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ORIGINAL RESEARCH

Directional Model of Health-Related Quality of Life After Percutaneous Coronary Intervention: A Structural Equation Model Analysis

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Abstract

Background: Although percutaneous coronary intervention (PCI) improves survival and clinical outcomes in patients with acute coronary syndrome (ACS), many patients continue to experience impaired health-related quality of life (HRQoL). However, the direct determinants and mediating pathways influencing HRQoL among patients with ACS following PCI remain incompletely understood.
Purpose: This study aimed to test the relationships among HRQoL determinants based on the revised Wilson and Cleary model in patients with ACS following PCI.
Methods: This cross-sectional study involved 240 patients recruited through consecutive sampling. Data were collected using the Cardiac Self-Efficacy Scale, Fatigue Assessment Scale, Seattle Angina Questionnaire-7, Depression Anxiety Stress Scale 21, Social Functioning Questionnaire, and MacNew Quality of Life Questionnaire. Structural equation modeling was performed with SmartPLS version 3.2.7.
Results: Self-efficacy, fatigue, anxiety, and social functioning had significant direct effects on HRQoL (β = 0.276, β = -0.151, β = -0.152, and β = 0.307, respectively; $p < 0.05$). Social functioning had the greatest direct effect (β = 0.307, $f^2 = 0.219$), whereas self-efficacy had the greatest total effect on HRQoL (β = 0.789, $f^2 = 0.166$).
Conclusion: Self-efficacy, fatigue, anxiety, and social functioning were significant determinants of HRQoL in patients with ACS following PCI. These findings may inform comprehensive patient assessment and the development of targeted, patient-centered nursing care strategies to improve HRQoL.

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1. Introduction

Cardiovascular disease remains the leading cause of mortality both globally and in Indonesia. According to the Indonesian Heart Association, coronary artery diseases (CADs) account for 36% of all deaths globally and 26.4% of deaths in Indonesia in 2020 (Indonesian Heart Association, 2022), a pattern consistent with global estimates from the World Health Organization, which reported approximately 19.8 million deaths from cardiovascular diseases in 2022, representing 32% of all global deaths. Of these deaths, 85% were attributed to myocardial infarction and stroke (World Health Organization, 2025). National data further indicate that the cardiovascular disease prevalence in Indonesia reached 85 per 10,000 population in 2023 (Health Development Policy Agency, 2023). Ischemic heart disease is also regarded as the second leading cause of mortality (Institute for Health Metrics and Evaluation, 2023). Given the substantial burden of ischemic heart disease, acute coronary syndrome (ACS) remains one of the most common and life-threatening cardiovascular emergencies requiring prompt diagnosis and treatment.

ACS is a clinical manifestation of coronary artery disease that encompasses a spectrum of conditions caused by acute myocardial ischemia or infarction resulting from a sudden reduction in coronary blood flow (Virani et al., 2023). Clinically, ACS includes ST-segment elevation myocardial infarction (STEMI), which is usually associated with complete coronary artery occlusion, as well as non-ST-segment elevation myocardial infarction (NSTEMI) and unstable angina, which are generally associated with partial coronary obstruction and may occur with or

without myocardial injury (Visseren et al., 2021). Since ACS is associated with high morbidity and mortality, early diagnosis and timely reperfusion therapy are essential to restore coronary perfusion, limit myocardial damage, and improve survival rates. Percutaneous coronary intervention (PCI) is therefore recommended as the preferred reperfusion strategy for eligible patients with ACS, particularly those with STEMI and selected high-risk NSTEMI patients, to achieve optimal clinical outcomes.

PCI is the preferred treatment for patients with ACS (Rao et al., 2025), as it reduces recurrent ischemia and provides predictable, consistent revascularization in cases of multivessel coronary artery disease (Ibanez et al., 2017). Advances in PCI have substantially improved survival and reduced short-term cardiovascular complications among patients with ACS. Accordingly, conventional nursing management following PCI primarily focuses on maintaining hemodynamic stability, preventing recurrent ischemic events, promoting medication adherence, and facilitating early functional recovery after the acute episode (Kaambwa et al., 2020). However, despite these improvements in clinical outcomes, many patients continue to experience persistent physical symptoms, psychological distress, and social limitations that extend beyond hospital discharge. Therefore, evaluating patients' quality of life has become an important component of post-PCI care and long-term recovery.

ACS affects multiple dimensions of patients' quality of life, including physical, psychological, emotional, and social aspects (Aljabery et al., 2022; Imam & Jitpanya, 2022; Nurhamsyah et al., 2022). Consequently, impaired health-related quality of life (HRQoL) may delay recovery, reduce treatment adherence, limit patients' ability to perform activities of daily living, and increase the risk of hospital readmission, complications, and mortality (Musthofa et al., 2022). Furthermore, poor HRQoL has been associated with greater healthcare utilization and increased long-term disease burden, highlighting that successful treatment should be evaluated not only by survival probabilities but also by patients' overall well-being (Amin et al., 2021; Subih et al., 2020). Previous studies have identified various determinants, including age, marital status, primary caregiver, duration since the first PCI, New York Heart Association (NYHA) classification, anxiety, and depression (Kim, 2022), as well as symptom severity, low-density lipoprotein cholesterol, educational level, and social support (Kim et al., 2019). In addition, HRQoL has been shown to be associated with psychological, physical, and environmental health domains and gender (Endalew et al., 2021) and correlated with emotional status, pain, functional status, dyspnea, and self-efficacy (Imam & Jitpanya, 2022). Meanwhile, social support, depression, and vital exhaustion were found to significantly and directly affect the HQoL in post-PCI CAD patients (Huriani & Mailani, 2023; Kang et al., 2017; Saengsiri et al., 2014). However, these studies have largely investigated the determinants separately, providing limited understanding of combined relationships among biological, symptom-related, psychological, functional, and social factors that collectively influence HRQoL after PCI. This gap highlights the need for a comprehensive model to better understand the determinants of HRQoL in patients with ACS following PCI.

Despite extensive efforts to conceptualize the determinants of HRQoL, understanding how multiple biological, psychological, functional, and environmental factors interact to influence HRQoL remains challenging. Among the available conceptual frameworks, this study adopted the revised Wilson and Cleary model proposed by Ferrans and colleagues (Ferrans et al., 2005), which integrates biomedical and social science perspectives into a comprehensive framework for explaining HRQoL. Within this model, HRQoL is influenced by individual characteristics, biological functioning, environmental factors, symptom experience, functional status, and overall health perceptions (Figure 1). This model serves as a conceptual framework for identifying interrelationships among HRQoL predictors, facilitating the identification of key determinants and informing the development of targeted, evidence-based nursing interventions (Ojelabi et al., 2017). The revised model also provides practical guidance for applying each component within nursing practice and healthcare, advancing understanding and use of HRQoL as a patient-centered outcome. Furthermore, the model has been recognized as an appropriate middle-range theory that is consistent with the nursing metaparadigm and demonstrates conceptual coherence, parsimony, testability, and empirical and pragmatic adequacy (Jang & Vincent, 2019). However, despite this framework's strengths, empirical studies that simultaneously examine both direct determinants of HRQoL and mediating pathways through which these factors influence HRQoL among patients with ACS after PCI remain limited. Therefore, this study applied the revised

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Wilson and Cleary model to comprehensively examine the determinants and pathways influencing HRQoL in this population.

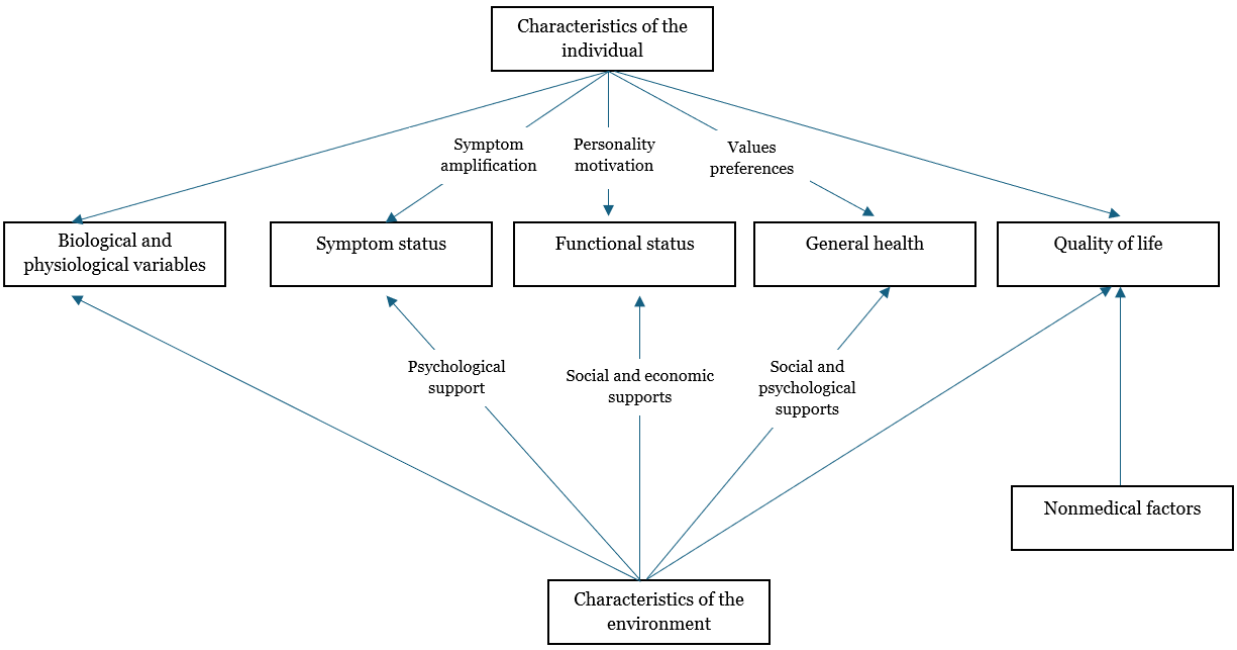


Figure 1. Conceptual model depicting relationships among measures of patient outcomes in health-related quality of life (Ferrans et al., 2005)

This study aimed to test the relationships among biological/physiological factors, symptom status, functional status, and overall quality of life, as proposed in the Revised Wilson and Cleary directional model of HRQoL, in ACS patients after PCI. To the best of our knowledge, no previous study in Indonesia has examined HRQoL and its associated factors based on the revised Wilson and Cleary model among ACS patients after PCI. Consequently, evidence to guide comprehensive assessment of HRQoL determinants in this population remains limited. By addressing this gap, the present study provides empirical evidence on the direct and indirect pathways influencing HRQoL after PCI. The findings help validate the applicability of the revised Wilson and Cleary model in the Indonesian context and improve understanding of the factors associated with HRQoL. This understanding is essential for developing evidence-informed, targeted nursing interventions that address modifiable determinants and ultimately improve the quality of life of patients with ACS following PCI.

2. Methods

2.1 Research design

This cross-sectional study examined associations among individual characteristics, social environmental characteristics, biological and physiological variables, symptom status, functional status, and HRQoL. To describe patients' quality of life in a comprehensive and broader context, we tested the Wilson and Cleary model of quality of life as revised by Ferrans et al. (2005), with the exclusion of general health perception, as adopted from a previous study (Saengsiri et al., 2014). Therefore, we tested the associations between individual characteristics (age, gender, education, and self-efficacy), social environmental characteristics (marital status and living area), biological and physiological variables (comorbidities, body mass index (BMI), number of PCIs, and number of stents), symptom status (fatigue, angina, dyspnea, stress, anxiety, and depression), functional status (NYHA classification and social functioning), and HRQoL in patients with ACS after receiving PCI. We hypothesized that age, gender, education, self-efficacy, marital status, and living area would exert both direct and indirect effects on comorbidities, BMI, number of PCI, number of stents, fatigue, angina, dyspnea, stress, anxiety, depression, NYHA classification, social functioning, and HRQoL. The subsequent hypothesis posited that comorbidities, BMI, number of PCI, number of stents, fatigue, angina, dyspnea, stress, anxiety,

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depression, NYHA classification, and social functioning would exert both direct and indirect effects on HRQoL (Figure 2).

2.2 Setting and samples

Data were collected from September to November 2022 at a cardiac clinic of a referral hospital in West Sumatra Province, Indonesia. The target population comprised patients attending the cardiac clinic following an onset of ACS who had undergone PCI. Inclusion criteria were as follows: (1) patients diagnosed with ACS who had previously undergone PCI; (2) being aged between 40 and 75 years; (3) having completed PCI treatment at least three months prior to data collection; and (4) being able to understand and communicate in the Indonesian language. Exclusion criteria included patients with documented cognitive impairment or psychiatric disorders that could interfere with their ability to provide reliable responses.

The minimum sample size was determined using an a priori power analysis in G*Power 3.1 based on the maximum number of predictors in the structural model. Assuming a medium effect size (f^2 = 0.15), a significance level of 0.05, a statistical power of 95%, and 18 predictors, the minimum required sample size was 220 participants. Data were collected over a three-month period, yielding 241 responses. One response was excluded due to incomplete answers, resulting in a final sample of 240 participants. This sample exceeded the minimum required sample size and was therefore considered adequate for PLS-SEM analysis. Participants were recruited using consecutive sampling, whereby all eligible individuals who met the inclusion criteria were approached and recruited sequentially during the data collection period.

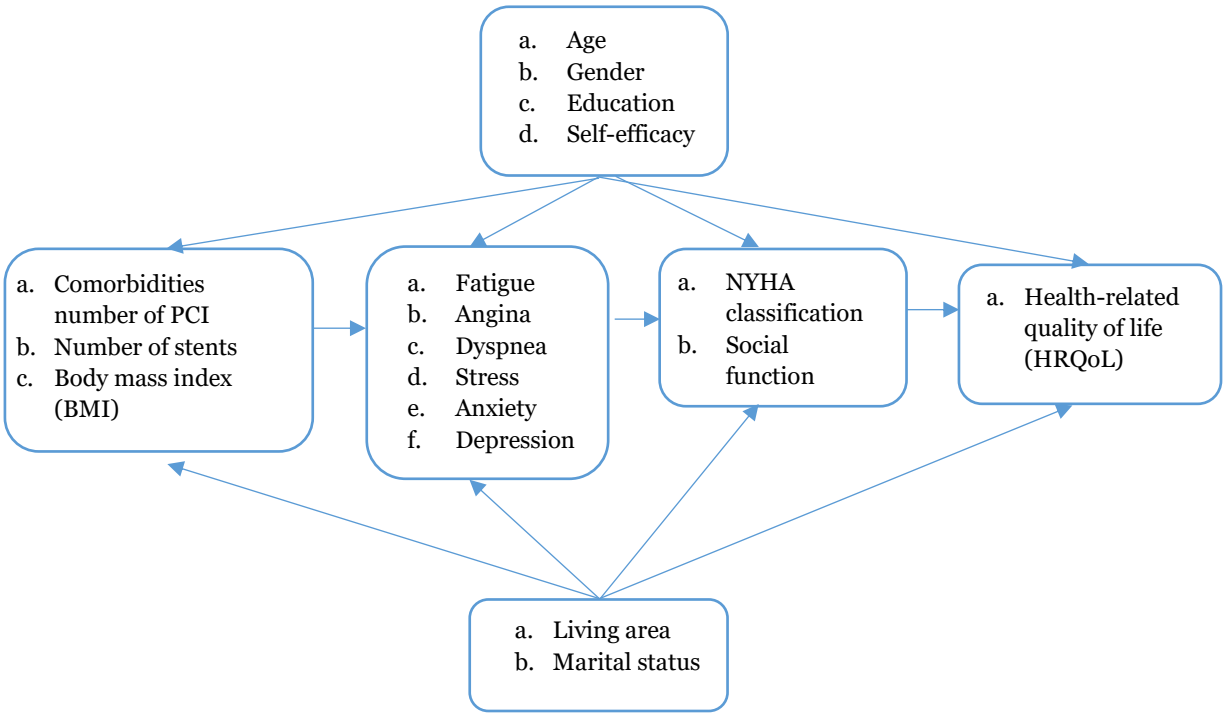


Figure 2. Hypothesized model

2.3 Measurement and data collection

Data were collected using interviewer-administered questionnaires. Participants were recruited based on predefined inclusion and exclusion criteria and informed about the study objectives and procedures. Participation was voluntary, and written informed consent was obtained before the interviews. Trained interviewers followed standardized procedures, reading each question aloud and recording participants' responses on the questionnaire to ensure consistency and minimize interviewer bias. Each interview took approximately 10–20 minutes. The questionnaires were checked for completeness before being collected. The instruments used in this study included a sociodemographic and clinical data sheet and six questionnaires.

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2.3.1 Sociodemographic and clinical data

The personal, social, and clinical data sheet was used to collect information on age, gender, education, employment status, economic status, marital status, living area, comorbidities, weight, height, number of PCIs, number of stents, the modified Medical Research Council (mMRC) Dyspnea Scale, and NYHA classification. The mMRC Dyspnea Scale assessed baseline functional disability due to dyspnea (Sunjaya et al., 2022). It consists of five statements that describe the range of dyspnea severity, from none (Grade 0) to almost complete incapacity (Grade 4). It is widely accepted as a valid, reliable, and clinically applicable tool and is officially endorsed by the Indonesian Ministry of Health for assessing the severity of breathlessness/ shortness of breath (Ministry of Health of the Republic of Indonesia, 2019). The NYHA classification evaluates the severity of functional limitations caused by a patient's heart failure based on the symptoms experienced during activity. It classifies patients based on limitations during physical activity; these limitations or symptoms are related to normal breathing and varying degrees of shortness of breath and/or angina pain (Bredy et al., 2017). The research team assessed the participants' current physical activity limitations using the NYHA classification.

2.3.2 Cardiac self-efficacy

The Cardiac Self-Efficacy Scale (C-SES) consists of 13 items that assess participants' confidence or self-efficacy in knowing or controlling cardiac symptoms and illness and maintaining their functioning. Respondents were asked to rate their confidence on a five-point Likert scale (0 = not at all confident to 4 = completely confident) (Fors et al., 2015). A higher score on this scale indicates higher levels of self-efficacy. This scale demonstrated high internal consistency, as measured by Cronbach's alpha of 0.93 and good convergent and discriminant validity across different and similar scales (Cajanding, 2015). The questionnaire was translated into Indonesian, and the translated version was reviewed and discussed collaboratively by the research team to ensure the clarity and appropriateness of the wording for the Indonesian context. However, formal psychometric validation, including validity and reliability testing, was not conducted as part of this study.

2.3.3 Fatigue

The Fatigue Assessment Scale (FAS) was used to measure fatigue. It comprises ten questions that assess physical fatigue and mental fatigue, with responses ranging from "never" to "always" on a five-point scale. The total FAS score ranges from 10 to 50. Higher scores indicate greater fatigue. A total FAS score of less than 22 indicates no fatigue, a score of 22-34 indicates fatigue, and a score of 35 or higher indicates extreme fatigue (Hendriks et al., 2018). The Cronbach's alpha for the FAS was 0.93 (Horisberger et al., 2019). Based on local adaptation testing, the FAS items demonstrated good validity through bivariate Pearson product-moment correlations with the total scores ranging from 0.453 to 0.723. The FAS also showed good internal consistency, with Cronbach's alpha values ranging from 0.812 to 0.829, indicating that the instrument was reliable for assessing fatigue levels in the Indonesian population (Zuraida & Chie, 2014).

2.3.4 Angina

The 7-item version of the Seattle Angina Questionnaire-7 (SAQ-7) was used to assess the health status of patients with coronary artery disease. The SAQ-7 assesses the frequency of angina, its impact on patients' physical function, and quality of life over the past 4 weeks. SAQ-7 scores for each domain are converted to a range of 0 to 100, with higher scores indicating less frequent angina, better function, and better quality of life. The Indonesian version of the SAQ-7 has demonstrated validity and reliability, as shown by item correlations above the critical r value (r = 0.278; n = 50; $p < 0.05$), with item correlations ranging from 0.565 to 0.998 across the three domains and Cronbach's alpha of 0.904 (Supriyadi et al., 2026).

2.3.5 Depression, anxiety, and stress

The Depression Anxiety Stress Scale 21 (DASS-21), a 21-item questionnaire that assesses symptoms of depression, anxiety, and stress (seven items for each dimension) (Evans et al., 2017) was also used in this study. Participants rated each item's applicability based on their experience in the past week on a four-point scale ranging from 0 (very untrue of me) to 3 (very true of me).

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Scores for depression, anxiety, and stress are calculated by summing the scores for each relevant item. A higher score on this scale indicates higher levels of the emotional states of depression, anxiety, and stress. The Indonesian DASS-21 had satisfactory composite reliability values of 0.872, 0.806, and 0.816 for the depression, anxiety, and stress subscales, respectively (Muttaqin & Ripa, 2021). The Principal Component Analysis (PCA) values showed a residual value of 39.7%, indicating that the items in the DASS-21 are valid for measuring depression, anxiety, and stress (Ifdil et al., 2020).

2.3.6 Social functioning

The Social Functioning Questionnaire (SFQ) consists of a list of statements and possible responses for a quick assessment of perceived social functioning. It has demonstrated good test-retest and inter-rater reliability, as well as construct validity (Tyrer et al., 2021). This questionnaire includes eight questions covering the essential aspects of social interaction: work and household tasks, financial concerns, relationships with family, sexual activities, social contacts, and leisure activities. The SFQ is scored on a four-point scale (0-3) with a total possible score of 24. A higher score on this scale indicates higher levels of social functioning. The internal consistency of the SFQ was acceptable (Cronbach's alpha 0.75) while the Spearman's rho was 0.426 (Verduin & Scholte, 2014). The SFQ was translated into Indonesian and subsequently reviewed by the research team to ensure linguistic clarity and contextual appropriateness. However, no formal psychometric evaluation of the translated version, including validity and reliability testing, was performed in this study.

2.3.7 Quality of life

The MacNew Heart Disease Health-related Quality of Life Questionnaire (Dixon et al., 2002) was the final instrument. The questionnaire comprises 27 items that assess HRQoL. It has three subscales: physical limitation, emotional limitation, and social functioning, with a two-week time frame. The scores of the MacNew items and subscales range from 1 (all of the time) to 7 (none of the time), with a higher score indicating better HRQoL. The internal consistency of the Indonesian version of this questionnaire was good for the global scale and all three subscales (exceeding 0.95). The concurrent validity between the three subscales of this questionnaire and the Indonesian version of the SF-36 ranged from 0.47 to 0.71, indicating moderate to strong correlations (Basuki et al., 2021).

2.4 Data analysis

All authors reviewed the data analyses, and no missing data were identified. Descriptive statistics, including means and standard deviations for numerical data and frequencies and percentages for categorical data, described participants' personal and social characteristics and the variables in the hypothetical model. Structural Equation Modeling (SEM) was conducted using the partial least squares structural equation modeling (PLS-SEM) approach to examine the effect of individual characteristics, social environmental characteristics, biological and physical variables, symptom status, and functional status on HRQoL. The analysis was performed with SmartPLS version 3.2.7. PLS-SEM includes a two-step procedure, including the evaluation of the outer measurement model and the inner structural model. Since PLS does not presuppose a specific distribution for parameter estimation, normality of the distribution was not required (Evi & Rachbini, 2022; Hair et al., 2011).

The outer measurement model was used to calculate the reliability, internal consistency, and validity of the observed variables in this study. Outer loadings greater than 0.5 indicated good reliability; Cronbach's alpha and composite reliability greater than 0.70 indicated good internal consistency; and average variance extracted (AVE) greater than 0.5 indicated acceptable convergent validity for this study. The discriminant validity of the latent constructs was assessed using the Fornell and Larcker criterion and cross-loadings. A construct should not have the same variance as any other construct greater than its AVE value (Rahadi, 2023).

The outcomes of the inner structural model were calculated using the coefficient of determination (R^2), the effect size (f^2), the path coefficient (β), the t-statistic, and the standardized root mean square residual (SRMR). The coefficient of determination measures the predictive accuracy. An R^2 value of 0.75 is considered substantial, an R^2 value of 0.50 is considered moderate, and an R^2 value of 0.26 is considered weak. The effect size (f^2) examines the degree to

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which each exogenous latent construct influences the endogenous latent construct. An f^2 value of ≥ 0.02 indicates a weak effect, ≥ 0.15 indicates a moderate effect, and ≥ 0.35 indicates a strong effect. The β value, which represents the expected change in the dependent construct for a unit variation in the independent construct(s), was used to assess the significance of the hypothesis through a bootstrapping procedure. To test the significance of the β coefficient and t-statistic, a bootstrapping procedure using 500 subsamples was performed. The greater the beta coefficient (β), the stronger the effect of an exogenous latent construct on the endogenous latent construct. The SRMR is a measure of the estimated model fit. An SRMR value of ≤ 0.1 was considered to indicate good model fit (Rahadi, 2023).

2.5 Ethical considerations

Approval to conduct this study was obtained from the Medical Research Ethics Committee of Dr. M. Djamil Hospital Padang, with reference number LB.02.02/5.7/176/2022. Written informed consent was obtained from all participants prior to their enrollment. Participants were allowed to withdraw from the survey at any time they wished. The survey was anonymous, and the confidentiality of information was assured.

3. Results

3.1 Individual and social-environmental characteristics

Among the 240 participants, the mean age was 59.73 (SD = 7.63) years, and the majority were male (87.5%). About half of the participants had completed senior high school (47.9%) and 39.2% were employed. Most participants were married (94.6%), lived in an urban area (92.1%), and rated their economic status as moderate (82.9%). The mean total self-efficacy score was 38.6 (SD = 8.58), with mean scores of 12.8 (SD = 2.91), 12.6 (SD = 2.81), and 13.3 (SD = 3.51) for the symptom control, illness control, and maintaining function domains, respectively (Table 1).

Table 1. Individual and social environmental characteristics of the participants (n = 240)

Characteristics	f	%	M	SD
Age (years)			59.73	7.63
Gender				
Male	210	87.5		
Female	30	12.5		
Education (%)				
Elementary	35	14.6		
Junior high	30	12.5		
Senior high	115	47.9		
Bachelor	52	21.7		
Master	7	2.9		
Doctor	1	0.4		
Employment status				
Employed	94	39.2		
Retired	56	23.3		
Unemployed	89	37.1		
Disability pensioned	1	0.4		
Economic status				
Low	11	4.6		
Moderate	199	82.9		
High	30	12.5		
Marital status				
Married	227	94.6		
Divorced/widowed/unmarrried	13	5.4		
Living area				
Urban	221	92.1		
Rural	19	7.9		
Self-efficacy			38.6	8.58
Symptom control			12.8	2.91
Illness control			12.6	2.81
Maintaining function			13.3	3.51

Note. f = frequency; M = mean; SD = standard deviation

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3.2 HRQoL and its determinants

Biological and physiological functions, symptom status, functional status, and health-related quality of life are presented in Table 2. The most common comorbidity was hypertension (33.3%). The results showed that most participants underwent PCI once (69.2%), had 1 stent inserted (62.1%), and had a BMI within the normal range (52.9%). Fatigue was reported by 49.2% of participants. Based on the results of the SAQ-7, the mean score for angina was 70.4 (SD = 12.11). The results of the dyspnea assessment showed that 59.2% of the participants had an mMRC score of 0, indicating that the participants experienced dyspnea with strenuous exercise. Furthermore, the psychological symptoms reported by the participants indicated that 85.8% of the participants had a normal level of stress, 60% had a normal level of anxiety, and 71.7% had a normal level of depression. According to the NYHA classification, more than half of the participants were in class I, and social functioning had a mean score of 15.1 (SD = 3.91). Participants rated their overall HRQoL as 5.2 (SD = 0.92), with the emotional functioning domain having the highest mean score of 5.3 (SD = 0.98), followed by the social functioning domain.

Table 2. Biological and physiological functions, symptom status, functional status, and health-related quality of life of the participants (n = 240)

Variables	f	%	Mean	SD
Biological and physiological functions				
Comorbidities*				
Hypertension	80	33.3		
Hyperlipidemia	51	21.2		
Diabetes mellitus	47	19.6		
Stroke	13	5.4		
Kidney disease	7	2.9		
None	111	46.3		
Number of PCI				
1	166	69.2		
2	49	20.4		
3	12	5.0		
4	10	4.2		
5	2	0.8		
6	1	0.4		
Number of stents				
1	149	62.1		
2	49	20.4		
3	23	9.6		
4	11	4.6		
5	5	2.1		
6	2	0.8		
7	1	0.4		
Body mass index (BMI)				
Obesity	64	26.7		
Overweight	42	17.5		
Normal	127	52.9		
Underweight	7	2.9		
Symptom status				
Fatigue				
No fatigue	107	44.6		
Fatigue	118	49.2		
Extreme fatigue	15	6.3		
Fatigue dimension				
Physical fatigue			14.1	3.13
Mental fatigue			9.0	4.73
Angina			70.4	12.11
Physical limitation			60.3	12.02
Angina frequency			82.6	18.53
Quality of Life			73.2	16.14

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Table 2. Continued

Variables	f	%	Mean	SD
Dyspnea (mMRC score)				
0	142	59.2		
1	70	29.2		
2	17	7.1		
3	10	4.2		
4	1	0.4		
Stress levels				
Normal	206	85.8		
Mild	14	5.8		
Moderate	5	2.1		
Severe	15	6.3		
Anxiety				
Normal	144	60.0		
Mild	10	4.2		
Moderate	63	26.3		
Severe	4	1.7		
Extreme severe	19	7.9		
Depression				
Normal	172	71.7		
Mild	9	3.8		
Moderate	41	17.1		
Severe	4	1.7		
Extreme severe	14	5.8		
Functional status				
NYHA Classification				
Class I	146	60.8		
Class II	76	31.7		
Class III	18	7.5		
Class IV	0	0		
Social function			15.1	3.91
Quality of life (Global)			5.2	0.92
Emotional function domain			5.3	0.98
Physical limitation domain			5.1	0.95
Social function domain			5.2	0.93

Note. *Multiple responses were allowed; percentages were calculated based on the total number of respondents.

3.3 Evaluation of outer measurement model

An evaluation of the standardized outer loadings of the observed variables was performed to evaluate the outer measurement model. Observed variables with an outer loading of 0.5 or greater were acceptable, while observed variables with outer loadings less than 0.5 were discarded. The evaluation showed that all outer loadings were greater than 0.608. Cronbach's alpha and composite reliability (CR) were used for internal consistency evaluation of the construct. The Cronbach's alpha and CR values for all latent constructs exceeded the minimum threshold level of 0.70, with all values greater than 0.810. The AVE of each latent construct was more than 0.5, indicating that the convergent validity was established for this study model (Supplementary Table S1). The discriminant validity of the latent constructs was evaluated using the Fornell and Larcker criterion. All the correlations were smaller than the square root of the average variance exerted along the diagonals, implying satisfactory discriminant validity. In summary, the proposed conceptual model was considered acceptable, with adequate reliability, convergent validity, and discriminant validity, thereby verifying the research model (Supplementary Table S2).

3.4 Evaluation of the inner structural model

Table 3 presents the absolute coefficients of determination for this model. The coefficient of determination for the HRQoL model was 0.835. This indicated that all independent constructs in the model substantially explained 83.5% of the variance in HRQoL. Because the adjusted R2 was > 0.75, all exogenous constructs strongly influenced HRQoL (Evi & Rachbini, 2022). In addition,

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Supplementary Table S3 presents the effect size of each exogenous latent construct on the endogenous latent construct. The effect size (f^2) ranged from 0.000 to 1.436, indicating that each exogenous latent construct had a different level of impact on the endogenous latent construct.

Table 3. The coefficient of determination for the inner structural model (R^2)

Variable	R^2	Adjusted R^2
Comorbidities	0.107	0.095
Fatigue	0.388	0.377
Angina	0.249	0.236
Dyspnea	0.066	0.050
Stress	0.394	0.383
Anxiety	0.385	0.375
Depression	0.406	0.395
NYHA classification	0.697	0.684
Social function	0.613	0.596
Health-related quality of life	0.835	0.826

3.5 Correlation coefficient of latent variables

Finally, the path coefficients (β values) for the direct effects of the causal variables on the outcome variables and the R2 were calculated, yielding the final model. Variables with either direct or indirect effects on HRQoL were included in the final model. The final model (Figure 3) shows the relationships among the level of education, self-efficacy, living area, comorbidities, fatigue, angina, dyspnea, stress, anxiety, and depression, NYHA classification, social functioning, and HRQoL in ACS patients after PCI. Individual characteristics (age and gender), social environmental characteristics (marital status), and biological and physiological factors (BMI, number of PCIs, and number of stents) did not have significant direct or indirect effects on HRQoL and were therefore excluded from the statistical model. Consequently, their statistical results were not reported in the test results.

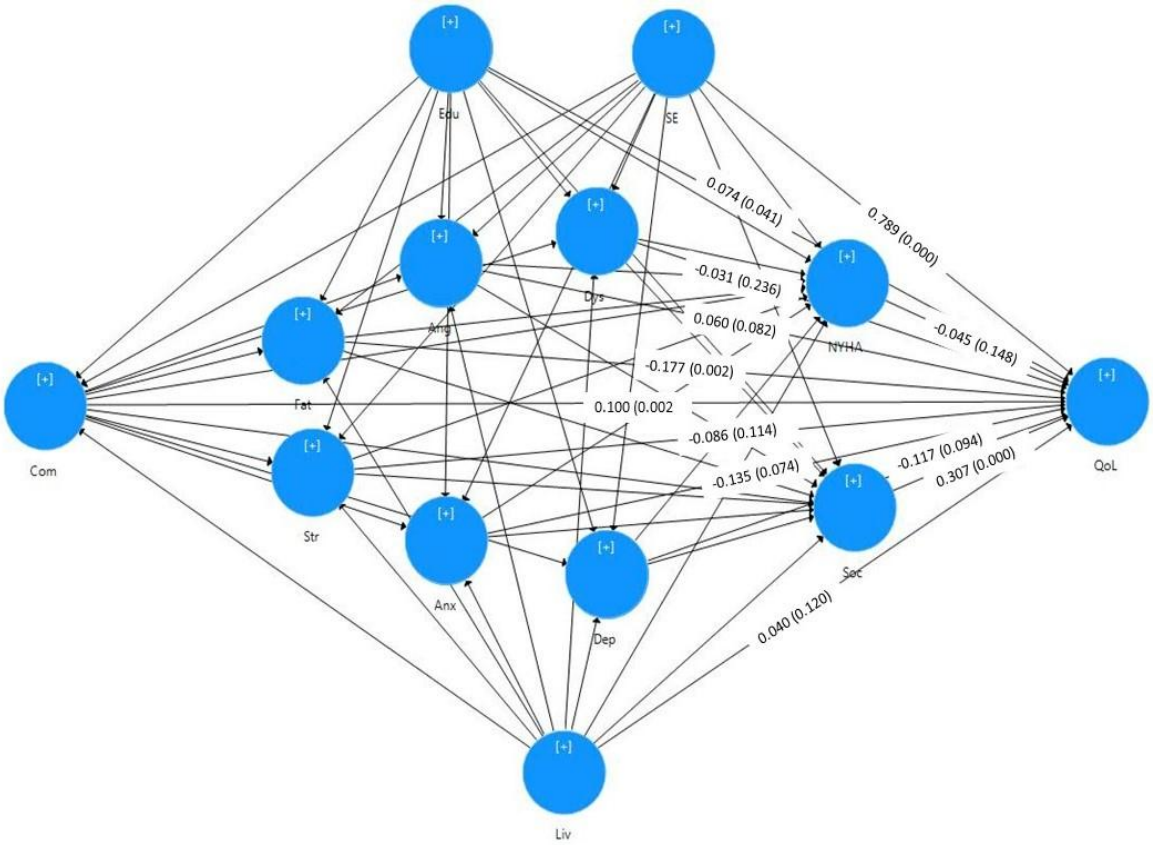


Figure 3. Final model with path coefficients (β values) and p-values of total effect of causal variables on HRQoL

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Note for Figure 3. Arrows indicate the direction of effects. Edu = education; SE = self-efficacy; Com = comorbidities; Fat = fatigue; Ang = angina; Dys = dyspnea; Str = stress; Anx = anxiety; Dep = depression; Soc = social function; NYHA = New York Heart Association classification; QoL = health-related quality of life; Liv = living area.

Table 4 presents the estimated path coefficients (β values), t-values, and significance levels for the direct, indirect, and total effects of the latent variables on HRQoL. Self-efficacy (β = 0.276), fatigue (β = -0.151), anxiety (β = -0.152), and social functioning (β = 0.307) had significant direct effects on HRQoL ($p < 0.05$). In addition, education level (β = 0.056), self-efficacy (β = 0.513), and comorbidities (β = 0.063) had significant indirect effects on HRQoL ($p < 0.05$). Meanwhile, education level (β = 0.074), self-efficacy (β = 0.789), comorbidities (β = 0.100), fatigue (β = -0.177), and social functioning (β = 0.307) had significant total effects on HRQoL ($p < 0.05$). In summary, seven determinants had direct, indirect, or total effects on HRQoL in the studied population. Social functioning had the greatest direct effect on HRQoL. The f^2 values indicated that the effect sizes for self-efficacy ($f^2 = 0.166$) and social functioning ($f^2 = 0.219$) were moderate, whereas the effect size for fatigue was weak ($f^2 = 0.039$) (Table 4, Supplementary Table S3).

Interestingly, self-efficacy showed significant direct, indirect, and total effects on HRQoL ($p < 0.05$). These results highlight the importance of self-efficacy in this model (Table 4). The standardized root mean square residual (SRMR) was 0.086, suggesting a good model fit (Supplementary Table S4).

Table 4. Direct, indirect, and total effects of latent variables on HRQoL

Path diagram	Direct			Indirect			Total			Effect size (f^2)
	β	T	*p*	*β*	T	*p*	*β*	T	*p*	
Edu -> QoL	0.018	0.564	0.287	0.056	1.800	0.036	0.074	1.738	0.041	0.001
SE -> QoL	0.276	4.570	0.000	0.513	11.192	0.000	0.789	26.822	0.000	0.166
Liv -> QoL	0.014	0.407	0.342	0.026	1.101	0.136	0.040	1.175	0.120	0.001
Com -> QoL	0.036	1.485	0.069	0.063	2.388	0.009	0.100	2.923	0.002	0.007
Fat -> QoL	-0.151	2.473	0.007	-0.026	1.052	0.147	-0.177	2.825	0.002	0.039
Ang -> QoL	-0.161	0.325	0.237	-0.001	0.160	0.436	0.060	1.393	0.082	0.014
Dys -> QoL	0.010	0.102	0.460	-0.041	1.000	0.159	-0.031	0.721	0.236	0.000
Str -> QoL	-0.087	1.246	0.107	0.001	0.010	0.496	-0.086	1.064	0.144	0.006
Anx -> QoL	-0.152	1.917	0.028	0.016	0.503	0.308	-0.135	1.451	0.074	0.017
Dep -> QoL	-0.039	0.506	0.307	-0.077	1.622	0.053	-0.117	1.317	0.094	0.001
NYHA -> QoL	-0.045	1.048	0.148				-0.045	1.048	0.148	0.003
Soc -> QoL	0.307	5.253	0.000				0.307	5.253	0.000	0.219

Notes. Edu: education; SE: self-efficacy; Com: comorbidities; Fat: fatigue; Ang: Angina; Dys: Dyspnea; Str: stress; Anx: anxiety; Dep: depression; Soc: social function; NYHA: NYHA classification; QoL: health-related quality of life; Liv: living area.

4. Discussion

This study examined the relationships among the determinants of health-related quality of life (HRQoL) based on the revised Wilson and Cleary model in patients with Acute Coronary Syndrome following percutaneous coronary intervention. In this study, overall HRQoL among ACS patients after PCI was relatively good, as the mean score was closer to the maximum possible score of 7, with the highest mean score observed in the emotional functioning domain, followed by the social functioning domain. This result was almost identical to previous studies in West Java (Nurhamsyah et al., 2022) and East Java, Indonesia (Imam & Jitpanya, 2022). This may reflect the participants' shared social background, culture, and healthcare capacity. This is similar not only to previous studies from Indonesia, but also to studies from Pakistan (Mujtaba et al., 2019) and Greece (Tsoulou et al., 2023). The findings suggest that revascularization may improve perceived health and daily functioning. Restoring coronary blood flow after PCI may alleviate ischemic symptoms and improve patients' functional capacity, thereby contributing to better perceived HRQoL. This study highlights that PCI is associated with relatively good HRQoL among patients with ACS, although further improvements are still needed in specific domains. Overall HRQoL scores may mask persistent difficulties in specific domains, highlighting the need to identify areas that require further improvement. Therefore, post-PCI care should extend beyond

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successful revascularization to include ongoing assessment of patients' physical, psychological, and social functioning to support sustained HRQoL improvements.

This model explained 83.6% of the variance in HRQoL among patients with ACS following PCI and identified four determinants with significant direct effects on HRQoL: self-efficacy, fatigue, anxiety, and social functioning. Among these determinants, social functioning demonstrated the strongest direct effect on HRQoL. This finding is consistent with a previous study that identified deficits in social functioning as a key factor influencing long-term quality of life after PCI (Li et al., 2019). In that study, path analysis showed that social support, acceptance-resignation coping style, deficits in social functioning, number of adverse cardiac events, and sleep quality significantly affected long-term QoL in PCI patients, in descending order. Patients satisfied with their social functioning have valuable social interactions, including work and household tasks, financial concerns, family relationships, sexual activities, social contacts, and leisure activities, which ultimately improve their quality of life (Li et al., 2019). Compared with the study by Saengsiri et al. (2014), which explained 54% of the variance in quality of life using the same conceptual model, the present study demonstrated a higher proportion of explained variance (83.5%), suggesting that the inclusion of additional determinants may provide a more comprehensive explanation of HRQoL among patients with ACS following PCI. Overall, these findings reinforce the importance of addressing social functioning as a key component of comprehensive HRQoL assessment and management in patients with ACS following PCI.

The findings showed that self-efficacy demonstrated the strongest direct, indirect, and total effects on HRQoL among all variables examined. This study adopted the revised Wilson and Cleary model of quality of life (QoL), which proposes that health-related quality of life (HRQoL) is influenced by individual characteristics, biological functioning, environmental factors, symptom experience, functional status, and overall health perceptions. Within this model, self-efficacy, as an individual characteristic, exhibits an indirect relationship with symptoms (including fatigue, stress, anxiety, and depression) as well as with functional status (specifically social functioning) and overall quality of life (Ferrans et al., 2005). This is evidenced by the β-coefficients and the statistical significance of the direct, indirect, and total effects derived from the PLS-SEM analysis. Previous evidence also supports this finding, showing that cardiac self-efficacy is crucial in explaining HRQoL in people with coronary heart disease (Banik et al., 2018; Meesoonthorn et al., 2022). As explained in the Revised Wilson and Cleary model, people with high self-efficacy are confident in controlling symptoms and maintaining function, leading to improved HRQoL (Saengsiri et al., 2014). Nurses and healthcare teams should attach importance to cultivating and improving patients' self-efficacy by strengthening patients' confidence and belief in their abilities to implement actions or overcome difficulties they face, such as through strengthening health education for patients, developing self-care programs, and guiding patients to be active in dealing with the adverse effects of disease and PCI in order to improve their quality of life (Ahmadi et al., 2022; Mohammadzadeh et al., 2022; Nuraeni et al., 2019).

In the present study, self-efficacy was also negatively correlated with stress, anxiety, and depression. Patients with higher self-efficacy experienced less stress, lower anxiety, and less depression. This may be because individuals with greater confidence in their ability to manage their illness are more likely to cope effectively with disease-related challenges, perceive greater control over their health, and experience less psychological distress. This interpretation is consistent with a previous study showing that self-efficacy in patients with AMI following PCI was inversely correlated with negative emotions such as stress and depression (Liu et al., 2018).). This suggests that nurses, healthcare teams, and caregivers should work to improve patients' self-efficacy through educational strategies used in previous studies, thereby improving their physical, social, and psychological well-being.

5. Implications and limitations

The results of this study have several implications for nurses and multidisciplinary health care teams caring for ACS patients after PCI. An observed relationship between social functioning and HRQoL may inform comprehensive patient assessment and the planning of patient-centered care. Nurses play a key role in assessing these modifiable factors and coordinating interventions such as health education, discharge planning, psychosocial support, and referral when appropriate. Collaborative efforts among nurses, physicians, rehabilitation professionals,

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psychologists, and caregivers may further support patients' recovery and optimize HRQoL following PCI. Nurses, health care teams, and caregivers are expected to help improve patients' self-efficacy and provide support for better social functioning, which may contribute to patients' recovery after PCI. A nurse-led health education or discharge planning program can improve self-efficacy and provide social support for patients. In addition, nurses and healthcare teams should establish counseling programs to alleviate the negative emotions of the patients.

A major strength of this study is the application of partial least squares structural equation modeling (PLS-SEM) within the revised Wilson and Cleary model to examine the determinants of health-related quality of life (HRQoL) in patients with Acute Coronary Syndrome following PCI. Unlike conventional statistical methods that assess relationships individually, PLS-SEM enables the simultaneous evaluation of multiple direct and indirect relationships among the study variables within a single conceptual framework. In addition, this study extends the work of Saengsiri et al. (2014) by incorporating stress, anxiety, and individual characteristics into the revised Wilson and Cleary model, providing a more comprehensive assessment of the factors influencing HRQoL. These methodological and conceptual strengths enhance the understanding of the complex pathways affecting HRQoL in patients with ACS following PCI.

Additional strengths of this study include its novelty, sample size, and study setting. To the best of our knowledge, this is the first study in Indonesia to examine the relationships proposed in the revised Wilson and Cleary model among patients with Acute Coronary Syndrome following PCI. The relatively large sample enabled the evaluation of relationships among eighteen variables within the proposed conceptual framework. Furthermore, the study was conducted at a PCI-capable tertiary referral hospital serving patients from central Sumatra, providing findings that may be applicable to similar clinical settings and populations in the region.

Several limitations should be considered when interpreting and using this study's results. First, participants were ACS patients who were 3 months to 13 years after their first PCI and 3 months to 2 years after their recent PCI. As a result, the data showed substantial variability. Similar variability in the duration since PCI has also been reported in previous HRQoL studies involving patients with ACS or CAD after PCI, reflecting the challenges of recruiting patients within a uniform follow-up period. Nevertheless, this heterogeneity may have influenced the observed associations and should be considered when comparing the findings with those of other studies. The study is also limited by its single-point design. Finally, the Indonesian versions of the C-SES and SFQ were translated and reviewed by the research team without formal psychometric evaluation, which may affect the measurement properties of these instruments in the Indonesian context. Nonetheless, this study provides useful information about the highlighted factors that influence quality of life and should be evaluated to improve the quality of life of patients with ACS.

6. Conclusion

A comprehensive evaluation of factors affecting quality of life using the Revised Wilson and Cleary Model was valuable for measuring both the impact of illness on daily functioning and the clinical outcomes of interventions. The results of this study emphasized self-efficacy as the factor with the greatest impact on quality of life, alongside other factors, including fatigue, anxiety, social functioning, education level, and comorbidities, that also had substantial effects on the quality of life. These findings provide an evidence base for comprehensive patient assessment and support the development of patient-centered nursing care strategies to improve health-related quality of life. Future longitudinal studies are needed to examine changes in health-related quality of life over time and to evaluate the relationships among these determinants at more uniform time points following PCI, thereby providing stronger evidence for long-term patient management.

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Author contribution

EH conceived and designed the study, performed the data analysis, and drafted and revised the manuscript. EH and FM collected the data. Both authors reviewed, revised, and approved the final version of the manuscript.

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Conflict of interest

The authors declare that they have no conflicts of interest in this study.

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Declaration of Generative Artificial Intelligence (AI)

The authors used ChatGPT (OpenAI) to assist with English language editing, grammar improvement, and refinement of academic writing. The AI tool was not used to generate, analyze, or interpret the study data, nor to develop the scientific content or conclusions of the manuscript. The authors carefully reviewed, edited, and verified all outputs and take full responsibility for the accuracy, integrity, and final content of the manuscript.

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