pathways linking housing quality to METS.

Conclusion

Our study underscores the importance of housing quality as a determinant of metabolic syndrome. Interventions aimed at improving housing conditions could have a substantial impact on reducing the burden of chronic diseases in LMICs, particularly among vulnerable populations such as older adults. Policymakers should prioritize efforts to enhance housing quality as part of comprehensive strategies to address the growing epidemic of non-communicable diseases in these settings.

Acronyms

METS, Metabolic syndrome; RHQ, Residential housing quality; HQI, Housing quality index; CVD, Cardiovascular diseases; BMI , Body mass index; WHR, Waist-to-hip ratio; LMIC, Low-and-middle income countries; WHO. World Health Organization; OR, odds ratio; CI, confidence intervals.

Authors' contributions

AGF and APO conceptualized and designed the study. AHM and AGF wrote the first draft. JO, AAA, LRO, TB, CAA, ESM, BEI, directed the study's implementation and review of the instruments; AGF and OPA designed and executed the analytical

strategy. JO, AAA, LRO, TB, CAA, ESM, and BEI contributed to the introduction, methods and discussion sections of the manuscript. APO provided an extensive review of the original draft. All authors gave final approval and agreed to be accountable for all aspects of the manuscript.

Data sharing statement

Data are available by contacting the corresponding author.

Disclosure

The authors declare no conflicts of interest in this work.

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