

Metabolic syndrome prevalence and correlates among university and hospital staff in southwestern Uganda

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Abstract

Metabolic syndrome (MetS) represents a convergence of interrelated cardiometabolic abnormalities that substantially increases the risk of type 2 diabetes mellitus and cardiovascular disease. University and hospital staff may have distinct occupational and lifestyle exposures that contribute to cardiometabolic risk, yet evidence from Uganda remains limited. This study assessed the prevalence, component patterns, and correlates of MetS among university and hospital staff in southwestern Uganda. We conducted an institution-based cross-sectional study among 231 university and hospital staff at Mbarara University of Science and Technology and Mbarara Regional Referral Hospital in Mbarara City, southwestern Uganda, during October 20, 2025–January 25, 2026. MetS was defined using modified harmonized Joint Interim Statement criteria as at least three of five cardiometabolic risk components: central obesity, elevated blood pressure, elevated triglycerides, reduced high-density lipoprotein cholesterol, and dysglycaemia. Dysglycaemia was defined as $HbA1c \geq 5.7\%$ or being on glucose-lowering medication. We used modified Poisson regression with robust variance to estimate crude and adjusted prevalence ratios (aPRs) with 95% confidence intervals (CIs). 164 (71.0%) were university staff and 139 (60.2%) were male. Overall MetS prevalence was 29.4% (68/231; 95% CI 23.6–35.8%). Reduced HDL-C, dysglycaemia, and central obesity were present in 150 (64.9%), 118 (51.1%), and 74 (32.0%) participants, respectively. In multivariable analysis, MetS prevalence was higher among females than males (aPR=3.01, 95% CI 2.00–4.51), among participants aged 35–49 years (aPR=2.23, 95% CI 1.10–4.52) and ≥ 50 years (aPR=2.72, 95% CI 1.17–6.32) compared with those aged 18–34 years, and among current alcohol consumers compared with non-consumers (aPR=1.79, 95% CI 1.22–2.62). MetS affected nearly one-third of surveyed university and hospital staff in southwestern Uganda, and reduced HDL-C and dysglycaemia were the predominant abnormalities. Higher MetS prevalence was associated with female sex, older age, and current alcohol consumption. These findings indicate a substantial cardiometabolic risk burden in this institutional workforce and support consideration of workplace-based risk assessment and health-promotion strategies in similar settings.

Keywords Metabolic syndrome · Health personnel · Occupational health · Prevalence · Uganda

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Abbreviations

aPR	Adjusted prevalence ratio
BMI	Body mass index
CI	Confidence interval
CKM	Cardiovascular-kidney-metabolic
cPR	Crude prevalence ratio
HbA1c	Glycated hemoglobin
GVIF	Generalized variance inflation factor
HDL-C	High-density lipoprotein cholesterol
HPLC	High-performance liquid chromatography
IPAQ-SF	International physical activity questionnaire-short form
IQR	Interquartile range
JIS	Joint interim statement
LDL-C	Low-density lipoprotein cholesterol
MetS	Metabolic syndrome
MRRH	Mbarara regional referral hospital
MUST	Mbarara University of science and technology
SANAS	South African National Accreditation System
SD	Standard deviation

Introduction

Metabolic syndrome (MetS) is a constellation of interrelated cardiometabolic abnormalities, including central obesity, dyslipidaemia, elevated blood pressure, and dysglycaemia, that together increase the risk of type 2 diabetes mellitus, cardiovascular disease, chronic kidney disease, and premature death^{1–3}. Although its additional predictive value beyond individual components remains debated, MetS provides a clinically useful framework for identifying clustering of modifiable cardiometabolic abnormalities and individuals who may benefit from early, multifaceted risk reduction^{4,5}. This concept is also reflected in the broader Cardiovascular-Kidney-Metabolic (CKM) framework, which emphasizes the interconnectedness of metabolic, cardiovascular, and renal disorders and the importance of early identification of shared risk factors⁵.

Sub-Saharan Africa is undergoing a rapid epidemiological transition characterized by urbanization, socioeconomic change, dietary shifts toward energy-dense foods, and declining physical activity, contributing to a growing cardiometabolic disease burden⁶. Uganda reflects this broader transition, although reported MetS prevalence varies across populations and diagnostic frameworks. Previous studies found a relatively low MetS prevalence of 19.1% in a rural household-based population compared with higher prevalence rates among corporate employees in Kampala, where prevalence ranged from 22.8 to 28.4% depending on the criteria used^{7,8}. Population-based studies have also documented a substantial burden of individual cardiometabolic abnormalities among Ugandan adults, particularly reduced HDL-C, hypertension, and dysglycaemia^{7,9}. These findings suggest that cardiometabolic risk varies across population and occupational contexts.

Professional workforces, including university personnel and healthcare workers, may have distinct cardiometabolic risk profiles because of differences in age, sex composition, working hours, workplace environment, duration of employment, and health-related behaviors. Age is associated with progressive accumulation of visceral adiposity, insulin resistance, dyslipidaemia, and hypertension, while sex influences adipose distribution and lipid and glucose metabolism, contributing to differences in MetS risk¹⁰. Longer working hours and prolonged occupational exposure may influence cardiometabolic health through reduced opportunities for physical activity, disrupted recovery, and other behavioural or physiological pathways^{11,12}. Similarly, workplace type and

years of employment may reflect differences in occupational demands and exposure patterns between academic and healthcare settings. Health-related behaviors, particularly alcohol consumption and smoking, may further contribute to cardiometabolic risk through effects on adiposity, blood pressure, glucose metabolism, and lipid profiles, while physical activity is generally associated with more favorable cardiometabolic health^{13,14}. Other occupational factors, including dietary patterns, sleep disruption, sedentary behavior, and psychological stress, may also contribute but were not directly assessed in the present study.

Restricting assessment to individuals who meet the diagnostic threshold for MetS may underestimate emerging cardiometabolic risk. Although one or two abnormalities do not satisfy the conventional MetS definition, their clustering may represent an evolving adverse metabolic profile associated with increased future risk of diabetes and cardiovascular events¹⁵. Characterising such subthreshold clustering may therefore provide complementary insight into cardiometabolic risk before the diagnostic threshold is reached. Evidence among professional employees in Uganda remains limited. We therefore conducted an institution-based cross-sectional study among university and hospital staff in Mbarara, southwestern Uganda, to: (i) estimate the prevalence of MetS using a modified Joint Interim Statement (JIS) definition; (ii) characterize sex-stratified patterns of individual MetS components; (iii) describe subthreshold metabolic clustering among participants with one or two MetS components; and (iv) identify independent correlates of MetS in this professional workforce.

Methods

Study design and setting

We conducted an institution-based cross-sectional study among staff of Mbarara University of Science and Technology (MUST) and Mbarara Regional Referral Hospital (MRRH) in Mbarara City, southwestern Uganda, from October 20, 2025, to January 25, 2026. MUST is a public university founded in 1989, and MRRH is its primary teaching hospital. MRRH is a 350-bed tertiary referral hospital serving a catchment population of more than four million people in southwestern Uganda. At study commencement, payroll records listed 906 staff members (666 at MUST and 240 at MRRH), who constituted the source population.

Study population and eligibility criteria

The study population comprised academic, clinical, administrative, and support staff working at MUST or MRRH. Eligible participants were full-time staff aged ≥ 18 years who had worked at either institution for at least 6 months and provided written informed consent. We excluded pregnant women because waist circumference, a key component of MetS, could not be reliably interpreted during pregnancy. We also excluded part-time staff and staff with less than 6 months of service because workplace characteristics would be difficult to interpret consistently in these groups. Participants identified their primary place of employment before data collection.

Sample size determination

The sample size was estimated using the Kish–Leslie formula for cross-sectional studies, assuming a MetS prevalence of 27.6% from a similar study in Ethiopia¹⁶, a 95% confidence level, and a margin of error of 5%, yielding an initial sample size of 307. Because this exceeded 10% of the finite source population, a finite population correction was applied, resulting in a minimum sample size of 230 participants.

Participant selection and recruitment

The sample was proportionally allocated by institution, with 169 participants from MUST and 61 from MRRH. Within each institution, staff were further stratified by employment category to ensure representation of academic, clinical, administrative, and support staff. Participants were selected from institutional payroll lists using proportionate stratified random sampling without replacement; therefore, each eligible staff member could be selected only once.

Because some selected staff were expected to be ineligible, unavailable, or unwilling to participate, an additional reserve list was generated randomly within the same institution and employment strata. Reserve participants were approached only when a staff member from the primary list was ineligible or did not participate, thereby preserving the proportional allocation across institutions and staff categories.

Study variables and operational definitions

Primary outcome

The primary outcome was metabolic syndrome (MetS), defined using a modified harmonized Joint Interim Statement (JIS) definition. MetS was classified as the presence of ≥ 3 of five components: central obesity (waist circumference ≥ 94 cm in men or ≥ 80 cm in women); elevated blood pressure (systolic ≥ 130 mmHg, diastolic ≥ 85 mmHg, or antihypertensive treatment); elevated triglycerides (≥ 150 mg/dL [≥ 1.7 mmol/L] or pharmacological treatment); reduced HDL-C (< 40 mg/dL [< 1.0 mmol/L] in men or < 50 mg/dL [< 1.3 mmol/L] in women, or treatment); and dysglycaemia (HbA1c $\geq 5.7\%$ or glucose-lowering medication). Because fasting plasma glucose was unavailable, HbA1c $\geq 5.7\%$ was used as the glycaemic criterion and applied uniformly. Subthreshold clustering was defined as exactly one or two MetS components.

Explanatory variables

Sociodemographic and occupational characteristics included age (18–34, 35–49, and ≥ 50 years), sex, marital status (unmarried vs. married), primary workplace setting (university vs. hospital), institutional work experience (≤ 10 vs. ≥ 11 years), and daily working hours (≤ 8 vs. > 8 h/day).

Behavioural characteristics included alcohol consumption, smoking history, and physical activity. Alcohol consumption was defined as any self-reported intake during the preceding 30 days and categorised as non-consumption versus current consumption. Smoking history was categorised as non-smoker versus ever-smoker, defined as any history of cigarette or other tobacco use.

Family history of cardiometabolic disease was self-reported and defined as a reported history of hypertension, diabetes mellitus, stroke, or cardiovascular disease in a parent, sibling, or child.

Physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) and categorised as low, moderate, or high according to the standard IPAQ scoring protocol^{17,18}.

Physical, anthropometric, and biochemical measurements

Data were collected by a trained study team comprising a medical doctor and certified laboratory technologists. Physical and anthropometric measurements were obtained privately using standardized procedures. Blood pressure was measured using an automated digital sphygmomanometer (OMRON 3 Series) after 5 min of seated rest with back support. Two measurements were taken 5 min apart, and the mean was used for analysis. The device, cuff, battery, and display were checked daily for proper function before use. Waist circumference was measured at the midpoint between the lower costal margin and iliac crest at the end of normal expiration using a non-stretchable tape.

Participants were not required to fast. Approximately 5 mL of venous blood was collected aseptically. EDTA blood was used to measure HbA1c by high-performance liquid chromatography, while serum from gel-separator tubes was analysed for total cholesterol, HDL-C, LDL-C, and triglycerides using enzymatic colorimetric methods on an automated clinical chemistry analyser (Roche Cobas e402). The laboratory was accredited by the South African National Accreditation System (SANAS; Accreditation No. M0861). Current use of antihypertensive, glucose-lowering, and lipid-lowering medications was assessed by structured interview and, where available, verified from prescription records and incorporated into the corresponding MetS component definitions.

Statistical analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as means and standard deviations (SDs), medians and interquartile ranges (IQRs), or geometric means, as appropriate. Complete-case analysis was used for participants with complete outcome and covariate data.

MetS prevalence was estimated overall with 95% confidence intervals (CIs). Individual MetS components were described overall and stratified by sex. Component burden was categorized as 0, 1, 2, or ≥ 3 components, with ≥ 3 components corresponding to MetS. Subthreshold cardiometabolic clustering was defined as the presence of exactly one or two MetS components. Among participants with exactly two components, dual-component patterns were described overall and stratified by sex, age category, and workplace type.

Associations with MetS were assessed using modified Poisson regression with robust variance estimation, yielding crude prevalence ratios (cPRs), adjusted prevalence ratios (aPRs), and 95% CIs. Variables for multivariable adjustment were selected a priori based on clinical relevance, directed acyclic graph-informed considerations, and potential confounding. The final multivariable model included age category, sex, marital status, workplace type, daily work hours, institutional work experience, current alcohol consumption, and physical activity. Smoking history was not included in the multivariable model because the number of ever-smokers was small.

Sequential models were fitted to examine how adjustment for selected covariates influenced the prevalence-ratio estimates for current alcohol consumption and workplace type. A change of approximately 10% or greater from the crude estimate was considered evidence of meaningful confounding. Multicollinearity was assessed using generalized variance inflation factors. Model convergence, dispersion, and the number of MetS events relative to model parameters were also assessed.

Multiplicative interaction terms were assessed using robust Wald tests, including sex $\times$ workplace, sex $\times$ age, sex $\times$ alcohol, workplace $\times$ alcohol, alcohol $\times$ age, workplace $\times$ age, and workplace $\times$ daily work-hours interactions. Interaction terms were not retained in the primary model unless statistically supported and epidemiologically interpretable. All tests were two-sided, with $p < 0.05$ considered statistically significant. Analyses were conducted using Stata version 17.0 (StataCorp, College Station, TX, USA).

Ethical considerations

The study was approved by the Mbarara University of Science and Technology Research and Ethics Committee (approval number MUST-2025-461). All participants provided written informed consent before enrolment.

Results

Participant recruitment flow

From a source population of 906 staff members, 250 were randomly selected and approached. Twelve staff members were ineligible, including six with less than six months of service, four part-time staff, and two pregnant

women. Of the 238 eligible staff members, seven declined to participate because of competing work commitments (Fig. 1). Overall, 231 participants were enrolled and included in the complete-case analysis. The participation rate among eligible staff was 97.1% (231/238), while 92.4% of all approached staff were included in the analysis.

Participant characteristics

A total of 231 participants were included in the analysis. Of these, 139 (60.2%) were male, 164 (71.0%) were university staff, and 174 (75.3%) reported working more than 8 h per day. The mean age was 41.1 years (SD, 9.3). Overall, 68 participants (29.4%) met the diagnostic criteria for MetS. Participants with MetS were older than those without MetS; among those with MetS, 43 (63.2%) were aged 35–49 years and 18 (26.5%) were aged ≥ 50 years, compared with 84 (51.5%) and 24 (14.7%), respectively, among those without MetS ($p < 0.001$). Among participants with MetS, 42 (61.8%) were women and 26 (38.2%) were men ($p < 0.001$). Compared with participants without MetS, those with MetS were more often married (82.4% vs. 65.6%, $p = 0.017$), more likely to report working > 8 h per day (85.3% vs. 71.2%, $p = 0.035$), more often university-based than hospital-based (80.9% vs. 66.9%, $p = 0.048$), and more likely to report a family history of cardiometabolic disease (51.5% vs. 36.2%, $p = 0.045$) (Table 1).

Prevalence of MetS, individual components, and subthreshold clustering

Prevalence of MetS components and component burden

Among the 231 participants, 68 participants met the modified diagnostic criteria for metabolic syndrome (MetS), giving a prevalence of 29.4% (95% CI 23.6–35.8%).

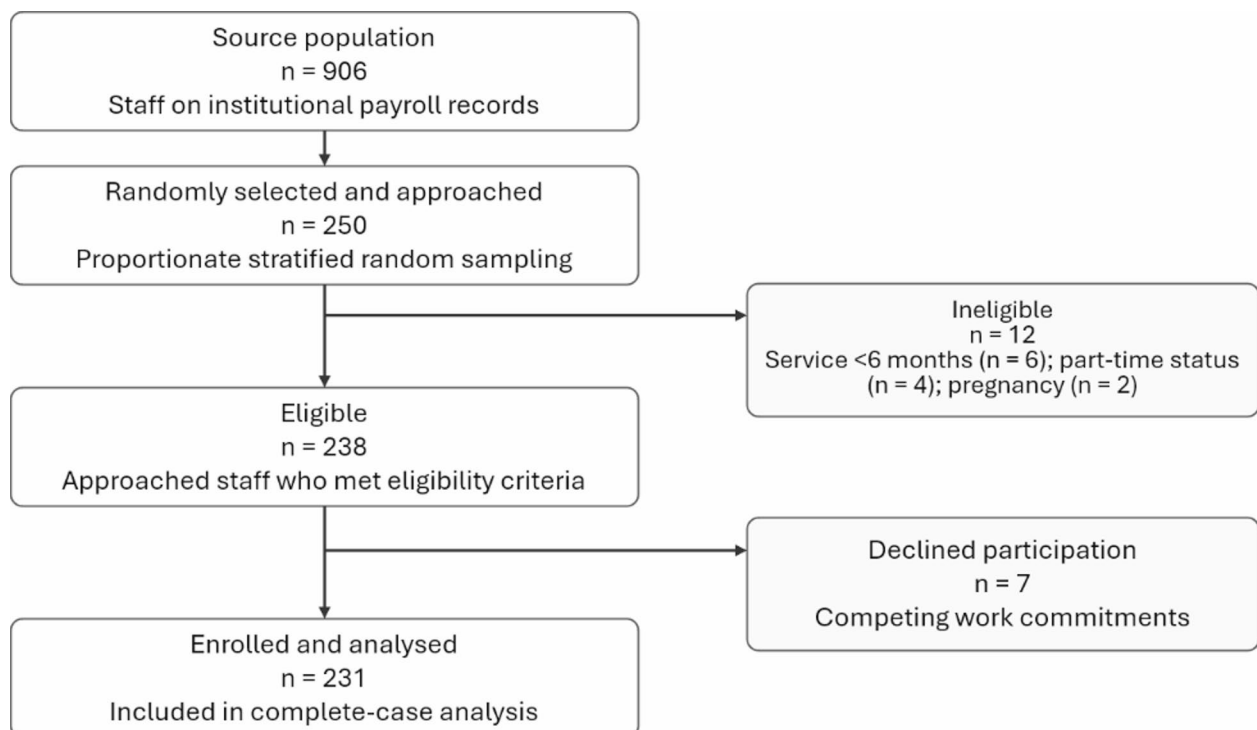


Fig. 1 Participant recruitment and inclusion flow for the metabolic syndrome study among university and hospital staff in southwestern Uganda, October 2025–January 2026.

Table 1 Characteristics of study participants by metabolic syndrome status ($N=231$).

Characteristic	Overall $N=231$	No MetS $N=163$	MetS present $N=68$	p -value
Age category				<0.001
18–34 years	62 (27%)	55 (34%)	7 (10%)	
35–49 years	127 (55%)	84 (52%)	43 (63%)	
≥50 years	42 (18%)	24 (15%)	18 (26%)	
Sex				<0.001
Male	139 (60%)	113 (69%)	26 (38%)	
Female	92 (40%)	50 (31%)	42 (62%)	
Marital status				0.017
Not married	68 (29%)	56 (34%)	12 (18%)	
Married	163 (71%)	107 (66%)	56 (82%)	
Workplace type				0.048
Hospital	67 (29%)	54 (33%)	13 (19%)	
University	164 (71%)	109 (67%)	55 (81%)	
Staff category				0.053
Academic	103 (45%)	73 (45%)	30 (44%)	
Admin/support	61 (26%)	36 (22%)	25 (37%)	
Clinical	45 (19%)	35 (21%)	10 (15%)	
Laboratory/technical	22 (10%)	19 (12%)	3 (4%)	
Daily work hours				0.035
Standard (≤8 h/day)	57 (25%)	47 (29%)	10 (15%)	
Extended (>8 h/day)	174 (75%)	116 (71%)	58 (85%)	
Institutional work experience				0.310
≤10 years	175 (76%)	127 (78%)	48 (71%)	
≥11 years	56 (24%)	36 (22%)	20 (29%)	
Alcohol consumption, past 30 days				0.240
No	154 (67%)	113 (69%)	41 (60%)	
Yes	77 (33%)	50 (31%)	27 (40%)	
Smoking history				>0.99
No	222 (96%)	157 (96%)	65 (96%)	
Yes	9 (4%)	6 (4%)	3 (4%)	
Family history of cardiometabolic disease				0.045
Negative history	137 (59%)	104 (64%)	33 (49%)	
Positive history	94 (41%)	59 (36%)	35 (51%)	
Physical activity level				0.405
High	110 (48%)	81 (50%)	29 (43%)	
Moderate	121 (52%)	82 (50%)	39 (57%)	

Values are n (%). Percentages in the Overall column use $N=231$ as denominator; percentages in MetS-status columns use the corresponding column denominators. p -values are from Pearson chi-square tests.

Reduced HDL-C was the predominant MetS component, affecting 150 (64.9%), followed by dysglycaemia in 118 (51.1%). Central obesity and elevated triglycerides were present in 74 (32.0%) and 72 (31.2%) participants, respectively, while elevated blood pressure was the least frequent component, affecting 42 (18.2%). The sex pattern was notable: women had substantially higher prevalence estimates of central obesity than men (53.3% vs. 18.0%) and reduced HDL-C (82.6% vs. 53.2%), whereas elevated triglycerides were slightly more common among men than women (33.8% vs. 27.2%) (Fig. 2).

Overall, 20 of 231 participants (8.7%) had no MetS components, 61 (26.4%) had one component, 82 (35.5%) had two components, and 68 (29.4%) had at least three components. Component burden was higher among women than men: 42 of 92 women (45.7%) had ≥3 components compared with 26 of 139 men (18.7%). Component burden also increased with age; ≥3 components were present in 7 of 62 participants aged 18–34 years (11.3%), 43 of 127 aged 35–49 years (33.9%), and 18 of 42 aged ≥50 years (42.9%) (Fig. 3).

Component burden also appeared higher among university than hospital staff: 55 of 164 university staff (33.5%) had ≥3 components compared with 13/67 hospital staff (19.4%). Conversely, having no MetS components was

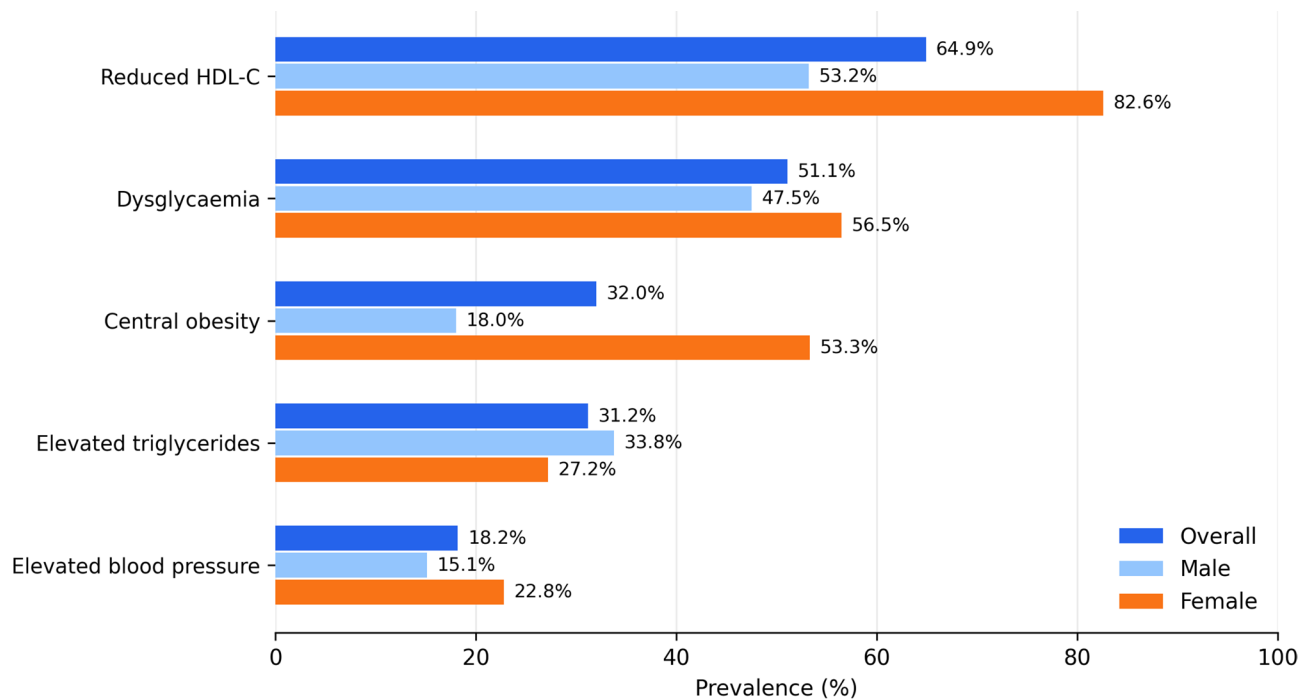


Fig. 2 Prevalence of individual metabolic syndrome components overall and by sex among university and hospital staff in southwestern Uganda, October 2025–January 2026. Bars show the prevalence of each modified JIS component overall and stratified by sex.

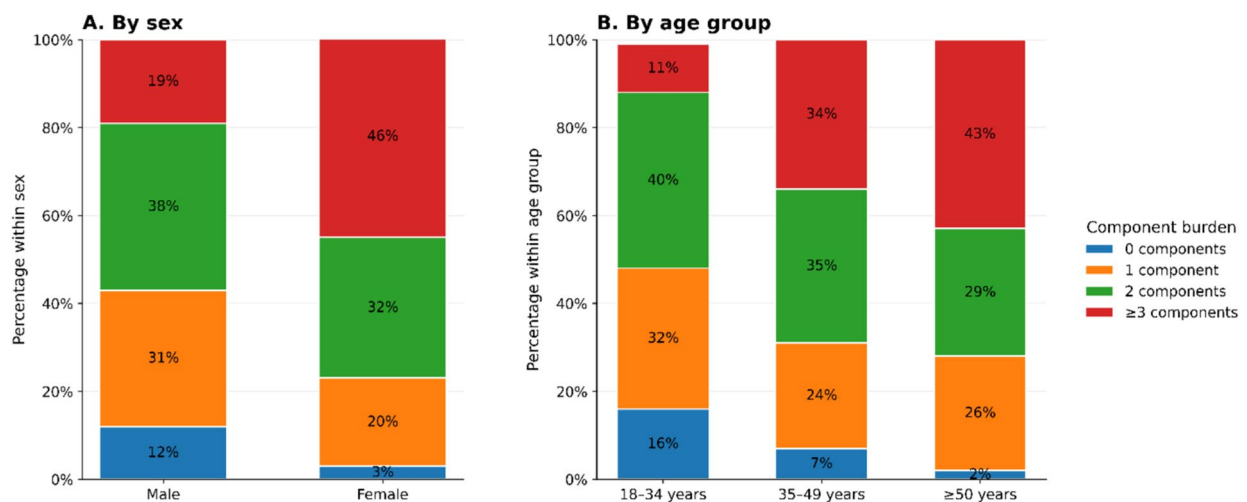


Fig. 3 MetS component burden by sex and age group. Stacked bars show the percentage within each subgroup with 0, 1, 2, or ≥ 3 MetS components. The ≥ 3 components category corresponds to MetS.

more common among hospital staff than university staff (13.4% vs. 6.7%). The proportion with two components was similar across workplace groups, affecting 23/67 hospital staff (34.3%) and 59/164 university staff (36.0%) (Supplementary Table S2).

Subthreshold dual-component patterns

Among the 82 participants with exactly two MetS components, the most frequent dual-component pattern was reduced HDL-C plus dysglycaemia, observed in 27 participants (32.9%), followed by elevated triglycerides plus reduced HDL-C in 19 (23.2%). Central obesity plus reduced HDL-C and elevated triglycerides plus dysglycaemia were each present in 9 participants (11.0%). Patterns differed by sex. Among women with exactly two components, reduced HDL-C plus dysglycaemia was the dominant pattern, accounting for 12/29 dual-component profiles (41.4%), followed by central obesity plus reduced HDL-C in 6 (20.7%). Among men, reduced HDL-C plus dysglycaemia accounted for 15/53 profiles (28.3%), while elevated triglycerides plus reduced HDL-C accounted for 14 (26.4%) and elevated triglycerides plus dysglycaemia for 9 (17.0%) (Fig. 4). Detailed age- and workplace-stratified patterns are provided in Supplementary Table S3.

Correlates of metabolic syndrome

After adjustment for age, sex, marital status, workplace type, daily work hours, institutional work experience, current alcohol consumption, and physical activity, female sex, older age, and current alcohol consumption were independently associated with MetS (Table 2). Females had approximately three times the prevalence of MetS compared with males (aPR=3.01, 95% CI 2.00–4.51; $p<0.001$). Compared with participants aged 18–34 years, MetS prevalence was higher among those aged 35–49 years (aPR=2.23, 95% CI 1.10–4.52; $p=0.026$) and those aged ≥ 50 years (aPR=2.72, 95% CI 1.17–6.32; $p=0.020$). Current alcohol consumption was not statistically significant in crude analysis (cPR=1.32, 95% CI 0.88–1.97; $p=0.179$) but was associated with higher MetS prevalence after adjustment (aPR=1.79, 95% CI 1.22–2.62; $p=0.003$).

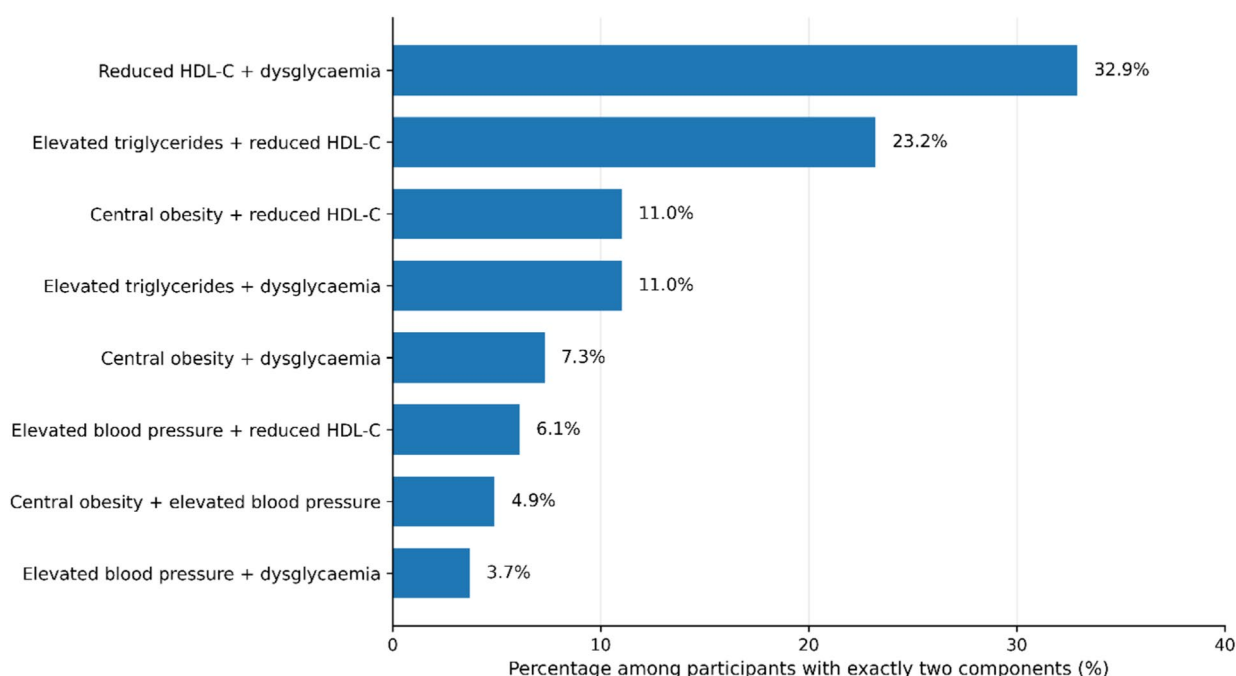


Fig. 4 Dual-component patterns among participants with exactly two MetS components. Percentages are calculated among participants with exactly two components ($n=82$).

Table 2 Correlates of metabolic syndrome among university and hospital staff, southwestern Uganda, October 2025–January 2026.

PR, prevalence ratio; CI, confidence interval. Prevalence ratios were estimated using modified Poisson regression with robust variance estimation. The adjusted model included age category, sex, marital status, workplace type, daily work hours, institutional work experience, alcohol consumption in the past 30 days, and physical activity level.

Variable	Category	Crude PR (95% CI)	Crude <i>p</i> -value	Adjusted PR (95% CI)	Adjusted <i>p</i> -value
Age category	18–34 years	Reference		Reference	
	35–49 years	3.00 (1.43–6.28)	0.004	2.23 (1.10–4.52)	0.026
	≥50 years	3.80 (1.74–8.28)	<0.001	2.72 (1.17–6.32)	0.020
Sex	Male	Reference		Reference	
	Female	2.44 (1.62–3.69)	<0.001	3.01 (2.00–4.51)	<0.001
Marital status	Not married	Reference		Reference	
	Married	1.95 (1.12–3.39)	0.019	1.32 (0.80–2.19)	0.274
Workplace type	Hospital	Reference		Reference	
	University	1.73 (1.01–2.95)	0.044	1.65 (0.93–2.93)	0.085
Daily work hours	Standard, ≤8 h/day	Reference		Reference	
	Extended, >8 h/day	1.90 (1.04–3.46)	0.036	1.64 (0.96–2.79)	0.072
Institutional work experience	≤10 years	Reference		Reference	
	≥11 years	1.30 (0.85–1.99)	0.225	0.98 (0.60–1.60)	0.932
Alcohol consumption, past 30 days	No	Reference		Reference	
	Yes	1.32 (0.88–1.97)	0.179	1.79 (1.22–2.62)	0.003
Physical activity level	High	Reference		Reference	
	Moderate	1.22 (0.82–1.83)	0.331	0.92 (0.59–1.43)	0.715

The primary model converged and showed no problematic multicollinearity (maximum adjusted GVIF = 1.21) or overdispersion (Pearson dispersion ratio = 0.67). With 68 MetS events and nine parameters, the events-per-parameter ratio was 7.56. Prespecified interaction terms were not statistically supported (all $p > 0.18$) and were not retained.

Sequential adjustment showed that the alcohol–MetS estimate strengthened mainly after adjustment for sex, from a crude PR of 1.32 to 2.11 after sex adjustment and 1.79 in the full model. For workplace type, the crude university-versus-hospital estimate was 1.73; it was attenuated after age adjustment to 1.52 and remained imprecise in the full model (PR = 1.65, 95% CI 0.93–2.93) (Supplementary Table S4).

Discussion

In this cross-sectional study of university and hospital staff in southwestern Uganda, nearly one in three participants met the diagnostic criteria for MetS, and a substantially larger proportion had one or two metabolic abnormalities below the diagnostic threshold. Reduced HDL-C and dysglycaemia were the most common abnormalities, and older age, female sex, and current alcohol consumption were independent correlates of MetS. The predominance of lipid and glycaemic abnormalities suggests that workplace-based cardiometabolic screening should identify not only overt MetS, but also earlier metabolic changes that may precede clinically apparent disease.

The observed MetS prevalence is broadly consistent with the burden reported in occupational and urban adult populations in the region. In Kampala, a study among corporate employees reported MetS prevalence estimates of 22.8% using NCEP-ATP III criteria and 28.4% using IDF criteria; notably, most participants without MetS already had at least one metabolic abnormality⁸. Similar findings have been reported among public servants and healthcare workers in Ethiopia and Rwanda, with prevalence estimates ranging from 25.2 to 31.5%^{16,19}. At the continental level, pooled African estimates suggest that MetS affects approximately one-third of adults, with a similar estimate when JIS criteria are applied; the burden is also higher among women and in East Africa, patterns that are consistent with the present findings²⁰. Earlier sub-Saharan African evidence has similarly shown higher MetS prevalence among women and urban populations⁶. Differences in age, sex distribution, population

characteristics, sampling methods, and diagnostic criteria should nevertheless be considered when interpreting these comparisons.

The high prevalence of subthreshold clustering in this study adds important context beyond the conventional MetS classification. Among participants with exactly two components, the most frequent pattern was reduced HDL-C with dysglycaemia, followed by reduced HDL-C with elevated triglycerides. This suggests that many participants who did not meet the full diagnostic threshold for MetS already had multiple coexisting metabolic abnormalities. Cardiometabolic risk is therefore better understood as a continuum rather than a strictly binary condition, consistent with the broader Cardiovascular-Kidney-Metabolic framework, which emphasizes early identification of interconnected metabolic, cardiovascular, and renal risk^{5,15,21,22}. However, the cross-sectional design prevents determining whether these subthreshold patterns progress to MetS or subsequent cardiovascular or metabolic disease.

The component profile observed in this cohort is also notable. Reduced HDL-C was the most common metabolic abnormality, consistent with reports from Uganda and other African populations. In rural Uganda, for example, reduced HDL-C has been reported in more than half of adults⁷, suggesting that this abnormality may be part of a broader regional lipid pattern in sub-Saharan Africa²³. In the present study, reduced HDL-C was particularly frequent among women, which may partly explain the higher MetS prevalence observed in females. However, reduced HDL-C should not be interpreted in isolation as a direct surrogate for cardiovascular risk. Some African populations may have lower HDL-C alongside relatively low total and non-HDL cholesterol, and the relationship between HDL-C, adiposity, and cardiovascular outcomes may differ across populations²³. In this study, reduced HDL-C is therefore best understood as an important component of the overall MetS phenotype, particularly because it commonly coexisted with dysglycaemia and central obesity. This pattern reinforces the value of identifying early metabolic abnormalities before the full syndrome is established.

Alongside reduced HDL-C, dysglycaemia was a prominent feature of the MetS profile in this study. HbA1c was used instead of fasting plasma glucose because fasting blood collection is often difficult to standardize in workplace studies, particularly where staff have variable schedules. HbA1c reflects average glycaemic exposure over the preceding 8–12 weeks and may therefore capture more sustained dysglycaemia than a single fasting glucose measurement. This distinction is relevant because a Ghanaian study reported higher MetS prevalence when HbA1c, rather than fasting plasma glucose, was used as the glycaemic criterion²⁴. However, HbA1c is not without limitations. It may be affected by anaemia, haemoglobinopathies, malaria, iron deficiency, and other conditions that alter erythrocyte lifespan or haemoglobin characteristics. Evidence from the OPTIMAL multicentre observational study in Uganda suggests that HbA1c can remain useful for assessing glycaemic control in populations where such conditions are common²⁵. Thus, HbA1c strengthened feasibility and reflected longer-term glycaemia in this study, while also limiting direct comparison with fasting glucose-based MetS studies.

MetS prevalence increased with age, consistent with the progressive accumulation of adiposity, insulin resistance, dysglycaemia, dyslipidaemia, and blood-pressure abnormalities over the life course²⁶. With increasing age, changes in body composition, insulin sensitivity, lipid metabolism, blood pressure regulation, physical activity, and energy expenditure may increase the likelihood that multiple MetS components cluster in the same individual. For women, menopausal transition-related hormonal changes may additionally influence fat distribution and metabolic risk²⁷. However, the cross-sectional design limits inference about temporal progression.

The higher prevalence of MetS among women also aligns with regional meta-analytic data and studies from sub-Saharan Africa⁶. These patterns may reflect a combination of biological, social, and behavioral influences that vary across settings and stages of adult life. Oestrogen influences adipose-tissue distribution, insulin sensitivity, hepatic lipid metabolism, and energy homeostasis. Declining oestrogen during the menopausal transition is associated with greater visceral adiposity and adverse metabolic changes^{28,29}. However, menopausal status, reproductive history, and detailed measures of adipose distribution were not collected, precluding direct attribution of the observed sex difference to these mechanisms.

The association between current alcohol consumption and MetS is biologically plausible but should be interpreted with caution. Alcohol may influence cardiometabolic risk through effects on hepatic fat accumulation,

lipid metabolism, glucose regulation, inflammation, and adiposity^{30,31}. However, these effects vary by drinking frequency, amount consumed, drinking pattern, sex, diet, and body size. Because the present study assessed current alcohol use without detailed quantification of these dimensions, the observed association should be viewed as hypothesis-generating rather than causal.

These findings have several public health implications. First, they support integrating cardiometabolic risk assessment into occupational health services for university and hospital staff, particularly in resource-limited settings where preventive care is often underdeveloped. Second, the high frequency of subthreshold cardiometabolic risk clustering suggests that screening should not focus only on staff who already meet the MetS definition, but should also identify those with one or two metabolic abnormalities who may benefit from early counseling and risk reduction. Third, prevention efforts should be designed around low-cost, implementable workplace actions, such as periodic blood pressure and waist-circumference checks, scheduled glucose and lipid testing, brief lifestyle counseling, healthier food options within institutional settings, opportunities for physical activity during the workday, and support for reducing harmful alcohol use. Because MetS prevalence was higher among women, older staff, and current alcohol consumers in this study, these groups may warrant more proactive screening and tailored prevention support.

Limitations

This study has several limitations. First, the cross-sectional design precludes establishing temporality or causal relationships between the identified correlates and MetS. Second, the institution-based sample was drawn from two professional workplaces in southwestern Uganda, which may limit generalizability to other occupational groups, unemployed adults, rural populations, or the general population. The findings may also be affected by healthy-worker bias, since employed staff may differ from the broader adult population in health status, socioeconomic position, and access to health information. Third, behavioral exposures, including alcohol use and physical activity, were self-reported and may be affected by recall or social-desirability bias. Alcohol use was measured as current consumption and did not capture quantity, frequency, binge-drinking patterns, or duration of use, limiting interpretation of the observed association. Fourth, several relevant determinants of cardiometabolic risk, including diet, sedentary time, sleep, psychological stress, menopause status, and detailed occupational exposures, were not measured, leaving potential for residual confounding. Finally, dysglycaemia was assessed using HbA1c rather than fasting plasma glucose; although HbA1c offers the advantage of reflecting longer-term glycaemic exposure, this choice may affect comparability with studies that use fasting glucose-based MetS definitions. Despite these limitations, the study provides useful evidence on the burden and pattern of MetS among professional workers in Uganda, a population for which data remain limited.

Conclusion

Nearly one-third of university and hospital staff had metabolic syndrome (MetS), and an even larger proportion had subthreshold cardiometabolic risk clustering. Reduced HDL-C and dysglycaemia were the most frequent abnormalities, and older age, female sex, and current alcohol consumption were associated with higher MetS prevalence. These findings support consideration of workplace-based cardiometabolic screening and targeted prevention strategies and underscore the need for longitudinal studies to clarify the clinical and prognostic implications of subthreshold clustering and to evaluate feasible interventions in similar resource-limited professional settings.

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Author contributions AHC designed the study, collected the data, performed the statistical analysis, and drafted the original and revised manuscript. PK supervised the study and provided clinical expertise and interpretation of findings. DCA contributed to study design, provided methodological input, and critically reviewed the manuscript for important intellectual content. ROO contributed to data interpretation, provided technical and academic input, and critically reviewed the manuscript for important intellectual content. RM conceived the study, participated in the study design, supervised the study, contributed to data curation, and participated in revising the manuscript. All authors read and approved the final manuscript.

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Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors declare no competing interests.

Ethics approval and consent to participate Ethical approval for this study was obtained from the Research Ethics Committee of Mbarara University of Science and Technology (Reference No. MUST-2025-461). Written informed consent was obtained from all participants prior to enrolment in the study. All methods were carried out in accordance with relevant guidelines and regulations and in accordance with the ethical principles of the Declaration of Helsinki.

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