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Redefining Cardiometabolic Risk: Comparing Metabolic Syndrome (NCEP ATP III) and Cardio-Kidney-Metabolic (CKM) Syndrome in Indonesian Adult after COVID-19 Pandemic

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Article

Keywords: Metabolic Syndrome (MetS), Cardio-Kidney-Metabolic Syndrome (CKM), Adults, Indonesia

Posted Date: July 31st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10426900/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Metabolic syndrome (MetS) and cardio-kidney-metabolic (CKM) syndrome share overlapping risk factors but differ in their diagnostic criteria and clinical implications.

Objective

To compare the prevalence of MetS with CKM syndrome staging in adults.

Methods

This research utilized secondary data from the project “Investigasi Perubahan Diet dan Aktivitas Akibat Pandemi COVID-19 dan Implikasi Terhadap Status Kesehatan dari Remaja dan Dewasa di Bandung, Indonesia.” The original study was a cross-sectional study that studied MetS and CKM syndrome on 204 adults. MetS was diagnosed according to NCEP ATP III criteria (≥ 3 of 5 risk factors: abdominal obesity, elevated triglycerides, low HDL cholesterol, hypertension, and impaired glucose. CKM syndrome was staged based on American Heart Association (AHA) 2023 framework (stages 0–2), incorporating obesity, dysglycemia, dyslipidemia, hypertension, and albumin-creatinine ratio (ACR).

Results

The prevalence of MetS was 34.8%, with abdominal obesity (46.1%), elevated triglycerides (25.5%), low HDL (32.4%), hypertension (60.8%), and diabetes/prediabetes (30.4%) as major contributors. By contrast, the prevalence of CKM stage 2 was markedly higher (94.1%), reflecting the inclusion of early metabolic abnormalities and kidney markers, including microalbuminuria (12.3%) and macroalbuminuria (1.9%).

Conclusion

CKM syndrome criteria demonstrated higher sensitivity in detecting at-risk adults compared with traditional MetS criteria, especially those with isolated renal abnormalities or early metabolic disturbance. These findings suggest that CKM staging may provide a broader and more clinically relevant framework for risk stratification in Indonesian adults.

INTRODUCTION

The metabolic syndrome (MetS) serves as a recognized framework that integrates multiple distinct yet interconnected risk factors for cardiovascular diseases (CVDs) into a single, measurable condition linked

to a heightened risk of CVD.[1] It includes various metabolic abnormalities such as hyperglycemia, hypertension, visceral obesity, atherogenic dyslipidemia, endothelial dysfunction, and genetic predisposition. These conditions develop due to influences like urbanization, high-calorie diets, physical inactivity, and the growing prevalence of obesity.[2] It leads to an increasing MetS global prevalence varied from 12.5% to 31.4% according to the definition considered.[3] Indonesia with the 4th largest population in the world, also contributed to MetS globally. In 2019 based on the harmonized MetS definition from the Joint Interim Statement (JIS), the prevalence of MetS in Indonesia is21.66%. There were differences between MetS criteria that resulted broad prevalence of MetS.[4,5]

Diagnostic criteria for MetS varied across time. In 1998, the World Health Organization (WHO) proposed that MetS be recognized using insulin resistance. However, some of the proposed measurements (for example, serum insulin concentration) were not always available to many healthcare practitioners. In 2001, the National Cholesterol Education Program–Third Adult Treatment Panel (NCEP-ATP III) introduced a set of straightforward clinical indicators and threshold values intended for use in primary care to identify individuals exhibiting characteristics of insulin resistance (IR) syndrome.[6] Among these indicators, particularly abdominal visceral obesity, defined as excessive fat accumulation within the abdominal cavity, was recognized as one of the most common and significant comorbidities associated with IR syndrome. Consequently, the panel recommended waist circumference (WC) as a practical surrogate measure of abdominal obesity, accompanied by four additional markers: fasting triglyceride and high-density lipoprotein (HDL) cholesterol levels, blood pressure, and fasting glucose.

Since insulin or direct measures of insulin resistance were not included in the NCEP- ATP III diagnostic framework, the term metabolic syndrome (MetS) was introduced to describe this cluster of interrelated metabolic disturbances. Based on clinical outcome associations, the diagnosis of MetS was defined by the presence of at least three of the five proposed criteria, as any combination was shown to predict a higher risk of cardiovascular disease (CVD).[7]

The NCEP-ATP III is the most practically used framework in the field. Nevertheless, in 2023, the American Heart Association (AHA) broadened the framework of MetS to establish the cardiovascular–kidney–metabolic (CKM) syndrome, to enhance the early detection and comprehensive management of individuals across the spectrum of metabolic, cardiovascular, and renal dysfunctions. This expanded concept underscores the pathophysiological interconnections among cardiovascular disease (CVD), chronic kidney disease (CKD), and metabolic disorders, emphasizing the integrated nature of these conditions. The CKM syndrome framework highlights the convergence of cardiovascular, renal, and metabolic risk factors that collectively contribute to poor outcomes in both cardiovascular and kidney health.[8]

A recent investigation utilizing the cardiovascular–kidney–metabolic (CKM) framework in an Asian cohort demonstrated that among 33,685 Chinese adults, 18.8% were categorized as stage 0, 15.5% as stage 1, 42.1% as stage 2, 14.7% as stage 3, and 8.9% as stage 4, with the advanced stages (3–4) collectively accounting for 23.6% of the population. A comparable study employing a larger, population-

based dataset in Taiwan found that 46.3% of 515,062 participants were classified within CKM stage 2.[9,10] These findings consistently indicate that most individuals with metabolic risk factors are concentrated in stage 2, underscoring a pivotal window for early detection and preventive intervention.

Despite these developments, no existing studies have directly compared the NCEP- ATP III criteria, currently regarded as the most practical and widely applied framework for diagnosing metabolic syndrome, with the CKM staging system, either globally or within the Indonesian population. Furthermore, the 2025 Indonesian National Clinical Practice Guideline (NCPG) for Obesity introduced an additional diagnostic measure based on body fat percentage, as determined through bioelectrical impedance analysis (BIA), defining obesity as greater than 25% body fat in males and greater than > 35% in females. This criterion, however, is not recognized by either the NCEP-ATP III or CKM frameworks.

Therefore, the present study aims to compare the diagnostic utility of the NCEP-ATP III, CKM, and the fat mass–based criteria proposed by the Indonesian NCPG in identifying metabolic syndrome within the Indonesian population.

METHODS

The present study utilized secondary data derived from a primary research project entitled *"Dietary habits, nutrient intakes, physical activity, and health status among adults and adolescents in Bandung, Indonesia,"*. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines and complied with the Declaration of Helsinki. Institutional review board approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Padjajaran University (approval number: 067/UN6.KEP/EC/2022), and all participants provided written informed consent. This collaborative research was carried out by the Faculty of Medicine, Universitas Padjadjaran, in partnership with the University of Otago, New Zealand. Data collection took place between September 2022 and January 2023 in ten urban villages within Bandung City.

A descriptive cross-sectional approach was employed, involving 204 adults aged > 18 years living in areas served by selected community health centres (*Puskesmas*) in Bandung, West Java. Participants were selected through purposive sampling facilitated by neighbourhood associations (*Rukun Warga* or RW) located in the designated *Puskesmas* zones. Eligible participants included adults aged > 18 years who were permanent residents of the study sites. Individuals were excluded if they were female and pregnant or had a known history of congenital or chronic conditions such as hypertension, hyperlipidaemia, prediabetes, insulin resistance, metabolic syndrome, or diabetes mellitus.

Anthropometric evaluation in this study included measurements of Body Mass Index (BMI) and waist circumference. BMI was calculated by dividing body weight in kilograms by height in meters squared (kg/m^2) and categorized based on the Asia-Pacific classification as follows: underweight (< 18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), obesity class I (25.0–29.9 kg/m^2), and obesity class II (≥ 30.0 kg/m^2).[11] Abdominal obesity in adults was defined based on waist circumference

is > 90 cm for males and > 80 cm for females, according to the Asian classification from International Diabetes Federation (IDF).[12] Obesity was additionally classified using fat mass criteria (visceral and subcutaneous fat), defined as > 25% for men and > 35% for women in accordance with Indonesian NCPG guidelines.[13]

Blood pressure was measured using a calibrated sphygmomanometer and categorized based on the *Indonesian Society of Hypertension guidelines* as follows: Normal (< 120/<80 mmHg), Elevated (Systolic 120–139 mmHg and Diastolic 80–90 mmHg), Hypertension Stage 1 (Systolic 140–159 mmHg or Diastolic 90–99 mmHg), and Hypertension Stage 2 (Systolic ≥ 160 mmHg or Diastolic ≥ 100 mmHg).[14] Glycemic status was evaluated through HbA1c levels in accordance with the 2024 American Diabetes Association (ADA) guidelines: Normal (< 5.7%), Prediabetes (5.7–6.4%), and Diabetes mellitus (≥ 6.5%).[15] Albuminuria was evaluated based on Kidney Disease Improving Global Outcomes (KDIGO) 2025 guidelines as follows: Normal (uACR < 30 mg/g), microalbuminuria (uACR 30–300 mg/g), and macroalbuminuria (uACR > 300 mg/g).[16]

Metabolic syndrome was identified according to the criteria established by the NCEP ATP III. Based on this definition, metabolic syndrome is diagnosed when at least three out of five specific conditions are present: central (abdominal) obesity, elevated blood pressure, increased triglyceride levels, reduced HDL cholesterol, and impaired glucose regulation.[17] The CKM syndrome is described as a systemic condition involving interrelated dysfunctions among metabolic abnormalities, CKD, and cardiovascular health, ultimately resulting in multiorgan impairment and an increased risk of adverse cardiovascular events. The classification of CKM syndrome followed the 2023 AHA framework, which categorizes stages from 0 to 2 based on the presence of factors such as obesity, dysglycemia, dyslipidemia, hypertension, and the albumin-to-creatinine ratio (ACR).[8]

Fisher's exact test was used to analyze the cross-tabulation between MetS and CKM syndrome. This test was selected due to the relatively small number of subjects in the study. A p-value of less than 0.05 was considered to indicate a statistically significant difference.

RESULTS

The median age of the study participants was 40.9 years (range: 26.0–51.6), with a predominance of female subjects. Obesity was identified in 87 participants based on body mass index criteria, while abdominal obesity was present in 94 participants. When assessed using fat mass measurements, 99 participants were classified as obese. Hypertension was observed in 51 participants, as summarized in Table 1.

Table 1
Baseline Clinical Characteristics Relevant to Cardiometabolic Risk (N = 204)

Variable	Total
Age, years, median (IQR)	40.9 (26.0–51.6)
Sex, n (%)	
Female	114 (55.9)
Male	90 (44.1)
Body mass index (BMI), n (%)	
Underweight	24 (11.8)
Normal	62 (30.4)
Overweight	31 (15.2)
Obese	87 (42.6)
Abdominal obesity, n (%)	94 (46.1)
Blood pressure category, n (%)	
Normal	80 (39.2)
Pre-hypertension	73 (35.8)
Stage 1 hypertension	33 (16.2)
Stage 2 hypertension	18 (8.8)
Fatty Mass, n (%)	
Obesity	99 (48,53%)
Non-Obesity	105 (51,47%)

With respect to glycemic status, the majority of participants (69.6%) exhibited normal glucose levels, while 26.5% were classified as having prediabetes and 3.9% had diabetes mellitus. In terms of lipid profile, normal triglyceride levels were observed in 53.9% of participants, whereas 20.6% had borderline high levels, 24.1% were categorized as high, and 1.4% had very high triglyceride concentrations. Regarding renal function, most participants (85.8%) presented with microalbuminuria, followed by 12.3% with a normal albumin-to-creatinine ratio (ACR), and 1.9% with macroalbuminuria, as detailed in Table 2.

Table 2
Metabolic and Kidney-Related Risk Profiles (N = 204)

Variable	n (%)
Glycemic status	
Normal	142 (69.6)
Prediabetes	54 (26.5)
Diabetes	8 (3.9)
Triglyceride levels	
Normal	110 (53.9)
Borderline high	42 (20.6)
High	49 (24.1)
Very high	3 (1.4)
Albumin–creatinine ratio (ACR)	
Normal	25 (12.3)
Microalbuminuria	175 (85.8)
Macroalbuminuria	4 (1.9)

The prevalence of metabolic syndrome based on NCEP ATP III criteria was 34.8%. In contrast, almost all participants (97.1%) were classified as having CKM syndrome stage ≥ 2. A substantial proportion of individuals without metabolic syndrome were already classified as CKM stage ≥ 2, indicating that CKM syndrome identifies a broader spectrum of cardiometabolic risk compared with conventional metabolic syndrome criteria, as illustrated in Table 3.

Table 3
Prevalence of Metabolic Syndrome (NCEP ATP III) and CKM Syndrome Staging

Classification	n (%)
Metabolic Syndrome (NCEP ATP III)	
MetS present	71 (34.8)
MetS absent	133 (65.2)
CKM Syndrome Stage	
Stage 1	6 (2.9)
Stage 2	192 (94.1)

Table 4 presents the cross-tabulation between metabolic syndrome (MetS) and CKM syndrome. Among participants with MetS, all 127 individuals were classified within the CKM syndrome group, while none were categorized as non-CKM. In contrast, among those without MetS, 71 participants were classified as CKM and 6 as non-CKM. Overall, the majority of participants (198 out of 204) were categorized as having CKM syndrome. Statistical analysis using Fisher's exact test showed that the association between MetS and CKM syndrome was not statistically significant (p = 0.074).

Table 4
Cross-tabulation of Metabolic Syndrome and CKM Syndrome (Dummy Structure)

	non-CKM	CKM Syndrome	Total	p Value
MetS present	6	127	133	0.074
MetS absent	0	71	71	
Total	6	198	204	

DISCUSSION

In this Bandung-based study of 204 adults, 34.8% met NCEP-ATP III criteria for metabolic syndrome, while 94.1% were classified as CKM stage 2, and only 2.9% fell into CKM stage 1, with almost no representation of advanced CKM stages. This pattern suggests a predominance of metabolic and early renal–cardiovascular abnormalities without progression to overt clinical disease, differentiating the Indonesian cohort from regional and international CKM distributions and highlighting the unique epidemiological profile of metabolic risk in this population. Compared with the large nationwide Chinese study by Zheng et al. (2025), which reported a CKM stage distribution of 18.8% for stage 0, 15.5% for stage 1, 42.1% for stage 2, 14.7% for stage 3, and 8.9% for stage 4, the present Indonesian cohort demonstrates a markedly different pattern, while advanced stages were uncommon.[10] Studies in Taiwan and South Korea also revealed similar findings with an underlined stage 1–2 rather than advanced

CKM.[9,18] This contrasts with the Chinese population, where advanced CKM stages accounted for 23.6% and risk distribution was more heterogeneous across the staging continuum. In terms of metabolic syndrome defined by NCEP-ATP III, the Chinese study reported a prevalence of approximately 19.3%, whereas the Bandung sample exhibited a substantially higher prevalence of 34.8%, reflecting a greater clustering of metabolic abnormalities despite the smaller sample size and regional focus.

Additionally, the prevalence of obesity is proposed differently based on the Indonesian National Clinical Practice Guideline (NCPG) for Obesity, measured by two different methods in the Indonesian cohort: 42.6% by BMI and 48.53% by fat-mass criteria, underscoring potential diagnostic variability not addressed in the CKM or NCEP-ATP III frameworks. The fat-mass criteria yielded a higher percentage of obesity. Concomitantly, the recent Southeast Asian normal-weight obesity meta-analysis by Sruthi et al. (2025) reported prevalence estimates of normal-weight obesity defined by an elevated body fat percentage despite a normal BMI, in adult populations in the region, thereby underscoring the discrepancy between BMI and fat mass-based classification.[19] It found the pooled prevalence of NWO to be 57% (95% CI: 37%–75%), which was measured using fat mass criteria. In special cases, such as sarcopenic obesity, BMI was not reliable.[20] The gap between BMI- and fat-mass-derived obesity classification in our data aligns with Sruthi et al.'s emphasis on body-composition measures beyond BMI in Asian populations; therefore, incorporating fat mass assessment into metabolic-syndrome screening protocols is warranted.

The present findings show that the CKM syndrome framework demonstrates greater ability to identify at risk adults compared with the MetScore. While MetScore incorporates traditional metabolic components including central adiposity, blood pressure, glycemic status, HDL cholesterol, and triglycerides, it does not account for early target-organ involvement.[5] In contrast, CKM integrates metabolic dysfunction, cardiovascular abnormalities, and kidney markers such as eGFR reduction and albuminuria, and applies a progressive staging system (Stage 0–4), enhancing granularity in risk detection.[21] Because renal and vascular impairments often precede overt metabolic syndrome, CKM captures subclinical disease burden more effectively, particularly among adults with a lean metabolic phenotype, which is common in Asian populations.[22,23]

Prior studies consistently support these observations: reduced eGFR and albuminuria independently predict cardiovascular events and mortality beyond traditional risk factors.[24] These data reinforce the rationale for integrating kidney health into cardiometabolic risk assessment. Although MetScore remains clinically useful due to simplicity and established association with future cardiometabolic events, its reliance on anthropometric parameters may underestimate risk in phenotypes without overt obesity.[25] Taken together, the present results align with emerging evidence that CKM provides more comprehensive stratification by identifying individuals with early organ injury who may be overlooked by MetScore.

This study provides an important contribution to metabolic health research in Indonesia, as it represents the first investigation in the country to directly compare the CKM framework with the NCEP-ATP III

criteria for identifying metabolic syndrome. By applying both diagnostic approaches to a cohort of 204 participants in Bandung, the study offers novel insights into the applicability and differentiation of these frameworks within an Indonesian clinical context. However, the findings should be interpreted with caution, as the study population was drawn from a single geographic region, which may limit the generalizability of the results to other Indonesian provinces with diverse demographic and epidemiological profiles. Further multicenter studies with larger and more heterogeneous populations are warranted to validate and extend these observations.

CONCLUSION

The CKM syndrome criteria showed greater sensitivity in identifying at-risk adults than the traditional MetS criteria, particularly among individuals with isolated renal impairment or early metabolic changes. These results indicate that CKM staging may offer a more comprehensive and clinically meaningful approach for risk stratification in Indonesian adult populations.

Declarations

CONFLICT OF INTEREST

The authors report that there are no conflicts of interest associated with this study.

FUNDING

This research was funded by the Centre for International Health, Division of Health Sciences, University of Otago, New Zealand.

Author Contribution

Study concept and design: MRI and NI; acquisition of data: MRI; analysis and interpretation of data: RB, YS, and BW; drafting of the manuscript: NNMS, RS, and SP; critical revision of the manuscript: MRI, NNMS, and RS; statistical analysis: NI and RB; obtained funding: SP; administrative, technical, or material support: MRI; and study supervision: MRI.

ACKNOWLEDGEMENT

The authors wish to acknowledge with thanks the Otago Global Health Institute for funding the primary study. This publication charge is funded by Unpad through the Indonesian Endowment Fund for Education (LPDP) on behalf of the Indonesian Ministry of Higher Education, Science and Technology and managed under the EQUITY Program (Contract No. 4303/ B3/DT.03.08/2025 and 3927/UN6. RKT/HK.07.00/2025)

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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