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The role of changes in metabolic syndrome status on health-related quality of life in Bogor City, West Java, Indonesia: A cross-sectional study

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Abstract

Background: Metabolic syndrome (MetS) is a cluster of chronic conditions, including central obesity, hypertension, impaired glucose metabolism, and dyslipidemia (low HDL, high LDL, and triglycerides). A diagnosis of MetS is made when three or more of these symptoms are present. If left unmanaged, MetS can lead to serious health complications such as cardiovascular disease and type 2 diabetes. Over time, individuals with MetS may experience a decline in their health-related quality of life (HRQoL), especially due to its chronic nature.
Objective: This study aimed to evaluate the effects of changes in MetS status on HRQoL.
Methods: This study employed a cross-sectional design. Secondary data from the cohort study of Non-Communicable Disease (NCD) risk factors, conducted by the Health Research and Development Agency of the Ministry of Health of the Republic of Indonesia in Bogor City, was used. Data from four follow-up periods (2011/2012 to 2017/2018) were analyzed. A total of 874 respondents were selected via total sampling based on inclusion and exclusion criteria. Data were collected in 2021, which included measures of knowledge, health check-ups, and HRQoL using the SF-36 questionnaire. Statistical analyses, including chi-square tests, t-tests, and multiple regression analyses, were conducted to examine the associations between MetS status and HRQoL.
Results: Descriptive analysis revealed that 19% (171 participants) had worsened MetS status, while 80.4% (703 participants) showed improvement. Chi-Square analysis found that respondents with worsening MetS status were 1.6 times more likely to experience poor HRQoL in the physical dimension (95% CI = 1.1-2.3), but no significant effect was found for the mental dimension (PR = 1.1, 95% CI = 0.8-1.6). Multiple logistic regression analysis revealed that comorbidities interacted with worsening MetS status to significantly affect HRQoL in the physical dimension. The adjusted prevalence ratios (PR) were 27.5 (95% CI = 10.3-73.2) for those with comorbidities and 9.2 (95% CI = 5.7-15.0) for those without comorbidities, after controlling for age, mental health, BMI changes, routine health checks, and knowledge.
Conclusion: Changes in MetS status towards worsening have a significant negative effect on HRQoL, particularly in the physical dimension. The presence of comorbidities in individuals with worsening MetS status greatly increases the risk of poor HRQoL. Healthcare professionals and nurses should consider the interaction between MetS and comorbidities in patient management. Nurses are encouraged to monitor HRQoL in patients with MetS, promote education on managing comorbidities, and collaborate across disciplines to enhance patient care and intervention programs aimed at improving HRQoL.

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Indonesia; comorbidity; effect modification; dose-response relationship; health-related quality of life; metabolic syndrome; cardiovascular diseases

Background

The World Health Organization (WHO) highlights a significant global health challenge: the double burden of disease, disability, and premature death. Non-communicable diseases (NCDs) account for nearly 74% of all deaths worldwide. Each year, approximately 17 million people die from NCDs before reaching the age of 70. The leading causes of NCD-related deaths include cardiovascular diseases, cancer, chronic respiratory diseases, and kidney diseases caused by diabetes (WHO, 2024).

Several factors contribute to the development of NCDs. These can be categorized into non-modifiable and modifiable risk factors. Non-modifiable factors include age, gender, and genetics, while modifiable risk factors are behaviors such as smoking, insufficient physical activity, unhealthy eating habits, alcohol consumption, and poor sleep quality. These behaviors negatively affect the body's metabolism, leading to conditions such as dyslipidemia, hyperglycemia, hypertension, and obesity, collectively known as metabolic syndrome (MetS) (Al Shehri et al., 2022; Al-Qawasmeh & Tayyem, 2018; National Heart Lung and Blood Institute, 2022; WHO, 2024).

The prevalence of MetS varies by country and is influenced by factors such as economic development, environment, and ethnicity. A cross-sectional study in Iran reported a MetS prevalence of 30.6% (Rashvand et al., 2021). A prospective cohort study in Taiwan observed an increase in MetS prevalence from 14.8% in 2009-2010 to 25.1% in 2017-2018 (Lin et al., 2021). In Malaysia, 27.5% of individuals aged 15 and above are affected by MetS (Rampal et al., 2012).

In Indonesia, the Health Research and Development Agency, through a cohort study in Bogor City, West Java, reported a baseline MetS prevalence of 18.2% among 843 participants in 2011-2012 (Sihombing & Tjandrarini, 2015). New cases of MetS were consistently recorded during follow-up periods, with 459 new cases in the first two years (2013-2014), 414 new cases in the second two years (2015-2016), and 165 new cases in the third two years (2017-2018) (Riyadina et al., 2019). National data from Indonesia also shows an increase in MetS prevalence from 31% in 2013 to 32% in 2018 (Sigit et al., 2022), with rising rates of obesity and physical inactivity. Specifically, obesity increased from 14.8% to 21.8%, central obesity from 26.6% to 31%, and physical inactivity from 26.1% to 33.5% in individuals aged 10 and above (Indonesian Ministry of Health, 2013, 2018).

A study on ethnic differences in MetS prevalence across Indonesia showed variation, with rates ranging from 0% to 45.4% among 27 ethnic groups. The Betawi ethnic group in Jakarta had the highest prevalence (PR = 1.826; 95% CI = 1.628 - 2.048) (Herningtyas & Ng, 2019). Cultural influences, particularly dietary habits, play a significant role in these variations. A study in South Sulawesi found that local customs, such as serving large portions of high-calorie foods to traditional leaders, contributed to an elevated risk of MetS. Notably, 60% of traditional leaders tested were diagnosed with diabetes (Agustin et al., 2022). Despite these findings, there is limited research on the socio-cultural factors influencing lifestyle across all Indonesian ethnic groups.

While MetS risk factors are largely modifiable, they can be controlled through lifestyle changes with or without pharmacological treatment. A key strategy for combating NCDs in Indonesia is increasing community participation in early detection programs for NCD risk factors. These programs are implemented at healthcare centers and NCD-integrated health posts (Indonesian Ministry of Health, 2016), with success measured by achieving more than 80% coverage in districts or cities for individuals aged 15 and above (Indonesian Ministry of Health, 2022). Since 2017, the Indonesian Ministry of Health has promoted the Healthy Living Community Movement (GERMAS), a public health initiative encouraging regular physical activity, healthy eating, smoking cessation, alcohol avoidance, routine health checks, and maintaining hygiene and environmental cleanliness. A study found that adherence to GERMAS guidelines reduced MetS risk, particularly in individuals who engaged in physical activity, consumed more fruits and vegetables, and avoided alcohol (Sigit et al., 2022).

MetS development varies among individuals, depending on factors such as the order in which its components emerge and the timing of the exposure (Barceló et al., 2017). MetS risks typically peak in individuals in their 50s, with the condition worsening over time, especially among older adults (Grundy, 2020). For some individuals, MetS may persist throughout life, becoming chronic and requiring ongoing management. Persistent MetS often leads to complications and a decreased quality of life (Amiri et al., 2014). Health-related quality of life (HRQoL) is defined as a state related to an individual's experiences, beliefs, expectations, satisfaction, and perceptions of their physical functioning compared to what they believe to be ideal (Megari, 2013). More specifically, HRQoL is a concept that focuses on and is limited to the impact of a person's health status in terms of physical, psychological, and social well-being. Its application is specifically to pay attention to life affected by health or disease (Payot & Barrington, 2011). HRQoL research can help optimize physical and mental health by identifying strategies to minimize disability and improve long-term abilities in chronic disease management (Shofany, 2017).

MetS follows the natural course of chronic diseases, with a long clinical period that can last a lifetime. The condition may be transient, intermittent, or persistent, depending on factors such as comorbidities and lifestyle choices that influence the progression of MetS. Therefore, our research is crucial for healthcare professionals, particularly nurses, who must understand the impact of chronic conditions like MetS. This knowledge will enable them to provide appropriate nursing interventions to help individuals maintain independence, function, and satisfaction, thereby improving their HRQoL. This study aimed to explore the relationship between changes in MetS status and HRQoL among adults in Indonesia.

Methods

Study Design

This study used a cross-sectional design. The outcome variables—HRQoL, knowledge, and routine health checks in the past year—were measured only once. These variables were primary data collected directly by researchers in November 2021. The main independent variables (exposure), including MetS and potential confounders or effect modifiers, were based on secondary data from a cohort study on NCD risk factors conducted in Bogor City. The baseline data of this

cohort study spanned from 2011/2012 to 2017/2018. Initially, this cross-sectional study analyzed the secondary data and linked it to the outcome variables simultaneously. The development of MetS was assessed using secondary data from the cohort study conducted by the Health Research and Development Agency, Ministry of Health of the Republic of Indonesia. New cases of MetS identified in the cohort study underlined the importance of focusing on MetS components that can be controlled or prevented. Although the prevalence rate does not represent the entire population of Indonesia, the characteristics of Bogor City—such as its rapid population growth and urbanization—are similar to many cities across Indonesia. It is important to note that HRQoL was not measured as part of the development of NCD cases.

Samples/Participants

Participants were selected from the target population involved in the NCD cohort study in Bogor City, spanning the baseline period of 2011/2012 to 2017/2018. The inclusion criteria included participants with complete data on MetS components, such as blood pressure, fasting blood glucose, waist circumference, HDL levels, triglyceride levels, and other independent variables during the follow-up period. In addition, to gather primary data, participants had to consent to be interviewed by signing an informed consent form. Exclusion criteria involved participants who had severe comorbidities, hearing impairments, difficulty communicating, or who had died, resigned, or moved out of the study area. The researchers identified these participants by reviewing the routine monitoring reports created by the NCD cohort study team, which made it easy to track the activity of participants and determine those who were no longer active in the study.

Sample size calculation was performed with the aim of testing an Odds Ratio hypothesis using the formula for the difference between two proportions. Based on previous studies, such as one in Iran that reported a prevalence of poor HRQoL of 28.3% (Kazemi Karyani et al., 2019) and another study showing that intermittent MetS status increased the risk of poor HRQoL by 2.75 (Amiri et al., 2018), the researcher estimated a test power of 0.90 and an alpha of 0.05. The sample size calculation resulted in 235 participants, which was then doubled to 470 participants to accommodate two groups: the exposed group (those with worsening MetS status) and the unexposed group (those with improving MetS status).

Given Indonesia's cultural diversity and similarities to Iran in lifestyle and health practices, the researchers deemed Iranian studies relevant. The minimum required sample size was 470, and after applying inclusion/exclusion criteria, 874 eligible participants were identified. To enhance statistical precision, 874 participants were included (total sampling).

Instruments

To obtain data on independent variables such as MetS status (as the main exposure) and other independent variables like age, education level, income, mental health, BMI, and history of comorbidities, a cohort study from Bogor City was used. These data were collected through secondary data from a cohort study on NCDs, following the WHO STEPS procedure. The data were collected via interviews (demographics and behavior), physical examinations (weight, height, waist circumference, and blood pressure), and blood tests (fasting blood glucose and lipids) (Sulistiowati & Sihombing, 2016).

Demographic Data. Demographic data were collected through direct interviews with trained personnel using structured questionnaires. This data included gender, age, monthly income, education level, and mental health behavior (stress). These interviews provided a comprehensive understanding of participants' socio-economic background and mental health status. Physical examinations included abdominal circumference measurements using a non-elastic measuring tape with an accuracy of 0.1 cm. Participants stood in a relaxed position with no clothing that could interfere with the measurement. Abdominal circumference was measured horizontally between the iliac crest and the last rib at the level of normal expiration. Additionally, body weight was measured using a digital scale, with participants instructed to wear light clothing and stand barefoot. Blood pressure was measured with a digital tensiometer on the right arm. Measurements were taken twice, with a three-minute interval between readings. If the difference between the first and second measurements exceeded 10 mmHg, a third measurement was taken after a 10-minute rest (Tuminah & Sihombing, 2015).

In the demographic data, participants were categorized into four age groups: adults (34-45 years), early elderly (46-55 years), advanced elderly (56-65 years), and elderly (over 65 years). Participant education was grouped into two categories: low education (less than high school) and higher education (high school and above). BMI was calculated by dividing body weight in kilograms by height in meters squared (kg/m^2). The results were divided into four categories: thin if BMI was less than 18.5; normal if BMI was between 18.5 and 24.9; overweight if BMI ranged from 25 to 26.9; and obese if BMI was more than 27. The mental health status of participants was also obtained from secondary data. The Ministry of Health of the Republic of Indonesia, coordinated by the Health Research and Development Agency in the cohort study of NCD risk factors, used a questionnaire adapted from the Self Reporting Questionnaire-20 (SRQ-20) to measure the mental condition, and the results were recorded as stress scores. The instrument contained questions about emotional disorders, consisting of 20 items filled out directly by the participants. However, if a participant could not read due to illiteracy or visual impairment, the researcher helped by reading the questions without directing the answers. If the answer was "yes," it was scored as 1. Participants were categorized as experiencing emotional disorders (stress) if the score for the "yes" answers was equal to or greater than six (Sihombing & Tjandrarini, 2015).

Blood Tests. Experienced laboratory technicians collected 8 ml of venous blood from respondents after a fasting period of 10-12 hours. Blood samples were processed at the Center for Applied Health Technology and Clinical Epidemiology in Bogor and centrifuged at 5000 rpm for 3 minutes to separate plasma and serum. Blood glucose, total cholesterol, LDL, HDL, and triglycerides were measured at the Prodia Laboratory in Bogor. Plasma samples were sent to the Center for Biomedical and Health Technology for additional analysis. Blood glucose was measured using the hexokinase II method, total cholesterol using the enzymatic method, LDL and HDL cholesterol using the homogeneous method, and

triglycerides using the glycerol-3-phosphate oxidase method (Sulistiowati & Sihombing, 2016).

Metabolic Syndrome Diagnosis. The MetS diagnosis was made according to the NCEP-ATP III definition, where a person must meet at least three of the following five criteria: central obesity (waist circumference ≥ 90 cm for men, ≥ 80 cm for women), low HDL cholesterol (men <40 mg/dL, women <50 mg/dL), hypertriglyceridemia (≥150 mg/dL), increased blood pressure (≥130/85 mmHg), and fasting blood glucose (≥110 mg/dL) (Chackrewarthy et al., 2013; Mottillo et al., 2010; Parikh & Mohan, 2012). The definition used by the Research and Development Agency of the Ministry of Health of the Republic of Indonesia is simpler and more practical for implementation at different service levels (Sulistiowati & Sihombing, 2016). According to the PERKENI (Indonesian Endocrinology Association) organization, the guidelines from NCEP ATP III 2004 are still relevant today because the diagnostic procedures can be carried out at almost all levels of service in Indonesia (Makbul et al., 2019).

Secondary Data from the NCD Cohort Study. Four follow-up (FU) periods were observed: Period 1 at baseline (2011/2012), Period 2 FU (2013/2014), Period 3 FU (2015/2016), and Period 4 FU (2017/2018). Data on gender and education level were taken from FU 4 (2017/2018). The age of respondents was calculated from the year of birth to the year of primary data collection (2021). Researchers used monitoring data collected every two years for variables whose changes could be tracked. For family income, although the respondents' reported income in rupiahs was recorded, researchers analyzed changes in income levels from the period 2017/2018 to 2021. These changes in income levels were categorized into four groups based on the minimum wage for the city of Bogor in 2021 (4.2 million rupiahs): (1) unchanged, still below the minimum wage, (2) decreasing, lower than the minimum wage, (3) increasing, higher than the minimum wage, and (4) remaining the same, with a monthly income higher than the minimum wage.

Mental Health Status. The SRQ-20 questionnaire was used to assess stress, with participants categorized into four groups: persistent stress (score >6 in all FU periods), intermittent stress (score >6 in 2-3 FU periods), transient stress (score >6 in 1 FU period), and no stress (score ≤6 in all FU periods).

History of Comorbidities. Participants' history of NCDs, such as diabetes, cancer, stroke, and coronary heart disease, was recorded. They were categorized based on the number of NCDs, with participants either having more than one NCD or just one. Additionally, medication use for NCDs was documented and classified as either using one or more medications or not using any.

Changes in BMI. Changes in BMI were tracked over the four FU periods. Participants were classified into two groups: at risk (BMI increased from baseline to FU 4) and not at risk (BMI remained normal or returned to normal limits).

MetS Status. MetS status was categorized into four groups: persistent MetS (MetS diagnosed in all 4 FU periods), intermittent MetS (MetS diagnosed in 2-3 FU periods), transient MetS (MetS diagnosed in only 1 FU period), and no MetS (MetS not diagnosed in any FU periods). Changes in MetS status were categorized as worsening (MetS diagnosed in the 3rd or 4th FU period but not in the previous period) or improving (MetS not diagnosed in the 3rd or 4th FU period but diagnosed in the last period).

Confounder Variables. Two primary confounders were measured: routine health check-ups and knowledge. Routine health check-ups were classified based on frequency: (1) every month, (2) 2-3 times a year, (3) once a year, and (4) never. Knowledge was measured using a questionnaire consisting of fifteen statement items with true-false answer choices. The knowledge assessed included understanding chronic diseases such as hypertension, diabetes, and heart disease, covering definitions, signs, symptoms, and prevention methods. The stages of questionnaire development began with determining the purpose of the study, which was to identify participants' general understanding of metabolic syndrome. To establish the indicators to be measured, researchers examined the theoretical concept of metabolic syndrome (Grundy, 2020) and reviewed related research articles to identify previously existing questionnaire models (Jafar et al., 2018). This approach helped identify relevant indicators, such as knowledge of symptoms and causes, risk factors, management, treatment, and prevention methods.

Following this, researchers developed the questionnaire by creating question items for each identified indicator in the form of true-false choices. Efforts were made to ensure that the sentences were clear, easy to understand, and accurately represented the aspects of knowledge being measured. For content validation, discussions were conducted with health workers, including doctors and nurses at the Bogor City Health Center, to verify that the substance of the statement items was appropriate for individuals at risk of experiencing MetS. Additionally, researchers consulted community health cadres in the study area to ensure that the designed statement items were relevant and adjusted to the varying levels of participant understanding.

The final stage involved a questionnaire trial on a small population that met the participant inclusion criteria. The knowledge questionnaire was tested on October 14, 2021, in Bogor City, involving twenty-seven individuals who met the inclusion criteria. The validity test was conducted using Pearson correlation, yielding results between 0.387 and 0.660, which were greater than the *r*-table value (0.264). The Cronbach's Alpha reliability test produced a score of 0.516. The results of the knowledge measurement were categorized based on the mean value into two groups: poor knowledge if the value was less than 73 and good knowledge if the value was equal to or greater than 73.

HRQoL. Health-related quality of life was assessed using primary data collected directly by researchers through interviews with the SF-36 questionnaire, known as the 36-Item Short Form Health Survey. Several published studies indicated that the SF-36 was one of the most widely used instruments for measuring HRQoL, particularly in the MetS research (Postolova et al., 2014; Saboya et al., 2016). In Indonesia, no specific questionnaire had been developed to assess HRQoL in individuals with chronic diseases like MetS. Various HRQoL instruments have been widely applied in multiple countries, including those that met validity and reliability requirements, such as SF-36, WHOQOL-BREF, EQ-5D-5L, and others.

This study utilized SF-36 because it effectively identified issues reflecting individuals' health-related quality of life experiences. Additionally, the SF-36 questionnaire fulfilled key HRQoL measurement characteristics, requiring data to be based on personal opinions, relevant to different age groups, and presented in an easily understandable language. The questionnaire was a multidimensional instrument that was simple to use, required minimal time for completion, and was suitable for use in busy clinical settings. It has established reliability, validity, and responsiveness, meaning it can detect changes in individual health conditions (Megari, 2013). The SF-36 produced eight profile scales encompassing physical health (physical function, physical role, pain, and general health) and mental health (vitality, social function, emotional role, and mental health) (Shofany, 2017). This questionnaire has been utilized in many countries and translated into more than 170 languages. It is suitable for adults over 18 years old, can be completed within 5–10 minutes, and is highly accepted (RAND Health Care, 2020).

The HRQoL assessment was conducted in two stages. In the first stage, each response was assigned a score between 0 and 100, with higher scores indicating better health status. The 36 items were then grouped into eight profile scales. In the second stage, the average score of the question items from each scale was calculated and further categorized into two subscales: the physical dimension or Physical Component Summary (PCS), which included physical function, physical role, pain, and general health; and the mental dimension or Mental Component Summary (MCS), which comprised vitality (energy), social function, emotional role, mental health, and other aspects (RAND Health Care, 2020; Shofany, 2017).

To ensure proper use of the SF-36 instrument, researchers reviewed the terms and conditions outlined on the RAND Corporation website, RAND Health Care, available at: https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form/terms.html. RAND permitted the use of the 36-item Short Form Health Survey under specified conditions without requiring further written permission (RAND Health Care, 2020). Researchers adhered to these guidelines by using the SF-36 responsibly and maintaining the original format without modifications to ensure measurement accuracy.

The researchers employed the Indonesian version of the SF-36 questionnaire, which had previously been translated and validated by other researchers (Salim et al., 2017). Studies have demonstrated that the SF-36 is a widely used and well-established measurement tool recognized for its validity and reliability (Frempong-Ainguah & Hill, 2014; Novitasari et al., 2016).

To further validate and ensure the reliability of the SF-36 questionnaire, the researchers conducted a validity and reliability test on 27 individuals who met the inclusion and exclusion criteria. The Pearson correlation coefficient and statistical significance at a 5% alpha level were used to assess the validity of the 36 items representing the eight HRQoL dimensions. All items were deemed valid, as their correlation values (ranging from 0.390 to 0.946) exceeded the r-table value of 0.381. The Cronbach's Alpha coefficient for the eight HRQoL dimensions ranged between 0.587 and 0.957, confirming the reliability of all items.

For better interpretation, the HRQoL measurement results were categorized. The physical (PCS) and mental (MCS) dimensions were classified into low and high HRQoL categories using median values, as the data were not normally distributed. Previous studies had also categorized HRQoL measured with the SF-36 based on mean values as cut-off points, classifying HRQoL as poor when below the mean and good when equal to or above the mean for PCS and MCS (Amiri et al., 2018).

Data Collection

Data collection was conducted in two stages. The first stage involved obtaining secondary data. The researchers submitted a formal request to the Head of the Health Research and Development Agency, Ministry of Health of the Republic of Indonesia, seeking permission to use data from the NCD cohort study in Bogor City. This request included a research proposal as supporting documentation. Upon approval, the researchers received a data file in SPSS format containing all the requested variables. The dataset included information from 5,690 respondents across four follow-up periods.

A thorough examination of all available variables was then conducted. The completeness of the required data was assessed from the first to the last follow-up period. This evaluation covered demographic information such as respondent identity, address, date of birth, gender, family income, education level, history of comorbidities, history of NCD medication use, and mental health status. Physical examination data were also reviewed, including waist circumference, height, weight, and blood pressure. Additionally, laboratory test results such as fasting blood sugar, HDL, LDL, and triglyceride levels were examined. The researchers also checked whether respondents remained active in the study. After this verification process, 874 respondents were identified as meeting the eligibility criteria based on the established inclusion requirements.

The second stage involved primary data collection, which took place from November 8 to 14, 2021. The data collection team consisted of twelve individuals, including the lead researcher and eleven trained enumerators who were fresh graduates from a nursing undergraduate program. Each enumerator signed a statement confirming their commitment to performing their duties responsibly and adhering to the established schedule and targets.

The data was collected at ten NCD Posbindu service locations in the Kebon Kalapa sub-district, Central Bogor district. NCD Posbindu is a community-based initiative focused on the early detection and monitoring of NCD risk factors through routine, periodic, and integrated health efforts (Indonesia Ministry of Health, 2012). The specific locations were determined based on agreements within each community. Before the interviews, respondents received an invitation letter instructing them to attend the research interview at the designated Posbindu location nearest to their homes. The head of the health cadre collaborated with the researchers to schedule the interviews, and health cadres assisted in distributing the invitations.

During data collection, the research team conducted direct interviews using a structured questionnaire. The questionnaire package included an explanation of the interview procedure, an informed consent form, respondent identity details (name,

date of birth, gender, address), a knowledge questionnaire, a health check routine assessment for the past year, and the SF-36 questionnaire. All collected data were quantitative, and no qualitative data collection was involved.

Each enumerator interviewed 12 to 13 respondents daily, enabling data collection at all ten Posbindu locations to be completed within seven days. Enumerators were required to report their daily progress to the lead researcher and were responsible for ensuring the accuracy of the data they collected. To maintain data quality, the lead researcher verified the interview results daily, checking for consistency and accuracy before finalizing the dataset.

Data Analysis

Data analysis was conducted using IBM SPSS Statistics 29.0 software, utilizing a 30-day free trial subscription under ID 511887245. Descriptive statistical analysis was performed to determine the frequency distribution of each variable based on its category and to estimate measures of central tendency, including the mean, median, standard deviation, and minimum and maximum values. To examine the significance of relationships and measure associations, researchers applied the chi-square test and simple logistic regression, using the Prevalence Ratio (PR) as an indicator. Stratification analysis was employed to identify statistical interactions and test for confounding factors. A multivariate analysis was also performed using multiple logistic regression based on a causal model.

The selection of statistical tests was determined by the fact that the assumption of data normality was not met for the HRQoL variable, which served as the outcome variable. Measurement results allowed for categorization based on the median value as a cut-off point, dividing HRQoL into two categories: high HRQoL (values equal to or greater than 88.8) and low HRQoL (values less than 88.8). Multiple logistic regression analysis was chosen as it does not require the assumption of a linear relationship between independent and dependent variables.

Furthermore, the independent variables were not necessary to meet the assumptions of multivariate normality or homoscedasticity. Since the dependent variable was dichotomous in this study, the relationship was determined using a non-linear log transformation approach to predict the odds ratio, which was then interpreted as a probability (Fauziyah, 2019).

Ethical Considerations

This research received ethical clearance from the Research Ethics Committee of the Faculty of Public Health, University of Indonesia, under letter number Ket-483/UN2.F10.D11/PPM.00.02/2021. The approval was valid from December 16, 2020, to December 16, 2021.

Results

Characteristics of Respondents

Table 1 shows the demographic and health characteristics of the respondents. The majority were female (67.5%) and in the early elderly age group (46-55 years) (32%). Most respondents (60.8%) had an education level below high school, and 41.9% had an income below the regional minimum wage of Bogor City. Regarding mental health, 2.9% of respondents experienced persistent stress, while the majority (57%) were not stressed during the fourth observation period. In terms of health behavior, 35.2% did not undergo routine health check-ups, while 54.7% had a high level of health knowledge. BMI changes indicated that 54.8% of respondents fell into the at-risk category. Additionally, 21.9% had a history of at least one comorbid disease. MetS status and its progression revealed that 1.9% of respondents had persistent MetS. Meanwhile, 12.8% experienced worsening MetS status over time, compared to 10.3% who showed improvement.

Additionally, **Table 2** shows an increasing proportion of respondents experiencing issues with the five MetS criteria over time. The most significant increase was observed in central obesity among women, reaching 78.6% in the T4 period. Other MetS criteria also showed an upward trend in the T4 period, with low HDL levels affecting 31% of men and 36.4% of women. Additionally, 35.5% of respondents had hypertension, 21.9% had high triglyceride levels, and 38.2% had elevated fasting blood sugar levels.

Health-Related Quality of Life

The results of the HRQoL measurement using the SF-36 questionnaire reflect the respondents' health condition over the past month. However, the first question, "How is your current health compared to one year ago?" aims to assess changes in health status over the past year in a cross-sectional manner and is not included in evaluating the eight dimensions (scales) of HRQoL (Ware & Kosinski, 2001). As shown in **Table 3**, the responses reveal that 47.4% of respondents reported no change in their health condition compared to a year ago, indicating that it remained almost the same.

Question number one is a retrospective health transition question, widely recognized as a measure of change that can be used to assess the minimum clinically important difference. The clinical interpretation of the phrase “somewhat worse health than a year ago” may vary based on context and could have different meanings between the general population and those with specific medical conditions. Researchers must exercise caution during interviews or ensure that respondents understand the intent behind this question, as there is a potential for bias. Accurate respondents' memory regarding their health status from a year ago is essential.

A potential source of bias could arise if respondents, when answering this question, are influenced by other SF-36 items that assess recent changes in health status, leading them to recall their current health condition mistakenly. Despite these considerations, this question remains a valuable tool for cross-sectional population-level surveys, where rapid information about changes in health status is required. It is also valid for distinguishing between respondents whose health status is improving and those whose health is deteriorating (Knox & King, 2009).

Table 1 Respondents Characteristics (*N* = 874)

Respondents Characteristics Variables	Frequency	(%)
Gender		
Female	590	(67.5)
Male	284	(32.5)
Age		
Old (> 65 years)	105	(12.0)
Late elderly (56-65 years)	270	(30.9)
Early elderly (46-55 years)	280	(32.0)
Adult (34-45 years)	219	(25.1)
Education level		
Less than high school	531	(60.8)
Equal to or higher than high school	343	(39.2)
Change in family income level*		
Still less than the regional minimum wage of Bogor City	366	(41.9)
Decrease	319	(36.5)
Increase	64	(7.3)
Remains the same or more than the regional minimum wage	125	(14.3)
Mental health status		
Persistent stress (stress score > 6, at 4 times [follow-up periods])	25	(2.9)
Intermittent stress (stress score > 6, at 2 -3 times [follow-up periods])	136	(15.6)
Transient stress (stress score > 6, at 1 time [follow-up period])	215	(24.6)
No stress (stress score < 6, at 4 times [follow-up periods])	498	(57.0)
Routine medical examination in a year		
Routine, at least once a month	213	(24.4)
About 2-3 times	245	(28.0)
Only once	108	(12.4)
Never	308	(35.2)
Knowledge		
Low (score < 73)	396	(45.3)
High (score > 73)	478	(54.7)
BMI changes		
At risk	479	(54.8)
Not at risk	395	45.2)
History of comorbidities (NCD)		
Have > 1 type of NCD	186	(21.9)
Has no history of NCD	688	(78.1)
Taking medication for comorbidities = medication for heart disease, stroke, DM, hypertension		
Not taking medication	637	(72.9)
Take > 1 type of medication	237	(27.1)
MetS status		
Persistent (MetS at 4 times)	17	(1.9)
Intermittent (MetS at 2-3 times)	124	(14.2)
Transient (MetS at 1 time)	122	(14.0)
Not MetS on 4 times	611	(69.9)
MetS status changes		
MetS worsens (becomes sicker)	171	(19.6)
MetS improves (becomes healthier)	703	(80.4)

Note: *Change in family income level for fourth monitoring from 2017/2018 to 2021

Table 4 shows that the highest mean HRQoL score was for emotional roles, at 91.2 (95% CI = 89.6 – 92.8), indicating that emotional problems were unlikely to limit respondents' roles in everyday life. On the other hand, the lowest mean score was for vitality (energy), at 67.8 (95% CI = 67.1 – 68.5). The vitality scale, which combines questions about enthusiasm, energy, tiredness, and boredom, had responses ranging from always, almost always, quite often, sometimes, rarely, to never. Both the Physical Component Summary (PCS) and Mental Component Summary (MCS) subscales showed similar mean scores of 81.3 (SD = 17.6) and 84.1 (SD = 12.4), respectively. To better interpret HRQoL and make comparisons, both subscales were classified into two categories—low and high—using the median value as the cut-off point (Kolmogorov-Smirnov test sig <0.001, indicating a non-normal distribution of HRQoL scores). The data revealed that the proportion of respondents in the high HRQoL category for the physical (PCS) and mental (MCS) dimensions was almost identical, at 50.3% and 51%, respectively.

Bivariate Analysis

Table 5 shows that females were 1.2 times more likely to have low HRQoL in the physical dimension compared to males (PR = 1.2, 95% CI = 0.9 – 1.6). Gender did not significantly impact HRQoL in the mental dimension. Regarding age categories, physical and mental dimensions showed an increased risk of low HRQoL in older age groups. The PR values were 4.8 (95% CI = 2.9 – 7.9) for older adults, 3.0 (95% CI = 2.1 – 4.4) for the elderly, and 1.6 (95% CI = 1.1 – 2.3) for early elderly individuals, compared to the adult age group, which served as the reference. These findings align with the dose-response criteria used to establish a causal relationship. Respondents

with less than a high school education showed a significantly higher risk of low HRQoL in the physical dimension, with a PR value of 1.6 (95% CI = 1.2 – 2.1) than those with a high school education or higher. Additionally, respondents in the low-income group had a 1.8 (95% CI = 1.2 – 2.7) times higher risk of low HRQoL, and those with decreasing income levels had a 1.8 (95% CI = 1.2 – 2.8) times higher risk of low HRQoL. Mental health status was significantly linked to HRQoL in all categories, following a dose-response pattern. Regular health checks were notably associated with low HRQoL in both dimensions, suggesting poorer health status led to more frequent check-ups.

The history of comorbidities, including heart disease and stroke, was closely associated with low HRQoL in both the physical and mental dimensions. The prevalence ratio (PR) was 1.8 (95% CI = 1.3 – 2.5) for the physical dimension and 1.5 (95% CI = 1.1 – 2.1) for the mental dimension. This suggests that individuals with at least one comorbidity had a higher probability of experiencing low HRQoL compared to those without comorbidities. Respondents who took at least one type of NCD medication showed lower HRQoL in the physical dimension, with a PR of 1.8 (95% CI = 1.3 – 2.4) compared to those who did not take any medication. However, no significant relationship was found for the mental dimension in relation to medication use. The study also indicated that individuals with low health knowledge had a higher risk of low HRQoL for both scales compared to those with high health knowledge, with PR values of 1.9 (95% CI = 1.5 – 2.6) for the physical dimension and 1.3 (95% CI = 1.0 – 1.8) for the mental dimension.

Table 2 Frequency distribution of metabolic syndrome criteria (*N* = 874)

Variables	Follow-up Period (years)			
	T1 (2011/2012) (baseline)	T2 (2013/2014)	T3 (2015/2016)	T4 (2017/2018)
Waist circumference (WC)				
Male (*n* = 284)				
Central obesity (WC > 90 cm)	35 (12.3%)	39 (13.7%)	-	66 (23.2%)
No (WC < 90 cm)	249 (87.7%)	245 (86.3%)	-	218 (76.8%)
Female (*n* = 590)				
Central obesity (WC > 80 cm)	280 (47.5%)	343 (58.1%)	-	464 (78.6)
No (WC <80 cm)	310 (52.5%)	247 (41.9%)	-	126 (21.4)
HDL levels				
Male (*n* = 284)				
Low HDL (< 40 mg/dl)	81 (28.5%)	70 (24.6%)	60 (21.1%)	88 (31%)
High HDL (> 40 mg/dl)	203 (71.5%)	214 (75.4%)	224 (78.9%)	196 (69%)
Female (*n* = 590)				
Low HDL < 50	218 (36.9%)	190 (32.2%)	179 (30.3%)	215 (36.4%)
High HDL > 50	372 (63.1%)	400 (67.8%)	411 (69.7%)	375 (63.6%)
Blood pressure				
Hypertension (> 130/85 mmHg)	271 (31%)	310 (35.5%)	-	-
No (< 130/85 mmHg))	603 (69%)	564 (64.5%)	-	-
Triglyceride levels				
High (> 150 mg/dl)	136 (15.6%)	150 (17.2%)	171 (19.6%)	191 (21.9%)
Low - Normal (< 150 mg/dl)	738 (84.4%)	724 (82.8%)	719 (82.3%)	683 (78.1%)
Blood sugar levels fasting				
High (> 100 mg/dl)	104 (11.9)	73 (8.4%)	155 (17.7%)	334 (38.2)
Low - Normal (< 100 mg/dl)	770 (88.1)	801 (91.6)	719 (82.3%)	540 (61.8)
Metabolic Syndrome (MetS)				
MetS (> 3 criteria)	138 (15.8%)	146 (16.7%)	35 (4%)	171 (19.6%)
No MetS (< 3 criteria)	736 (84.2%)	728 (83.3%)	839 (96%)	703 (80.4%)

Table 3 Description of current health condition compared to one year ago (*N* = 874)

The first question: "How is your current health compared to one year ago?"	Frequency	(%)
Better now than one year ago	176	(20.1)
It's a bit better now than it was a year ago	69	(7.9)
Almost the same health situation now as one year ago	414	(47.4)
It's a bit worse now than it was a year ago	205	(23.5)
It's much worse now than it was a year ago	10	(1.1)
Total	874	(100)

Table 6 shows an increased risk of low HRQoL in the physical dimension for individuals with intermittent MetS, with a PR of 2.1 (95% CI = 1.4 – 3.2) compared to those without MetS. For the mental dimension, the PR was 1.4 (95% CI = 0.9 – 2.1) in respondents with intermittent MetS compared to those without it. Regarding changes in MetS status, individuals whose MetS status worsened (i.e., became sicker) had a higher risk of low HRQoL in the physical dimension, with a PR of 1.6 (95% CI = 1.1 – 2.3), compared to those whose MetS status improved. However, no significant association was found between changes in MetS status and the mental dimension.

Table 4 Description of HRQoL based on SF-36 questionnaire (*N* = 874)

HRQoL					
SF-36	**Mean**	**(95% CI)**	**SD**	**Median**	**Min-Max**
Physical function	86.2	(84.7 – 87.6)	22.4	100	0 - 100
Role limitations due to physical health problems	83.6	(81.5 – 85.7)	32.1	100	0 - 100
Pain	86.8	(85.4 – 88.1)	19.8	100	0 - 100
General health perception	68.8	(67.7 – 69.8)	16.3	70	5 - 100
Role limitations due to emotional problems	91.2	(89.6 – 92.8)	24.4	100	0 - 100
Vitality/Energy	67.8	(67.1 – 68.5)	10.7	70	30 - 100
Mental-emotional well-being	86.4	(85.3 – 87.4)	15.6	92	40 - 100
Social functioning	90.9	(89.9 – 91.9)	15.5	100	0 - 100
Measurement dimensions					
Physical Component Summary (PCS)	81.3	(80.2 – 82.5)	17.6	88.8	5 - 100
Mental Component Summary (MCS)	84.1	(83.2 – 84.9)	12.4	88.8	30 - 95
HRQoL categories	**Frequency**	**(%)**			
Physical components summary (PCS):					
Low (< 88.8)	434	(49.7%)			
High (> 88.8)	440	(50.3%)			
Mental components summary (MCS):					
Low (< 88.8)	428	(49%)			
High (> 88.8)	446	(51%)			

Note: the cut-off point is the median value

Table 5 Relationship between respondent characteristics and HRQoL (*N* = 874)

Characteristics	**HRQoL**					
	Physical dimension			**Mental dimension**		
	Low	**High**	**PR (95%CI)**	**Low**	**High**	**PR (95%CI)**
	***n* (%)**	***n* (%)**		***n* (%)**	***n* (%)**	
Gender						
Female	301 (51)	289 (49)	1.2 (0.9-1.6)*	290 (49.2)	300 (50.8)	1.0 (0.7-1.4)
Male	133 (46.8)	151 (53.2)	1	138 (48.6)	146 (51.4)	1
Age (at 2021)						
Old (> 66 year)	74 (70.5)	31 (29.5)	4.8 (2.9-7.9)*	63 (60.0)	42 (40.0)	2.1 (1.3-3.4)*
Late elderly (56-65 year)	163 (60.4)	107 (39.6)	3.0 (2.1-4.4)*	137 (50.7)	133 (49.3)	1.4 (1.0-2.1)*
Early elderly (46-55 year)	124 (44.3)	156 (55.7)	1.6 (1.1-2.3)*	137 (48.9)	143 (51.1)	1.3 (0.9-1.9)*
Adult (34-45 year)	73 (33.3)	146 (66.7)	1	91 (41.6)	128 (58.4)	1
Educational level						
Low (< high school)	287 (54.0)	244 (46.0)	1.6 (1.2-2.1)*	263 (49.5)	268 (50.5)	1.1 (0.8-1.4)
High (> high school)	147 (42.9)	196 (57.1)	1	165 (48.1)	178 (51.9)	1
Change in family income level*						
Less than regional minimum wage	191 (52.2)	175 (47.8)	1.8 (1.2-2.7)*	192 (52.5)	174 (47.5)	1.1 (0.7-1.6)
Decrease	166 (52.0)	153 (48.0)	1.8 (1.2-2.8)*	144 (45.1)	175 (54.9)	0.8 (0.5-1.2)
Increase	30 (46.9)	34 (53.1)	1.4 (0.8-2.7)	29 (45.3)	35 (54.7)	0.8 (0.4-1.5)
≥ regional minimum wage	47 (37.6)	78 (62.4)	1	63 (50.4)	62 (49.6)	1
Mental health status						
Persistent stress	19 (76.0)	6 (24.0)	5.0 (1.9-12.8)*	14(56.0)	11 (44.0)	1.8 (0.8-4.1)
Intermittent stress	95 (69.9)	41 (30.1)	3.7 (2.4-5.5)*	92 (67.6)	44 (32.4)	2.9 (2.0-4.5)*
Transient stress	128 (59.5)	87 (40.5)	2.3 (1.7-3.2)*	117 (54.4)	98 (45.6)	1.7 (1.2-2.3)*
No stress	192 (38.6)	306 (61.4)	1	205 (41.2)	293 (58.8)	1
Medical examination in a year						
Routine, at least once a month	139 (65.3)	74 (34.7)	3.1 (2.2-4.5)*	105 (49.3)	108 (50.7)	1.2 (0.8-1.6)
About 2-3 times	128 (52.2)	117 (47.8)	1.8 (1.3-2.5)*	124 (50.6)	121 (49.4)	1.2 (0.9-1.7)*
Only once	51 (47.2)	57 (52.8)	1.5 (0.9-2.3)*	58 (53.7)	50 (46.3)	1.4 (0.9-2.1)*
Never	116 (37.7)	192 (62.3)	1	141 (45.8)	167 (54.2)	1
Changes in BMI from T1 to T4						
At risk	258 (53.9)	221 (46.1)	1.5 (1.1-1.9)*	250 (52.2)	229 (47.8)	1.3 (1.0-1.7)*
Not at risk	176 (44.6)	219 (55.4)	1	178 (45.1)	217 (54.9)	1
History of comorbidities (NCD)						
Have > 1 type of NCD	113 (60.8)	73 (39.2)	1.8 (1.3-2.5)*	106 (57.0)	80 (43.0)	1.5 (1.1-2.1)*
Has no history of NCD	321 (46.7)	367 (53.3)	1	322 (46.8)	366 (53.2)	1
Taking medication for comorbidities						
Not taking medication	143 (60.3)	94 (39.7)	1.8 (1.3-2.4)*	117 (49.4)	120 (50.6)	1.0 (0.7-1.3)
Take > 1 type of medication	291 (45.7)	346 (54.3)	1	311 (48.8)	326 (51.2)	1
Knowledge						
Low (score < 73)	233 (58.8)	163 (41.2)	1.9 (1.5-2.6)*	210 (53.0)	186 (47.0)	1.3 (1.0-1.8)*
High (score > 73)	201(42.1)	277 (57.9)	1	218 (45.6)	260 (54.4)	1

Note: * significant at *p* <0.05

Table 6 Association of MetS status and changes with HRQoL (*N* = 874)

MetS status and changes	HRQoL					
	Physical dimension			Mental dimension		
	Low	High	PR (95%CI)	Low	High	PR (95%CI)
	n (%)	*n* (%)		*n* (%)	*n* (%)	
MetS status						
Persistent (MetS on 4T)	10 (58.8)	7 (41.2)	1.7 (0.6-4.5)	8 (47.1)	9 (52.9)	0.9 (0.4-2.6)
Intermitten (MetS on 2-3T)	80 (64.5)	44 (35.5)	2.1 (1.4-3.2)*	69 (55.6)	55 (44.4)	1.4 (0.9-2.1)*
Transient (MetS on 1T)	63 (51.6)	59 (48.4)	1.3 (0.9-1.9)	62 (50.8)	60 (49.2)	1.2 (0.8-1.7)
No MetS on 4T	281 (46.0)	330 (54.0)	1	289 (47.3)	322 (52.7)	1
Changes in MetS status from 3 periods T1, T2 and T4						
MetS worsens (becomes sicker)	101 (59.1)	70 (40.9)	1.6 (1.1-2.3)*	88 (51,5)	83 (48.5)	1.1 (0.8-1.6)
MetS improves (becomes healthier)	333 (47.4)	370 (52.6)	1	340(48.4)	363(51.6)	1

Note: * significant at p <0.05.

Stratification Analysis

Table 7 shows the role of a history of NCD comorbidities as an effect modifier in the relationship between changes in MetS status and HRQoL in the physical dimension. The association between changes in MetS status and low HRQoL differed depending on the presence of a history of comorbidities. For respondents with a history of more than one type of NCD, the PR (95% CI) was 2.8 (1.4 – 5.3), indicating an increased risk of low HRQoL in the physical dimension for those whose MetS status worsened. However, the association was weaker for respondents without a history of comorbidities, and the statistical significance was no longer observed, with a PR of 1.1 (95% CI = 0.7 – 1.6). The homogeneity test revealed a significance value of 0.012 (<0.05), suggesting that the association between changes in MetS status and HRQoL differed across strata due to the presence of a history of comorbidities.

Table 7 Stratification analysis of the relationship between MetS status and HRQoL, especially in the physical dimension

Interaction variable: history of comorbidities (NCD)	Main independent variable: Change in MetS Status	HRQoL Physical Dimensions		PR per stratum (95%CI)	Sig. Homogenity test	PRcrude (95%CI)	PRMH (95%CI)
		Low	High				
		n (%)	n (%)				
Have > 1 type of NCD	MetS worsens (becomes sicker)	54 (75)	18 (25)	2.8 (1.4-5.3)*	0.012*	1.6 (1.1-2.3)*	1.4 (1.0-2.0)*
	MetS improves (becomes healthier)	59 (51.8)	55 (48.2)	1			
Has no history of NCD	MetS worsens (becomes sicker)	47 (47.5)	52 (52.5)	1.1 (0.7-1.6)			
	MetS improves (becomes healthier)	274 (46.5)	315 (53.5)	1			

Note: * significant at p <0.05.

Multivariate Analysis

A multiple logistic regression multivariate analysis was conducted to examine the relationship between changes in MetS status and HRQoL, accounting for potential confounders and effect modifiers based on a causal relationship concept model. The analysis began with Model 1, which included the main independent variables of MetS status changes, HRQoL as the dependent variable, and all other independent variables considered potential confounders: gender, age, education level, income changes, mental health status, routine health checks, changes in BMI, history of NCD comorbidities, consumption of NCD drugs, and level of knowledge. Next, Model 2 was developed by retaining the changes in MetS status, HRQoL, and only the significant confounders: age, mental health status, routine health checks, changes in BMI, history of NCD comorbidities, and level of knowledge.

Finally, recognizing the theoretical importance of the history of NCD comorbidities as a potential biological interaction factor in the relationship between changes in MetS status and HRQoL and having observed significant statistical interactions, Model 3 was constructed. Model 3 incorporated changes in MetS status, HRQoL, and significant confounders such as age, mental health status, changes in BMI, routine health checks, and knowledge, along with the interaction variable of history of NCD comorbidities.

Table 8 shows that in the HRQoL physical dimension, a history of comorbidities (NCDs, such as heart disease, stroke, diabetes, and cancer) modifies the effect (interaction) based on two exposure strata. The Prevalence Ratio (95% CI) in the stratum with comorbidities indicates a stronger low HRQoL effect on the physical dimension (27.5, 95% CI = 10.3–73.2), compared to the stratum without comorbidities, which has a Prevalence Ratio of 9.2 (95% CI = 5.7–15.0), after controlling for age, mental health status, changes in BMI, routine health check-ups, and knowledge (as seen in Model 3). This interaction effect, described using the Prevalence Ratio, represents a multiplicative interaction, which is essential for explaining causality. However, HRQoL in the mental dimension did not show a significant relationship in any of the models.

Table 8 Relationship between changes in MetS status and HRQoL

Change in MetS status	PR adjusted (95%CI)				
	Model 1		Model 2		Model 3
	Physical dimension	Mental dimension	Physical dimension	Mental dimension	Physical dimension
MetS worsens (becomes sicker) MetS improves (becomes healthier) as a reference	1.1 (0.7-1.6)	0.9 (0.6-1.3)	1.1 (0.7-1.5)	0.9 (0.3-1.3)	PR = 27.5 (10.3 – 73.2) in the stratum of having NCD comorbidities > 1 type PR = 9.2 (5.7 – 15.0) in the stratum without comorbidities

Note: Model 1 is completely formed from the MetS status change, HRQoL, and all potential confounders, such as gender, age, education level, change in income, mental health status, routine health check-up, change in BMI, history of NCD comorbidities, taking NCD medication, and level of knowledge. Model 2 was formed from MetS status changes, HRQoL, and significant confounders, such as age, mental health status, routine health check-ups, change in BMI, history of NCD comorbidities, and level of knowledge. Model 3 was formed from MetS status change, HRQoL, and several statistically significant confounder variables, such as age, mental health status, changes in BMI, routine health check-ups, knowledge, and interaction variables, such as history of NCD comorbidities.

Discussion

Summary of the Findings

This study analyzed secondary data from a cohort study on NCD risk factors by the Indonesian Ministry of Health's Research and Development Agency, spanning four periods from 2011 to 2018. The results showed an increasing trend in MetS prevalence, although period 3 data may be inaccurate due to incomplete measurements. Despite this anomaly, the overall trend mirrors national findings, with an increase in obesity, abdominal obesity, and hypertension (Indonesian Ministry of Health, 2013, 2018). A similar increase in MetS prevalence was found in a Chinese cohort study (Jia et al., 2018), highlighting the global relevance of these trends as urbanization and lifestyle changes affect both countries.

The use of secondary data enabled tracking MetS status changes over time, categorized into worsening, improving, persistent, and transient states (Amiri et al., 2014). These changes reflect shifts in health status, with worsening MetS indicating poorer health and improving MetS indicating better health. This categorization aligns with a study in Taiwan, where persistent MetS was linked to worse HRQoL (Lin et al., 2021). Chi-square tests revealed significant associations between MetS status changes and physical HRQoL, although no dose-response relationship was found, suggesting the need for further exploration of causality. The study found that worsening MetS increased the risk of low HRQoL in the physical dimension, especially for older adults with mental health issues, obesity, and poor health knowledge. These findings align with previous research on MetS and HRQoL, which links chronic metabolic disorders to cardiovascular diseases and other serious health conditions (Mottillo et al., 2010).

The presence of comorbidities significantly affected the relationship between changes in MetS status and HRQoL, especially in the physical dimension. Individuals with more than one NCD had a higher risk of poor HRQoL when MetS worsened. The influence of NCD history highlights the complexity of biological interactions, where conditions like diabetes, hypertension, and heart disease exacerbate MetS and its impact on health (Regufe et al., 2020). Multivariate analysis confirmed that worsening MetS with multiple comorbidities increased the risk of low HRQoL, emphasizing the compounded effect of these conditions.

Age, mental health, routine health checks, obesity, and knowledge were significant confounders in the multivariate analysis, with older adults at higher risk of low HRQoL due to worsening MetS. This highlights the importance of prioritizing healthcare for older people, particularly in the context of Indonesia's health transformation program, which focuses on primary care services for aging populations. The clinical relevance of mental health in MetS management is also evident, as stress and depression can negatively affect HRQoL through biological pathways like endocrine dysregulation and increased visceral fat (Roohafza et al., 2012).

Finally, knowledge about MetS was linked to HRQoL, highlighting the role of patient education in managing chronic conditions. This aligns with the Common Sense Model, which suggests that understanding illness can influence coping strategies and psychological outcomes (Leventhal et al., 2016). This dynamic relationship suggests that improving knowledge and self-care, particularly in older adults, could enhathe nce quality of life and reduce the burden of MetS and its comorbidities (Asnani et al., 2017).

Implications for Nursing Practice

For nurses who play a vital role in patient care, the findings of this study offer valuable insights for enhancing health services and nursing practices. In primary healthcare settings, nurses should proactively identify factors that may affect the HRQoL of patients with MetS. Screening for HRQoL should be integrated into the assessment process for individuals with chronic diseases. Since many clinics, health centers, and hospitals now use electronic health records (EHRs), nurses can access comprehensive patient data—from registration to assessment, nursing diagnoses, intervention plans, evaluations, and documentation. This allows nurses to track patients' progress over time, especially since metabolic syndrome and HRQoL can fluctuate. The implication is that nurses should develop skills in longitudinal data analysis, enabling them to report nursing outcomes based on more accurate and reliable evidence.

Additionally, the study highlights that a history of chronic disease can worsen HRQoL in individuals with worsening MetS status. To address this, nurses can create targeted interventions that help prevent deterioration by educating patients on healthy lifestyle changes, including stress

management, medication adherence, and obesity prevention. These interventions should be tailored to the individual's capabilities and needs. Equally important is the involvement of the patient's family. Nurses should encourage family support, which can be crucial in improving the patient's health-related quality of life.

Recommendations

The findings offer valuable insights for several stakeholders, including the Ministry of Health of the Republic of Indonesia, which can use these results to guide the development of outcome variables for continuous measurement in NCD cohort studies. Given that changes in MetS status significantly impact HRQoL, this could inform future health monitoring. For local health authorities, such as the Bogor City Health Office, collaborative efforts across multiple disciplines are essential in designing effective health intervention programs.

For future research, this study lays the groundwork for expanding HRQoL measurement by utilizing additional instruments like the EQ-5D-5L. This tool can generate a utility index, aiding in the cost-benefit analysis of treatment programs or non-pharmacological interventions in healthcare settings. Further research could also investigate the impact of social support and community attitudes on the quality of life for individuals with metabolic syndrome. In terms of the mental dimension of HRQoL, only age was statistically significant in demonstrating a dose-response relationship, whereas other variables did not show such patterns. This suggests that factors such as depression, social support, interpersonal relationships, unsafe environments, and cultural influences—none of which were measured in this study—may be important contributors to mental HRQoL. Future research should explore these factors in greater depth.

Moreover, researchers should consider employing more advanced statistical techniques, such as imputation methods, to address issues with incomplete data. Incorporating diverse association measures (odds ratios, risk differences) tailored to the data type, as well as exploring interaction effects using alternative models like hierarchical or Bayesian approaches, could offer richer insights. Additionally, using non-parametric statistical analyses would be beneficial for handling HRQoL data that does not follow a normal distribution.

Study Limitations

HRQoL is a dynamic outcome that can change over time, particularly with the progression of chronic diseases like metabolic syndrome. This study, however, used a cross-sectional design with prevalence measures, meaning that HRQoL was assessed at only one point in time without considering when the health issues began. As a result, it is possible that some respondents had pre-existing chronic conditions (other than metabolic syndrome) that could have already affected their HRQoL before the study started. This cross-sectional approach limits the ability to establish causality. Although the study included a sample size larger than the minimum calculated to enhance statistical precision, it excluded individuals with serious comorbidities, hearing loss, or communication difficulties. This exclusion may introduce selection bias, as it leaves out a portion of the population who might have different HRQoL outcomes, thus limiting the generalizability of the results. Additionally, the study used secondary data from NCD risk factors specific to Bogor City, which means the findings on the relationship between changes in metabolic syndrome status and HRQoL may not apply to other populations in Indonesia.

The study noted an increasing trend in the prevalence of MetS across the four follow-up periods, but the data from the third follow-up period (2015/2016) may be less accurate. Missing data for critical variables such as blood pressure and waist circumference during that period raises concerns about the reliability of these estimates, introducing a potential information bias. Lastly, several important risk factors were not included in the analysis, such as diet and physical activity, which are known to influence the development of metabolic syndrome. The absence of these factors is a limitation, as they may have had an impact on HRQoL and could provide a more complete understanding of the relationships involved.

Conclusion

This study emphasizes the significant negative impact of worsening MetS status on health-related quality of life (HRQoL), particularly in the physical dimension. The presence of comorbidities, such as cardiovascular diseases or diabetes, further exacerbates the decline in HRQoL. Factors such as chronic disease history and lifestyle choices also influence HRQoL outcomes. These findings highlight the importance of healthcare professionals, particularly nurses, considering the interaction between MetS and comorbidities in patient management. Nurses are encouraged to monitor HRQoL closely, educate patients on managing comorbidities, and advocate for healthy lifestyle changes to improve overall health outcomes. By addressing these factors, nurses can contribute significantly to improving the well-being of individuals with MetS.

Declaration of Conflicting Interest

There is no conflict of interest to declare.

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Authors' Contributions

All authors contributed substantially to the conception and design, acquisition of data, or analysis and interpretation of data. In addition, all authors drafted the manuscript or revised it critically for important intellectual content and approved the final version.

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Data Availability

The dataset generated during and analyzed during the current study is available from the corresponding author upon reasonable request.

Declaration of Use of AI in Scientific Writing

There is nothing to declare.

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