Original Article

Prevalence of the Metabolic Syndrome and its Associated Factors among Hospital Workers at a Rwandan Provincial Hospital: A Cross-Sectional Study

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Abstract

Background
The metabolic syndrome (MetS) is a cluster of interconnected risk factors, affecting approximately 20–30% of the adult population worldwide, with a rising burden in sub-Saharan Africa, including Rwanda. Hospital workers, a critical component of the healthcare system, are at risk of developing MetS due to occupational stress, sedentary lifestyle, and poor dietary habits. This study aimed to determine the prevalence of MetS and its associated risk factors among hospital workers at a provincial hospital in Rwanda.

Methods
A cross-sectional study was conducted among healthcare workers aged 35–65 years at a provincial hospital in Rwanda. Data were collected using the World Health Organization (WHO) STEPwise tool and MetS was defined according to NCEP ATP III (National Cholesterol Education Program Adult Treatment Panel III) criteria. Statistical analyses were performed using Stata 15, with significance set at $p < 0.05$.

Results
The overall prevalence of MetS was 37.9%, significantly higher in females (48.7%) than males (7.7%, $p < 0.001$). Low High-Density Lipoprotein-C (HDL-C) was the most prevalent MetS component (60.8%), especially among females. Abdominal obesity was also significantly higher in females. Multiple logistic regression analysis identified increasing Body Mass Index (BMI) (adjusted odds ratio [aOR]: 1.25; 95% confidence interval [CI]: 1.09–1.44; $p = 0.001$) and age (aOR: 1.13; 95% CI: 1.03–1.23; $p = 0.010$) were identified as independent predictors of Metabolic Syndrome (MetS).

Conclusion
Metabolic syndrome is common among hospital workers in Rwanda, particularly among women. Higher BMI and older age are key predictors, highlighting the need for targeted workplace interventions to reduce modifiable risk factors and improve metabolic health in this population.
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Keywords: Prevalence, Metabolic syndrome, Hospital Workers, Rwanda

Introduction

The metabolic syndrome (MetS) is a complex condition characterised by a cluster of interconnected risk factors, including abdominal obesity, hypertension, dyslipidaemia, and impaired glucose regulation.[1] The global prevalence of MetS is alarming, affecting approximately 20-30% of the adult population worldwide.[2] In Africa, the burden of MetS is also rising. For instance, estimates in the 2000s, were often below 20% in many African regions.[3] However, according to a 2023 systematic review and meta-analysis covering 29 African countries and over 156,000 participants, the overall prevalence of MetS increased to 32.4% (95% CI: 30.2–34.7) across the continent.[4] This is driven mainly by rapid urbanisation, changes in dietary habits, and decreased physical activity.[3] The Sub-Saharan Africa region has experienced an epidemiological shift where the high burden of infectious diseases is slowly giving way to an increasing burden of non-communicable diseases (NCDs).[5] In 2000, NCDs accounted for 24% of all deaths in sub-Saharan Africa. By 2019, this figure rose to 37%, and projections estimate it will reach 51% of premature mortality by 2030.[6] Factors that characterize MetS, collectively increase the risk of developing type 2 diabetes mellitus fivefold and cardiovascular disease twofold.[7, 8] And these two conditions are the leading causes of morbidity and mortality globally.[9–11]

Previous studies have reported associations between MetS and hypertension, stroke, cancer, and increased mortality.[12–15] For example, all-cause mortality was moderately elevated, with a hazard ratio (HR) of 1.24, indicating a 24% higher risk of death from any cause in individuals with MetS.[15] Furthermore, women with high blood pressure had a MetS incidence rate of up to 23.21% over five years.[14]

Rwanda, a country in the Eastern Africa region, is experiencing a growing burden of NCD's, including MetS.[16] In 2024, 47.7% of health facility deaths and 59.3% of community deaths were due to NCDs.[16] In 2024, a cross-sectional study conducted at a referral teaching hospital in Rwanda among 421 adult outpatients found a high prevalence of Metabolic Syndrome (51.9%), with a marked gender disparity, 59.4% in females compared to 26.3% in males.[17] However, a critical gap remains in our understanding of the burden of MetS among healthcare workers in Rwanda.

Hospital workers, including healthcare professionals such as doctors, nurses, and clinical officers, as well as support staff like laboratory technicians, radiographers, and pharmacists, are indispensable to the healthcare system.[18] Their collaborative efforts enhance the delivery of person-centered care and improve both patient and system outcomes.[18] Their ability to mobilize quickly and work under pressure is especially critical during emergencies, where rapid response can significantly improve survival rates and stabilize communities.[19,20] Despite their vital role, the health and well-being of hospital workers are often neglected.[21,22] Burnout, moral injury, and workforce attrition are rising globally, yet healthcare systems continue to treat workforce sustainability as peripheral.[23,24] This neglect is increasingly recognized as a structural flaw that compromises the resilience and viability of care delivery.[25]

The hospital work environment can be stressful, given the often-long working hours, rigor of shift work, and exposure to infectious diseases, which can also contribute to the development of MetS.[26] Studies have consistently shown that hospital workers are at risk of developing MetS due to their occupation.[27–29] Physical inactivity, unhealthy eating habits, and occupational stress which are common among hospital workers, directly contribute to the development of metabolic syndrome risk factors.[30–32] Furthermore, hospital workers usually neglect their own health due to workload and time constraints, exacerbating the risk of MetS.[31]

Safeguarding the health of health workers is critical for ensuring the health of the citizenry at large which further helps to sustain national economic development.[19,20] Understanding the prevalence and risk factors of Metabolic Syndrome (MetS) among healthcare workers in Rwanda is essential for designing effective, evidence-based interventions. This study investigated the occurrence of MetS and its associated factors among hospital staff at a provincial hospital. The findings not only expand the existing body of knowledge on MetS in Rwanda but also provide a foundation for developing targeted workplace health promotion strategies and policies aimed at prevention and management.

Methods

Study design

This was a health facility-based cross-sectional study that recruited hospital employees across various professional categories. Data collection was conducted over a three-month period, from February to April 2023.

Study setting

The study was conducted at Ruhengeri Referral Teaching Hospital, located in Musanze District, Northern Province, Rwanda. The hospital serves as a referral center for 18 surrounding health centers and has an estimated catchment population of approximately 400,000 individuals. With a bed capacity of 400, the hospital provides a wide range of clinical services and functions as a key healthcare institution in the region.[33]

Study population

This study targeted hospital employees aged 35 years and above, in alignment with the Rwandan Ministry of Health's Non-Communicable Diseases screening policy,[34] which prioritizes screening for individuals within this age group due to their increased risk for NCDs, including MetS. By adopting this age criterion, the study ensured relevance to national public health priorities and focused on a population where MetS is more likely to be observed. The hospital where the study was conducted has an estimated workforce of 270 employees across various professional categories. All eligible and available staff members within the specified age range were invited to participate during the data collection period.

Study sample and Sampling strategy

In this study, we employed a convenience sampling approach, recruiting all hospital employees who were willing, available, and eligible during the data collection period (February to April 2023). Out of an estimated 270 hospital staff members, 107 employees were enrolled, and 103 participants with complete data sets were included in the final analysis. While no formal sample size calculation was performed due to the exploratory nature of the study and the limited target population, we ensured that the sample was representative of various professional categories within the hospital.

Inclusion and Exclusion Criteria

In order to ensure appropriate assessments of metabolic biomarkers, the eligible participants were consenting individuals between the ages of 35 and 65 who had fasted for 10 to 14 hours. To maintain the integrity of the study, we applied strict exclusion criteria, carefully screening out individuals who may have been compromised by underlying health conditions or physiological states. Specifically, we excluded those outside the 35-65 age range, pregnant or lactating women, individuals with severe illnesses, and patients attending the renal outpatient clinic, as their conditions may have confounded the study findings. Furthermore, enrollment was limited to participants who gave written informed permission, ensuring that all participants were fully aware of the study's procedures and potential risks even though minimal.

Data collection tools and procedures

Data collection for this study adhered to the WHO STEPwise approach to non-communicable disease surveillance,[35] progressing through three structured phases. The process began with interviewer-administered questionnaires designed to capture sociodemographic characteristics such as age, sex, marital status, education level, and residence, as well as lifestyle factors such as smoking habits, alcohol consumption, physical activity, and dietary patterns.

Following the questionnaire phase, trained personnel conducted physical measurements using standardized equipment. Height was measured in centimeters with a stadiometer, and weight in kilograms using a calibrated scale, both manufactured by Seca (Hamburg, Germany). Waist circumference was recorded using a non-stretchable tape placed midway between the lower rib margin and the iliac crest. Blood pressure (BP) was measured using an Omron digital automated device (Omron Healthcare Co., Ltd, Japan). After a five-minute rest period, three readings were taken; the first was discarded, and the average of the last two was used for analysis.

The final phase Involved biochemical analysis. After a 10–14 hour overnight fast, venous blood was drawn from each participant. A grey-top tube was used for fasting plasma glucose, and a red-top plain tube for lipid profiling. All samples were centrifuged at 3000 rotor per minute for 5to 10 minutes within 30 minutes of collection. Plasma and serum were harvested accordingly and analyzed using the COBAS C311 autoanalyzer (Roche Diagnostics, Rotkreuz, Switzerland), following good clinical laboratory practices and using manufacturer-supplied reagents.

Characterisation of metabolic syndrome

i) The criteria for the MetS were adopted from the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) guidelines 2009 as used in the United States of America,[36] which consider MetS as the presence of at least any three the following five factors:Abdominal obesity: defined as waist circumference (WC) > 102cm for men and > 88cm for women,

ii) Elevated serum triglycerides (TG): > 1.7 mmol/L or specific treatment for hypertriglyceridaemia.

iii) Decreased High-Density Lipoprotein-C (HDL-C): < 1.03 mmol/L for men or < 1.29 mmol/L for women or treatment for hypoalphalipoproteinaemia.

iv) Elevated Blood Pressure >130/85 mmHg or treatment of previously diagnosed hypertension, and;

v) Elevated fasting glucose > 5.6 mmol/L or treatment of previously diagnosed diabetes mellitus.

Data management and statistical analysis

Data were analyzed using Stata 15 (StataCorp, College Station, TX, USA). Categorical variables were summarized as frequencies and percentages; continuous variables were reported as medians with interquartile ranges. Fisher’s exact test and Wilcoxon rank-sum test were used for group comparisons. Logistic regression analysis was applied to identify factors associated with MetS, with bivariate models followed by multiple regression analysis. Logistic regression results are presented as odds ratios with 95% confidence intervals, and statistical significance was set at $p < 0.05$.

Ethical Approval

This study was conducted with respect for the rights and dignity of its participants, adhering to the highest standards of ethics and integrity. The study protocol underwent rigorous review and received approval from the Rwanda National Ethics Committee (Reference Number: 32/RNEC/2022), ensuring that the research was conducted in accordance with the principles outlined in the Declaration of Helsinki. Prior to enrolment, each participant provided written informed consent, a process that not only informed them of the study's objectives, procedures, and potential risks but also ensured that their participation was entirely voluntary. To further protect participant confidentiality, we implemented a robust anonymization protocol.

Each participant was assigned a unique identifier, effectively delinking their personal data from their identity. This meticulous approach ensured that all data collected during the study remained anonymous, thereby minimizing the risk of participant identification and maintaining the confidentiality of sensitive information.

Results

Social demographic and life style characteristics of study participants

This study was carried out on a total number of 103 hospital workers, including 76 females (73.8%) and 26 males (26.2%). The median [Interquartile Range (IQR)] age of the overall participants was 43 (39-49) years. The majority of the participants (88, 88.9%) had attained a tertiary level education and did not smoke cigarettes (100, 97.1%). There were no significant differences according to sex for education level (p = 0.188) and cigarette smoking status (p = 1.000). However, significantly more males (20, 80.0%) consumed alcohol compared to females (5, 20%) (p < 0.001) (Table 1).

Table 1. Demographic characteristics of study participants by gender

Variable	All participants *n* =103	Females *n* = 76	Males *n* = 26	***P*-value**
Age (years) Median (IQR)	43 (39-49)	43.5 (40-49)	42 (37-48)	0.219
Size of Family Median (IQR)	5 (4-6)	6 (4-7)	5 (4-6)	0.182
Age Category				
35-44 years	58 (56.9)	42 (56.0)	16 (57.7)	1.000
45-54 years	35 (34.3)	26 (34.7)	9 (34.6)	
>55years	9 (8.8)	7 (9.3)	2 (7.7)	
Residence				
Urban	89 (86.4)	66 (86.8)	22 (84.6)	0.750
Rural	14 (13.6)	10 (13.2)	4 (15.4)	
Education Level				
Primary school level or lower	3 (3.0)	3 (4.1)	0	0.188
Secondary school level	8 (8.1)	8(10.8)	0	
Tertiary level	99 (88.9)	63 (85.1)	24 (100.0)	
Marital Status				
Married	91 (88.4)	66 (86.8)	24 (92.2)	0.856
Separated	5 (4.9)	4 (5.30	1 (3.9)	
Widowed	4 (3.9)	4 (5.3)	0	
Never married	3 (2.8)	2 (2.6)	1(3.9)	
Socioeconomic Category				
Category 2	8 (7.8)	5 (6.6)	3 (11.5)	0.417
Category 3	95 (92.2)	71 (93.4)	23 (88.5)	
Cigarette Smoking Status				
No	100 (97.1)	74 (97.4	25 (96.2)	1.00
Yes	3 (2.9)	2 (2.6)	1 (3.8)	
Alcohol consumption				
No	52 (53.6)	46 (64.8)	5 (20.0)	**<0.001**
Yes	45 (46.4)	25 (35.2)	20 (80.0)	

Key: * All n (%) unless specified; IQR Interquartile Range

With regard to life style, the proportion of males who regularly engaged in physical exercise was significantly higher in male participants (75.0%) compared to female participants (36.6%); p = 0.002. The proportions of participants were comparable in terms of vegetable consumption, walking or cycling frequency, engaging in physically demanding work and a standing diagnosis of hypertension and diabetes mellitus (all p > 0.05). Data related to sociodemographic and lifestyle characteristics are depicted in Table 2.

Table 2. Lifestyle and clinical characteristics of study participants by gender

Variable	**All participants** *n* = 103	**Females** *n* = 76	**Males** *n* = 26	***p*-value**
Total Sedentary Hours/Week Median (IQR)	4 (3-6)	4 (3-6)	4.5 (2-6.5)	0.993
Ever Diagnosed with Hypertension?				
No	89 (86.4)	64 (84.2)	24 (93.3)	0.510
Yes	14 (13.6	12 (15.8)	2 (7.7)	
Ever Diagnosed with Diabetes Mellitus				
No	92 (92.9)	66 (86.8)	26 (100.0)	0.061
Yes	7 (7.1)	10 (13.2)	0	
Consumption of Vegetables				
Never/Rarely	1 (1.0)	1 (1.3)	0	0.790
Average (<1day)	8 (7.8)	5 (6.6)	3 (11.5)	
1-2days/week	28 (27.2)	20 (26.3)	7 (26.9)	
3-4days	66 (64.0)	50 (65.8)	16 (61.5)	
Physically Demanding Occupation				
No	58 (56.9)	43 (57.3)	14 (53.9)	0.820
Yes	44 (43.1)	32 (42.7)	12 (46.1)	
Do you Walk or Cycle regularly				
No	8 (7.8)	7 (9.2)	1 (3.9)	0.676
Yes	95 (92.3)	69 (90.8)	25 (96.2)	
Vigorous Exercise				
No	51 (53.1)	45 (63.4)	6 (25.0)	**0.002**
Yes	45 (46.9)	26 (36.6)	18 (75.0)	

Key: *All n (%) unless specified; IQR: Interquartile range

The prevalence of MetS among hospital workers at a Rwandan provincial hospital

The overall prevalence of the MetS was 37.9% (n = 39), with the prevalence significantly higher in females (48.7%) compared to 7.7% in males (p < 0.001). Overall, of the 39 participants with the MetS, 28 (27.2%) had only three components of the MetS whilst 11 (10.6%) had 4-5 components of the MetS.Significantly more females had higher clustering of MetS components (3-5) compared to males both of whom had the basic three components of the Mets (p < 0.001). The overall prevalence of abdominal obesity was 59.4% (n = 60) with a significantly higher proportion in females 78.7% versus 3.9% in males (p < 0.001). With regards to serum HDL-C levels, the overall prevalence of hypoalphalipoproteinaemia was 60.8% (n = 62) with significantly more females being hypoalphalipoproteinaemic compared to males (p = 0.002).

The remainder of the MetS components were comparably distributed according to gender (p > 0.05). The single most predominant MetS component was hypoalphalipoproteinaemia (60.8%) and the least prevalent was high blood pressure (19.6%). The same pattern was mirrored in female participants whilst in males, hypertriglyceridaemia was the most predominant single component of the MetS with Abdominal obesity being the least prevalent (Table 3).

Table 3. Prevalence and distribution of metabolic syndrome components by gender

	Gender			
Variable	**Overall**	**Females**	**Males**	***p*-value**
Metabolic syndrome				
No	64 (62.1)	39 (51.3)	24 (92.3)	**<0.001**
Yes	39 (37.9)	37 (48.7)	2 (7.7)	
The number of MetS components within study participants				
Nil	5 (4.9)	1 (1.3)	4 (15.4)	**<0.001**
One	30 (29.1)	15 (19.7)	14 (53.9)	
Two	29 (28.2)	23 (30.30	6 (23.1)	
Three	28 (27.2)	26 (34.2)	2 (7.7)	
Four	9 (8.7)	9 (11.8)	0	
Five	2 (1.9)	2 (2.6)	0	
Hypertension Status				
BP< 130/85	82 (80.4)	61 (80.3)	21 (80.0)	0.977
BP ≥130/85	20 (19.6)	15 (19.7)	5 (20.0)	
TG Category				
Normal < 1.7mmol/L	71 (69.6)	52 (69.3)	19 (69.2)	0.992
High ≥1.7mmol/L	31 (30.4)	23 (30.7)	8 (30.8)	
Waist Circumference Category				
Normal	41 (40.6)	16 (21.3)	25 (96.2)	**<0.001**
High Risk:	60 (59.4)	59 (78.7)	1 (3.9)	
Males > 102 cm				
Females > 88 cm				
HDL-C Category				
High Risk **Males** < 1.03mmol/L	62 (60.8)	52 (69.3)	10 (34.6)	**0.002**
Females < 1.29mmol/L				
Normal	40 (39.2)	23 (30.7)	17 (65.4)	
Fasting Plasma Glucose Status				
< 5.6mmol/L	57 (55.3)	39 (51.3)	17 (65.4)	0.213
≥ 5.6mmol/L	46 (44.7)	37 (48.7)	9 (34.6)	

Key: BP: Blood Pressure; HDL-C: High Density Lipoprotein Cholesterol; TG: Triglycerides.

Factors associated with metabolic syndrome

In bivariate analysis, male sex was significantly protective against MetS [cOR (Crude Odds ratio): 0.087, 95% CI: 0.019–0.40], but this association was not significant after adjustment [aOR (adjusted Odds Ratio): 0.20, 95% CI (Confidence Interval): 0.03–1.54)]. Similarly, sedentary hours were initially associated with increased risk (cOR: 1.30, 95% CI: 1.05–1.61), but not in the multiple regression model (aOR: 1.13, 95% CI: 0.84–1.54).

In contrast, both BMI and age remained significant predictors in both models. BMI (cOR: 1.25, 95% CI: 1.13–1.38; aOR: 1.25, 95% CI: 1.09–1.44) and age (cOR: 1.09, 95% CI: 1.02–1.16; aOR: 1.13, 95% CI: 1.03–1.23) were independently associated with higher odds of MetS. These findings show that while male sex and sedentary behavior initially appeared associated with MetS, their effects were not significant after adjusting for other factors. In contrast, increasing BMI and age remained strong, independent predictors of MetS in both bivariate and multiple regression analyses (Table 4).

Table 4. Bivariate and multiple logistic regression analysis of factors associated with metabolic syndrome

Variable	Bivariate		Multiple regression	
	cOR (95% CI)	*p*-value	aOR (95% CI)	*p*-value
Gender				
Female	**Referent**		**Referent**	
Male	0.087 (0.019-0.40)	**0.002**	0.20 (0.03-1.54)	0.122
Marital status				
Married	**Referent**		**Referent**	
Separated	2.77 (0.44-17.4)	0.279	Excluded	
Widowed	1.84 (0.25-13.7)	0.550		
Never Married	3.69 (0.32-42.3)	0.294		
Alcohol Consumption				
No	**Referent**		**Referent**	
Yes	0.57 (0.25-1.31)	0.186	1.20 (0.31-4.64)	0.787
Participation in Physical Work				
No	**Referent**		**Referent**	
Yes	0.62 (0.27-1.40)	0.247	0.46 (0.11-1.88)	0.287
Walking or Cycling Regularly				
No	**Referent**		**Referent**	
Yes	0.58 (1.37-2.47)	0.465	Excluded	
Regular Vigorous Exercises				
No	**Referent**		**Referent**	
Yes	0.55 (0.24-1.27)	0.162	1.03 (0.26-4.03)	0.962
Hours Sedentary/day	1.30 (1.05-1.61)	**0.016**	1.13 (0.84-1.54)	0.450
BMI	1.25 (1.13-1.38)	**<0.001**	1.25 (1.09-1.44)	**0.001**
LDLC-C	1.15 (0.73-1.71)	0.619	Excluded	
TC	1.13 (0.81-1.56)	0.483	Excluded	
Age (Years)	1.09 (1.02-1.16)	**0.009**	1.13 (1.03-1.23)	**0.010**

Key: cOR: Crude Odds Ratio; aOR: Adjusted Odds Ratio; TC: Total Cholesterol; BMI: Body Mass Index; LDLC: Low Density Lipoprotein Cholesterol; CI: Confidence Interval

Discussion

The aim of this study was to assess the prevalence and risk factors of metabolic syndrome among hospital workers, examining the impact of occupational stress, irregular work schedules, and lifestyle behaviors to inform targeted prevention and health promotion strategies. This study reveals a high burden of metabolic syndrome among hospital workers, particularly among females (48.7% vs. 7.7% in males), with Abdominal obesity and low HDL-C affecting 78.7% and 69.3% of participants respectively. These findings are consistent with regional and global trends that show a rising prevalence of MetS in occupational settings, especially among women.[37] The most prevalent components such as abdominal obesity and hypoalphalipoproteinaemia, are well-established cardiovascular risk factors, suggesting that a significant proportion of this workforce may be at elevated risk for future cardiometabolic complications.[38] Importantly, increasing BMI (aOR: 1.25, 95% CI: 1.09–1.44, p = 0.001) and age (aOR: 1.13, 95% CI: 1.03–1.23, p = 0.010) were identified as the strongest independent predictors of MetS. These associations underscore the cumulative impact of aging and adiposity on metabolic health, even among relatively young and educated populations such as healthcare workers.[37,39]

In the present study, the prevalence of MetS and its marked gender disparity are consistent with findings from previous research.[17] A study from Kenya on MetS and its predictors in an urban population reported a prevalence of (35%),[40] while a recent systematic review on the African population highlighted the prevalence of MetS of 32.4%.[41] Together these findings show a comparable trend to our study and this suggest that MetS is a growing public health concern across diverse African settings, including among healthcare workers. This further, underscores the need for region-specific strategies to address modifiable risk factors and implement early screening and intervention programs. Conversely, studies conducted among hospital workers in Turkey [42] and Pakistan [43] have reported lower prevalence rates (32.5% and 14.95% respectively). These differences may be attributed to variations in study populations, diagnostic criteria, lifestyle factors, and healthcare system contexts.

In the present study, abdominal obesity was significantly more prevalent among female hospital workers compared to males ($p < 0.001$). This finding is consistent with a growing body of evidence from sub-Saharan Africa and other low- and middle-income countries, where women consistently exhibit higher rates of central adiposity. For example, a study conducted in the Eastern Cape Province of South Africa reported a significantly higher prevalence of abdominal obesity among women (67.4%) compared to men (20.2%), highlighting a stark gender disparity in fat distribution.[44] Similarly, research conducted among healthcare workers in Kenya found that female staff had significantly higher waist circumference and waist-to-hip ratios than their male counterparts.[45] In Nigeria, a study among adult workers revealed that 62% of women had abdominal obesity compared to 28% of men.[46] These patterns are often attributed to a combination of biological,[47] behavioral,[48] and sociocultural factors,[49] including hormonal influences,[50] reduced physical activity,[51] and cultural norms that associate higher body weight with health and social status.[52] Abdominal obesity is a key driver of metabolic syndrome and is strongly associated with insulin resistance, systemic inflammation, and increased cardiovascular risk.[53] Its high prevalence among female healthcare workers is particularly concerning, as it may reflect occupational stress, sedentary work environments, and limited access to structured wellness programs.[54] These findings underscore the need for gender-sensitive interventions that promote physical activity, healthy eating, and regular screening for metabolic risk factors in healthcare settings.

In addition to abdominal obesity, in the present study, hypoalphalipoproteinaemia was significantly more prevalent among female hospital workers. This finding aligns with several studies across sub-Saharan Africa. For instance, Asiki et al.[55] reported low HDL-C levels in 79% of Ugandan women compared to 61% of men in a rural population-based study. Similarly, Peer et al.[56] found that urban South African women had significantly lower HDL-C levels than men, contributing to a higher overall burden of dyslipidaemia among females. In Ghana reported a higher prevalence of low HDL-C among women in a nationally representative adult population.[57] Although women are physiologically expected to have higher HDL-C levels due to the protective effects of estrogen, these findings suggest that modifiable risk factors such as poor diet, physical inactivity, and central adiposity, may override hormonal advantages. The consistent pattern of low HDL-C among women across different African contexts highlights a critical need for targeted interventions addressing lipid abnormalities in female populations.

While Abdominal obesity and low HDL-C were more prevalent among female participants, increasing BMI and age emerged as universal predictors of MetS across the study population. Specifically, BMI showed an adjusted odds ratio (aOR) of 1.25 (95% CI: 1.09–1.44, p = 0.001), while age had an aOR of 1.13 (95% CI: 1.03–1.23, p = 0.010). BMI, a proxy for overall adiposity, is closely linked to insulin resistance, dyslipidaemia, and systemic inflammation, which are all hallmark features of MetS.[58–60] Numerous studies have demonstrated that individuals with higher BMI are significantly more likely to meet the diagnostic criteria for MetS. For example, a study by Faijer-Westerink et al. (2020) in sub-Saharan Africa found that overweight and obese individuals had a 3- to 5-fold increased risk of MetS compared to those with normal weight.[61] Similarly, in a Ghanaian population, Ofori and Odia (2018) reported that BMI was a significant predictor of dyslipidaemia and MetS components.[62] Age is another well-established risk factor for MetS. As individuals age, metabolic processes become less efficient, and the risk of insulin resistance, endothelial dysfunction, and visceral fat accumulation increases.[63] This age-related metabolic shift contributes to the clustering of MetS components. A study in low- and middle-income settings found that the prevalence of MetS increased significantly with age, particularly among women.[64] These associations emphasize the cumulative impact of both adiposity and aging on metabolic health. This is particularly relevant even among relatively young and educated populations, such as healthcare workers, who may be perceived as less vulnerable to such risks. The findings are consistent with previous studies that have demonstrated similar trends in sub-Saharan Africa [4, 65–68] and other low- and middle-income settings,[69–71] where increasing BMI and age significantly elevate the risk of developing metabolic syndrome.

Strengths and limitations

This study has several notable strengths. It is among the first to assess the prevalence and risk factors of metabolic syndrome among hospital workers in Rwanda, employing standardized data collection tools and robust biochemical measurements. By including both clinical and support staff, the study provides a comprehensive overview of occupational risk within the hospital setting. However, there are important limitations to consider. The cross-sectional design precludes any inference of causality, and the sample was limited to a single hospital, which may affect the generalizability of the findings to all healthcare workers in Rwanda. Additionally, self-reported lifestyle data may be subject to recall bias, and the relatively small sample size could limit the statistical power for subgroup analyses.

Conclusion

Metabolic syndrome is highly prevalent among hospital workers in Rwanda, with a pronounced gender disparity that is largely attributable to higher rates of abdominal obesity and low HDL-C in females. Increasing BMI and age emerged as strong, independent predictors of metabolic syndrome in this population. These findings highlight the urgent need for targeted workplace interventions, particularly for women, to address modifiable risk factors and promote metabolic health among healthcare workers.

Availability of data and materials

All the necessary data and materials are within this manuscript.

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Author contributions

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Competing interests

No conflict of interest declared.

References

1. Hayden MR. Overview and New Insights into the Metabolic Syndrome: Risk Factors and Emerging Variables in the Development of Type 2 Diabetes and Cerebrocardiovascular Disease. *Medicina (B Aires)*. 2023; 59: 561. DOI: 10.3390/medicina59030561
2. Li W, Qiu X, Ma H, et al. Incidence and long-term specific mortality trends of metabolic syndrome in the United States. *Front Endocrinol (Lausanne); 13. Epub* ahead of print 17 January 2023. DOI: 10.3389/fendo.2022.1029736.
3. Charles-Davies MA, Ajayi OO. Redefining the Metabolic Syndrome in Africa: A Systematic Review between 2005 and 2022. *Dubai Diabetes Endocrinol J.* 2023; 29: 89–98. DOI: 10.3389/fcvm.2020.00022
4. Bowo-Ngandji A, Kenmoe S, Ebogo-Belobo JT, et al. Prevalence of the metabolic syndrome in African populations: A systematic review and meta-analysis. *PLoS One.* 2023; 18: e0289155. DOI: 10.1186/s13098-020-00601-8
5. Bilog NC, Mekoulou Ndongo J, Bika Lele EC, et al. Prevalence of metabolic syndrome and components in rural, semi-urban and urban areas in the littoral region in Cameroon: impact of physical activity. *J Heal Popul Nutr.* 2023; 42: 95. DOI: 10.5281/zenodo.10628257
6. Ward ZJ. Estimating trends in non-communicable disease mortality: implications for global health data and policy research. *Lancet.* 2025; 406: 1195–1197. DOI: 10.1016/S0140-6736(25)01733-7
7. Jha BK, Sherpa ML, Imran M, et al. Progress in Understanding Metabolic Syndrome and Knowledge of Its Complex Pathophysiology. *Diabetology* .2023; 4: 134–159. DOI: 10.3390/diabetology4020015
8. Lin TY, Chien KL, Chiu YH, et al. Dynamics of detailed components of metabolic syndrome associated with the risk of cardiovascular disease and death. *Sci Rep.* 2021; 11: 1–10. DOI: 10.1038/s41598-021-83118-y
9. Dal Canto E, Ceriello A, Rydén L, et al. Diabetes as a cardiovascular risk factor: An overview of global trends of macro and micro vascular complications. *Eur J Prev Cardiol.* 2019; 26: 25–32. DOI: 10.1159/000531552

10. Tan SCW, Zheng B-B, Tang M-L, et al. Global Burden of Cardiovascular Diseases and its Risk Factors, 1990–2021: A Systematic Analysis for the Global Burden of Disease Study 2021. *QJM An Int J Med.* 2025; 118: 411–422. DOI: 10.1093/qjmed/hcaf022
11. World Health Organization. Diabetes – WHO Fact Sheet. *World Health Organization.* https://www.who.int/news-room/fact-sheets/detail/diabetes . Accessed 15 September 2025.
12. Moghadam-Ahmadi A, Soltani N, Ayoobi F, et al. Association between metabolic syndrome and stroke: a population-based cohort study. *BMC Endocr Disord* .2023; 23: 1–9. DOI: 10.1186/s12902-023-01383-6
13. Uzunlulu M, Telci Caklili O, Oguz A. Association between Metabolic Syndrome and Cancer. *Annals of Nutrition and Metabolism.* 2016; 68: 173–179. DOI: 10.1159/000443743
14. Huo D, Tao L, Li X, et al. Association of blood pressure with development of metabolic syndrome components: a five-year Retrospective Cohort study in Beijing. *BMC Public Health.* 2013; 13: 912. DOI: 10.1186/1471-2458-13-912
15. Li W, Chen D, Peng Y, et al. Association Between Metabolic Syndrome and Mortality: Prospective Cohort Study. *JMIR Public Heal Surveill.* 2023; 9: e44073. DOI: 10.2196/44073
16. NCD Alliance. Background briefing document: Noncommunicable diseases in sub-Saharan Africa and Rwanda, accessed 2025 Nov 25. *ncdalliance* .2025. https://forum.ncdalliance.org/wp-content/uploads/2025/02/NCDs-in-Rwanda-and-Sub-Saharan-Africa_briefing-doc-2025.pdf. Accessed 2025 Nov 25
17. Gafirita J, Musarurwa C, Ntaganda E, et al. Frequency and Sex-Specific Associations of Metabolic Syndrome in Rwandans Seeking Outpatient Care: A Cross Sectional, Single Centre Study. *Diabetes, Metab Syndr Obes.* 2024; 17: 3803–3816. DOI: 10.2147/DMSO.S477481
18. McLaney E, Morassaei S, Hughes L, et al. A framework for interprofessional team collaboration in a hospital setting: Advancing team competencies and behaviours. *Healthc Manag Forum.* 2022; 35: 112–117. DOI: 10.1177/08404704211063584
19. Rai S, Mishra P, Ghoshal UC. Survival analysis: A primer for the clinician scientists. *Indian J Gastroenterol.* 2021; 40: 541–549. DOI: 10.1007/s12664-021-01232-1
20. Subbe CP, Edwards E, So RKL. Measuring the Quality of Rapid Response: Applying the Quadruple Aim to Patient Safety. In: Textbook of Rapid Response Systems. *Cham: Springer Nature Switzerlan*d. 2024, pp. 371–379. DOI: 10.1007/978-3-031-67951-3_30
21. Montgomery A. van der DM. PE. & LMP (Eds.). Connecting healthcare worker well-being, patient safety and organisational change: the triple challenge. *Springer International Publishing.* 2020. DOI: 10.1007/978-3-030-60998-6
22. Kong DT, Belkin LY. You Don't Care for me, So What's the Point for me to Care for Your Business? Negative Implications of Felt Neglect by the Employer for Employee Work Meaning and Citizenship Behaviors Amid the COVID-19 Pandemic. *J Bus Ethics.* 2022; 181: 645–660. DOI: 10.1007/s10551-021-04950-w
23. Hlubocky FJ, Dokucu ME, Back AL. The Ethical Implications of Burnout: A Moral Imperative to Prioritize Physician Well-Being, Resilience, and Professional Fulfillment. In: Depression, Burnout and Suicide in Physicians. *Cham: Springer International Publishing.* 2022, pp. 87–111. DOI: 10.1007/978-3-030-84785-2_7
24. Rotenstein LS, Brown R, Sinsky C, et al. The Association of Work Overload with Burnout and Intent to Leave the Job Across the Healthcare Workforce During COVID-19. *J Gen Intern Med.* 2023; 38: 1920–1927. DOI: 10.1007/s11606-023-08153-z

25. Xames MD. The fragile core of care: reframing the well-being of health professionals as critical infrastructure. *Heal Aff Sch; 3. Epub ahead of print* 1 July 2025. DOI: 10.1093/haschl/qxaf123.
26. Di Mario S, Filomeno L, Manai MV, et al. Strategies to reduce stress and burnout in healthcare workers: an RCT research protocol. *J Public Health (Bangkok).* 2025; 33: 895–900. DOI: 10.1161/circulationaha.111.067264
27. Zafar U, Khaliq S, Ahmad HU, et al. Metabolic syndrome: an update on diagnostic criteria, pathogenesis, and genetic links. *Hormones.* 2018; 17: 299–313. DOI: 10.1007/s42000-018-0051-3
28. Ichai C, Quintard H, Orban J-C (eds). Metabolic Disorders and Critically Ill Patients. *Cham: Springer International Publishing.* 2018. Epub ahead of print 2018. DOI: 10.1007/978-3-319-64010-5.
29. Angelico F, Baratta F, Coronati M, et al. Diet and metabolic syndrome: a narrative review. *Intern Emerg Med* .2023; 18: 1007–1017. DOI: 10.1161/CIRCULATIONAHA.109.192278
30. Sooriyaarachchi P, Jayawardena R, Pavey T, et al. Shift work and the risk for metabolic syndrome among healthcare workers: A systematic review and meta-analysis. *Obesity Reviews. 2*3. Epub ahead of print 2022. DOI: 10.1111/obr.13489. DOI: 10.1111/obr.13489
31. Tsou MT, Pai TP, Chiang TM, et al. Burnout and metabolic syndrome among different departments of medical center nurses in Taiwan-Cross-sectional study and biomarker research. *J Occup Health* .2021; 63: 1–13. DOI: 10.1002/1348-9585.12252
32. Jung H, Dan H, Pang Y, et al. Association between Dietary Habits, Shift Work, and the Metabolic Syndrome: The Korea Nurses' Health Study. *Int J Environ Res Public Health.* 2020; 17: 7697. DOI: 10.3390/ijerph17207697
33. Rwanda Ministry of Health, Rwanda Biomedical Centre, Non-Communicable Disease Division. Executive summary report for hospital accreditation performance progress surveys FY 2022/2023. *Kigali: Rwanda Ministry of Health.* 2023. https://www.moh.gov.rw/news-detail/rwanda-released-hospital-accreditation-survey-results-2023-2024-27-hospitals-achieve-level-ii-recognition. Accessed 2025 Nov 25.
34. Rwanda Ministry of Health, Rwanda Biomedical Centre, Non-Communicable Disease Division Rwanda Ministry of Health, Rwanda Biomedical Centre N-CDD. National Strategy and Costed Action Plan for the Prevention and Control of Non-Communicable Diseases in Rwanda (July 2020 – June 2025). *MoH.* 2020. https://share.google/R2tmn9GFM2n1D7XcQ. Accessed 20 September 2025
35. WHO. WHO Steps Surveillance Manual Last Updated: 26 January 2017. *who.* 2017. www.who.int › teams › surveillance › systems-tools › steps. Accessed 20 September 2025
36. Epidemiology F, Heart N, Alberti KGMM, et al. Harmonizing the Metabolic Syndrome International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* .2009; 120: 1640–1645. DOI: 10.1007/s10389-023-02080-3
37. Malekpour M-R, Rezaei N, Azadnajafabad S, et al. Global, regional, and national burden of injuries, and burden attributable to injuries risk factors, 1990 to 2019: results from the Global Burden of Disease study 2019. *Public Health* .2024; 237: 212–231. DOI: 10.1016/j.numecd.2019.12.012
38. Grundy SM. Metabolic Syndrome Pandemic. *Arterioscler Thromb Vasc Biol.* 2008; 28: 629–636. DOI: 10.1161/Circulationaha.111.067264
39. Cameron AJ, Shaw JE, Zimmet PZ. The metabolic syndrome: prevalence in worldwide populations. *Endocrinol Metab Clin North Am.* 2004; 33: 351–375. DOI: 10.1371/journal.pone.0289155

40. Omuse G, Maina D, Hoffman M, et al. Metabolic syndrome and its predictors in an urban population in Kenya: A cross-sectional study. *BMC Endocr Disord* .2017; 17: 37. DOI: 10.1186/s12902-017-0188-0
41. Asogwa OA, Boateng D, Marzà-Florensa A, et al. Multimorbidity of non-communicable diseases in low-income and middle-income countries: A systematic review and meta-analysis. *BMJ Open.* 2022; 12: 1-16. DOI: 10.1371/journal.pone.0126166
42. Alam MF, Nasreen S, Ullah E, et al. The awareness and prevalence of Metabolic Syndrome in medical community of Bahawalpur. *Oman Med J* . 2011; 26: 26–28. DOI: 10.5001/omj.2011.07 43.
43. Ozcelik. The Awareness of Abdominal Obesity and Metabolic Syndrome in Healthcare Workers. *J Endocrinol Metab. Epub ahead of print.* 2013. DOI: 10.4021/jem176w. DOI: 10.4021/jem176w
44. Musuva RM, Matey E, Masaku J, et al. Lessons from implementing mass drug administration for soil transmitted helminths among pre-school aged children during school based deworming program at the Kenyan coast. *BMC Public Health.* 2017; 17: 575. DOI: 10.1186/s12889-017-4481-7
45. Ghosh A, Charlton KE, Girdo L, et al. Using data from patient interactions in primary care for population level chronic disease surveillance: The Sentinel Practices Data Sourcing (SPDS) project. BMC Public Health 2014; 14: 557. DOI: 10.1186/1471-2458-14-557
46. Adeyemo WL, Bamgbose BO, Ogunlewe MO, et al. Overweight and obesity among patients attending a Nigerian oral surgery clinic: implications for oral surgical practice in Nigeria. *Afr Health Sci.* 2010. DOI: 10.4314/ahs.v10i1.52804
47. Lovejoy JC, Sainsbury A. Sex differences in obesity and the regulation of energy homeostasis. *Obes Rev.* 2009; 10: 154–167. DOI: 10.1111/j.1467-789X.2008.00529.x
48. Hill JO, Wyatt HR, Peters JC. Energy Balance and Obesity. *Circulation* .2012; 126: 126–132. DOI: 10.1161/Circulationaha.111.087213
49. Kruger HS, Venter CS, Vorster HH, et al. Physical inactivity is the major determinant of obesity in black women in the North West province, South Africa: the THUSA study. *Nutrition.* 2002; 18: 422–427. DOI: 10.1016/S0899-9007(01)00751-1
50. Carr MC. The Emergence of the Metabolic Syndrome with Menopause. *J Clin Endocrinol Metab.* 2003; 88: 2404–2411. DOI: 10.1016/j.ecl.2004.03.005
51. Owen N, Healy GN, Matthews CE, et al. Too Much Sitting. *Exerc Sport Sci Rev.* 2010; 38: 105–113. DOI: 10.1097/JES.0b013e3181e373a2
52. Mvo Z, Dick J, Steyn K. Perceptions of overweight African women about acceptable body size of women and children. *Curationis; 22. Epub ahead of print.* 1999. DOI: 10.4102/curationis.v22i2.719.
53. Després J-P. Body Fat Distribution and Risk of Cardiovascular Disease. *Circulation.* 2012; 126: 1301–1313. DOI: 10.1177/2047487319878371
54. M Alqarni SS. A Review of Prevalence of Obesity in Saudi Arabia. *J Obes Eat Disord; 02. Epub ahead of print.* 2016. DOI: 10.21767/2471-8203.100025.
55. Asiki G, Murphy GA V., Baisley K, et al. Prevalence of Dyslipidaemia and Associated Risk Factors in a Rural Population in South-Western Uganda: A Community Based Survey. *PLoS One* .2015; 10: e0126166. DOI: 10.1007/s11739-023-03226-7
56. Sharma RK, Donekal S, Rosen BD, et al. Association of subclinical atherosclerosis using carotid intima-media thickness, carotid plaque, and coronary calcium score with left ventricular dyssynchrony: The multi-ethnic Study of Atherosclerosis. *Atherosclerosis* .2015; 239: 412–418. DOI: 10.1016/j.atherosclerosis.2015.01.036
57. Gatimu SM, Milimo BW, Sebastian MS. Prevalence and determinants of diabetes among older adults in Ghana. *BMC Public Health.* 2016; 16: 1174. DOI: 10.1186/s12889-016-3845-8

58. Chait A, den Hartigh LJ. Adipose Tissue Distribution, Inflammation and Its Metabolic Consequences, Including Diabetes and Cardiovascular Disease. *Front Cardiovasc Med;* 7. Epub ahead of print 25 February 2020. DOI: 10.3389/fcvm.2020.00022. DOI: 10.1210/jc.2003-030242
59. Islam MS, Wei P, Suzauddula M, et al. The interplay of factors in metabolic syndrome: understanding its roots and complexity. *Mol Med.* 2024; 30: 279. DOI: 10.1186/s10020-024-01019-y
60. Fahed G, Aoun L, Bou Zerdan M, et al. Metabolic Syndrome: Updates on Pathophysiology and Management in 2021. *Int J Mol Sci.* 2022; 23: 786. DOI: 10.3390/ijms23020786
61. Jaspers Faijer-Westerink H, Kengne AP, Meeks KAC, et al. Prevalence of metabolic syndrome in sub-Saharan Africa: A systematic review and meta-analysis. *Nutr Metab Cardiovasc Dis;* 30. Epub ahead of print 2020. DOI: 10.1016/j.numecd.2019.12.012. DOI: 10.1016/j.numecd.2019.12.012
62. Ofori-Asenso R, Agyeman AA, Laar A, et al. Overweight and obesity epidemic in Ghana—a systematic review and meta-analysis. *BMC Public Health.* 2016; 16: 1239. DOI: 10.1186/s12889-016-3901-4
63. Avogaro A, de Kreutzenberg SV, Federici M, et al. The Endothelium Abridges Insulin Resistance to Premature Aging. *J Am Heart Assoc;* 2. Epub ahead of print 20 May 2013. DOI: 10.1161/JAHA.113.000262. DOI: 10.1136/bmjopen-2021-049133
64. Hu L, Li H, Gao C, You W, Yan M. Global burden, regional disparities, and decomposition analysis of metabolic risk-attributable diseases among women of reproductive age: GBD 2021. *BMC Womens Health.* doi:10.1186/s12905-025-04005-6.
65. Holdbrooke S, Afolabi M, Aina O. Prevalence of Metabolic Syndrome Among Underweight, Healthy. Overweight and Obese Indigenous Sub-Sahara African Adolescents: A Comparative Analysis. *Medicon Med Sci.* 2025; 8: 19–31. DOI: 10.5281/zenodo.10628256
66. Bamgboye MA, Afolabi M, Holdbrooke SJ, et al. Correlation Between Anthropometric Indices and Components of Metabolic Syndrome Among Sub-Saharan Black African Adolescents: Gender Differentiation. *Prim Sci Surg Res Pract.* 2024; 4: 2–9. DOI: 10.1161/JAHA.113.000262
67. Motala AA, Esterhuizen T, Pirie FJ, et al. The Prevalence of Metabolic Syndrome and Determination of the Optimal Waist Circumference Cutoff Points in a Rural South African Community. *Diabetes Care* 2011; 34: 1032–1037. DOI: 10.2337/dc10-1921
68. Bitew ZW, Alemu A, Ayele EG, et al. Metabolic syndrome among children and adolescents in low- and middle-income countries: a systematic review and meta-analysis. *Diabetol Metab Syndr* . 2020; 12: 93. DOI: 10.1186/s12902-025-01968-3
69. Madeira FB, Silva AA, Veloso HF, et al. Normal Weight Obesity Is Associated with Metabolic Syndrome and Insulin Resistance in Young Adults from a Middle-Income Country. *PLoS One* .2013; 8: e60673. DOI: 10.1371/journal.pone.0060673
70. Rahmawati ND, Andriani H, Wirawan F, et al. Body mass index as a dominant risk factor for metabolic syndrome among indonesian adults: a 6-year prospective cohort study of non-communicable diseases. *BMC Nutr.* 2024; 10: 43. DOI: 10.1186/s40795-024-00243-2