

Patient-Centered Care Communication and Patient Outcomes in Cardiovascular Patients: Evidence from Structural Equation Modeling

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ABSTRACT

Objective: This study examines the associations between patient-centered communication (PCC) and sequential patient outcomes—understanding, engagement, satisfaction, and treatment adherence—among cardiovascular patients. **Methods:** A quantitative cross-sectional design was conducted using a convenience sample of 100 cardiac patients at Pakuhaji Hospital Tangerang from February to May 2026. Data collected via a 20-item structured questionnaire were analyzed using covariance-based structural equation modeling (CB-SEM). **Results:** The measurement model demonstrated adequate validity and reliability. Goodness-of-fit indices supported the structural model (CFI=0.973, TLI=0.969, RMSEA=0.040). Path analysis revealed that PCC was not significantly associated with patient understanding ($\beta=-0.155$, $p=0.160$). However, significant positive sequential associations emerged from understanding to engagement ($\beta=0.388$, $p<0.01$), engagement to satisfaction ($\beta=0.504$, $p<0.01$), and satisfaction to adherence ($\beta=0.228$, $p=0.049$). **Conclusion:** While patient understanding, engagement, satisfaction, and adherence exhibit positive sequential associations, the primary pathway from PCC to patient understanding is not statistically significant. The assumption that general PCC automatically translates into clinical comprehension is unsupported within this framework. Due to the cross-sectional design, these relationships represent static concurrent associations rather than causal effects. Future longitudinal or interventional research is required to establish temporal ordering and verify targeted communication strategies.

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INTRODUCTION

Cardiovascular disease remains one of the leading global health challenges. Approximately 17.9 million people die each year from cardiovascular diseases, accounting for 32% of total global deaths (World Health Organization [WHO], 2023). More than 75% of these deaths occur in low- and middle-income countries, including Indonesia, indicating that cardiovascular disease continues to impose a significant public health burden worldwide. Recent global analyses further confirm that cardiovascular morbidity and mortality remain disproportionately high in developing regions due to limited access to preventive care and long-term disease management support (GBD 2021 ASEAN Cardiovascular Diseases Collaborators, 2025; Global Burden of Cardiovascular Diseases and Risks 2023 Collaborators, 2025).

In Indonesia, the prevalence of heart disease continues to rise. The Indonesian Basic Health Research (Kementerian Kesehatan Republik Indonesia, 2019) reported that the

prevalence of heart disease among individuals aged over 15 years reached 1.5% and shows an increasing trend annually. This condition not only increases the economic burden due to rising healthcare costs but also reduces productivity at the societal level. Therefore, comprehensive management is required, encompassing promotive, preventive, curative, and rehabilitative approaches. Among these, effective communication regarding cardiovascular health risks between healthcare professionals and patients plays a crucial role in motivating behavioral modifications and improving clinical treatment outcomes (Abraha et al., 2024).

Communication in healthcare settings is essential for establishing a therapeutic relationship between providers and patients. Effective communication enables healthcare professionals to clearly convey medical information, ensure patient understanding of diagnoses and treatment plans, and encourage active patient participation in managing their health (Street et al., 2009). In the context of cardiovascular disease, communication becomes particularly important

because patients often require long-term lifestyle modifications, strict medication adherence, and continuous health monitoring. Treatment success is not determined solely by medical intervention but also by patient understanding, adherence, and self-management capacity, all of which are strongly influenced by the quality of communication (Chia et al., 2025).

However, in clinical practice, communication between healthcare providers and patients is often still predominantly one-directional, with healthcare professionals dominating the interaction while patients remain passive recipients of information. This traditional model is considered less effective because it does not fully consider patients' needs, values, and preferences (Epstein & Street, 2011).

In response, patient-centered communication (PCC) has emerged, prioritizing empathy, respect, and partnership between healthcare providers and patients. It recognizes patients as individuals with unique experiences, values, and needs that should be considered in clinical decision-making (Barry & Edgman-Levitan, 2012). Key principles of PCC include active listening, encouraging patients to express concerns, using understandable language, and involving patients in shared decision-making (Hibbard & Greene, 2013). Various communication techniques can support this approach, such as motivational interviewing, teach-back methods, and shared decision-making strategies (Dennison Himmelfarb et al., 2023; Tamura-Lis, 2013).

Evidence from previous studies suggests that patient-centered communication positively affects outcomes in chronic disease management, including cardiovascular conditions. PCC significantly improves medication adherence across chronic diseases (Schnorrerova et al., 2025). Similarly, effective physician-patient communication enhances treatment understanding and self-management capacity (Iroegbu et al., 2025). Furthermore, communication improves patient emotional well-being, self-efficacy, and quality of life (Jiang, 2017).

Nationally, the implementation of PCC has gained increasing attention; however, several challenges remain. Studies in developing healthcare systems show that clinical communication is still often directive in nature, with limited consultation time and high workload among healthcare providers acting as major constraints that restrict shared decision-making (Mulure et al., 2024). In addition, variations in health literacy, cultural background, and language differences further influence the effectiveness of communication (Handtke et al., 2019).

At Pakuhaji Hospital Tangerang, the increasing number of cardiovascular patients and hospital readmissions indicate potential challenges in patient education and self-management support. These conditions highlight the need to examine communication practices in clinical settings and assess how PCC is implemented in cardiovascular care. While previous literature asserts that these challenges exist, current studies remain largely descriptive without mapping their structural mechanisms.

This study addresses this gap by establishing a distinct conceptual and methodological novelty. Rather than relying on simple descriptive or bivariate analyses, this study utilizes Structural Equation Modeling (SEM) to explicitly test the sequential understanding → engagement → satisfaction → adherence pathway within a single, integrated framework, grounded theoretically in Street's Pathways Model (Street et al., 2009) and Hibbard's Framework (Hibbard & Greene, 2013). Crucially, this structural pathway remains validated in recent structural modeling analyses across diverse chronic self-care domains, including diabetes distress and osteoporosis

(Elsehrawy et al., 2026; Marshall et al., 2024; Wang et al., 2026). Within this structural pathway, adherence is explicitly positioned as the final behavioral outcome because it represents the ultimate translation of cognitive understanding, active engagement, and patient satisfaction into concrete clinical action.

While proximal communication variables (such as understanding and satisfaction) establish the psychological and relational foundation, long-term health outcomes in chronic cardiovascular care depend entirely on the patient's sustained behavior outside the clinical setting. Furthermore, adherence is conceptualized as a complex, multidimensional construct rather than a singular action. To comprehensively capture the self-management behaviors required to mitigate readmission risks, adherence in this study is operationally defined and measured across four critical health-related areas: medication adherence, dietary adherence, exercise adherence, and rest adherence.

Consequently, this study aims to examine the associations between PCC and the sequential outcomes of patient understanding, patient engagement, patient satisfaction, and treatment adherence. To evaluate these proposed relationships and ensure their theoretical plausibility from the outset, we propose the following explicit hypotheses:

1. Hypothesis 1 (H1): Higher levels of patient-centered communication are positively associated with patient understanding of their cardiovascular condition and treatment plan.
2. Hypothesis 2 (H2): Increased patient understanding is positively associated with greater patient engagement in their self-management process.
3. Hypothesis 3 (H3): Greater patient engagement is positively associated with higher overall patient satisfaction with care.
4. Hypothesis 4 (H4): Higher patient satisfaction is positively associated with stricter treatment adherence.

METHODS

Study Design

This study employed a quantitative cross-sectional design to examine the relationships between PCC, understanding, engagement, satisfaction, and adherence among cardiac patients. Because data were collected at a single point in time, this design evaluates directional pathways as statistical associations rather than definitive causal relationships. The study used Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to test both the measurement and structural models.

Setting and Participants

The study was conducted at Pakuhaji Hospital Tangerang, Indonesia. The population consisted of cardiac patients receiving outpatient or inpatient care for specific, confirmed cardiovascular conditions. A total of 100 respondents were selected using a non-probability sampling technique (convenience sampling) based on explicit eligibility criteria.

Inclusion and Exclusion Criteria

Participants were eligible for inclusion if they had been clinically diagnosed with a primary cardiovascular condition, specifically coronary heart disease, heart failure,

hypertension, or arrhythmia; were 18 years of age or older; had received treatment for at least one month; were able to communicate effectively and complete the questionnaire independently; and provided informed consent to participate in the study. Patients were excluded if they had severe cognitive impairment or were critically ill to the extent that these conditions prevented them from participating in the study or completing the questionnaire independently.

Data Collection Procedure

Data were collected using a structured questionnaire administered directly to respondents. Participants were approached during hospital visits and provided with an explanation of the study objectives. After obtaining informed consent, respondents completed the questionnaire under supervision to ensure clarity and completeness. Data collection was conducted from February to May 2026.

Study Variables and Instruments

The study examined five latent constructs: PCC, patient understanding, patient engagement, patient satisfaction, and treatment adherence. All constructs were operationalized using a 20-item investigator-developed questionnaire specifically contextualized for the Indonesian cardiovascular care environment, containing 5 structural domains with 4 unique items per domain. The items were conceptually formulated based on established, validated literature and frameworks in health communication and patient behavior. To ensure maximum face validity, linguistic precision, and cultural appropriateness for Indonesian cardiac care, the draft questionnaire items underwent rigorous review and qualitative refinement by a panel of independent bilingual language and medical experts.

All items were measured using a uniform 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Data were collected using a 20-item investigator-developed questionnaire specifically contextualized for the Indonesian cardiovascular care environment. The questionnaire contains 5 structural domains, with 4 unique items per domain. Each indicator utilized in the Confirmatory Factor Analysis (CFA) represents a single questionnaire item rather than a composite score or item parcel.

The development of the specific items was conceptually informed by the domains found in established health communication, literacy, and behavioral frameworks, though no proprietary phrasing or verbatim scales were replicated. The structural domains are defined:

1. Patient-Centered Communication (PCC; 4 items): Formulated to capture the patient's perception of the care environment, conceptually informed by patient-centered communication literature and clinical interaction frameworks. It measures dimensions of verbal communication (VCOM), non-verbal communication (NVCOM), interactive education (INTEDU), and shared decision-making (SDM).
2. Patient Understanding (4 items): Designed to evaluate the patient's self-reported comprehension of their health status, conceptually informed by functional health literacy and cognitive comprehension literature. It assesses comprehension regarding lifestyle adjustments (LIFE), disease risk factors (RISK), therapeutic regimens (THER), and medical diagnoses (DIAG).
3. Patient Engagement (4 items): Formulated to capture proactive self-care behaviors, conceptually informed by

patient activation and chronic illness self-management frameworks. It evaluates patient preferences (PREF), proactive question-asking (ASK), independence in health management (INDEP), and the integration of care protocols into daily life (DAILY).

4. Patient Satisfaction (4 items): Evaluates the subjective experience of care received, conceptually informed by patient satisfaction and clinical care experience literature. It measures emotional reassurance (EMO), general communication satisfaction (GEN_COM), perceived quality of care (CARE), and overall care experience (EXP).
5. Treatment Adherence (4 items): Measures compliance with the recommended therapeutic lifestyle changes and clinical regimens, conceptually informed by cardiovascular self-care and therapeutic regimen adherence frameworks. It evaluates patient adherence to rest protocols (REST), physical exercise (EXERCISE), dietary guidelines (DIET), and prescribed medication regimens (MED).

The full item wording in its administered Indonesian form is provided in Supplementary File 1, and the distinct conceptual mapping procedure is detailed in Supplementary Table S1.

Content Validity, Readability, and Pilot Testing

To ensure the instrument's contextual appropriateness, content validity was evaluated by a panel of three experts, including two senior cardiologists and one expert in health communication. The panel calculated a Content Validity Index (CVI) for both items (I-CVI) and the overall scale (S-CVI). The overall S-CVI scale was 0.97, and the majority of items yielded an I-CVI of 1.00. While the quantitative indices demonstrated high consensus, specific items with lower initial agreement (i.e., DIAG regarding clinical diagnosis phrasing and INDEP regarding patient independence) were textually revised and refined based on the qualitative feedback provided by the experts to enhance patient-friendliness and contextual accuracy before final administration.

Following content validation, a readability test was performed with five cardiac outpatients (who were excluded from the final analysis) to confirm that the translated wording, sentence structures, and layout were clear, unambiguous, and easily comprehensible for the target population. No major textual modifications were required based on participant feedback.

Finally, an initial pilot study was executed with 30 cardiac patients at Pakuhaji Hospital (separate from the main sample of 100 respondents) to evaluate the initial reliability and internal consistency of the translated scales. All five constructs demonstrated acceptable initial reliability, with Cronbach's alpha coefficients ranging from 0.730 to 0.848, exceeding the standard threshold of 0.70. This confirmed that the instruments were robust and suitable for full-scale data collection.

Data Analysis

Data were analyzed using SEM with AMOS software (IBM SPSS AMOS, version 26). The analysis followed a two-stage approach consistent with covariance-based SEM (CB-SEM) procedures: (1) measurement model evaluation using CFA, and (2) structural model evaluation to examine hypothesized associations among constructs. All analyses were conducted using maximum likelihood estimation. Statistical significance was evaluated at $p < 0.05$.

Sample Size and Power Justification

While a sample size of $N = 100$ is relatively modest for Covariance-Based Structural Equation Modeling (CB-SEM), it satisfies the empirical thresholds required for this study's specific architectural complexity. To evaluate sample adequacy objectively, an a-priori statistical power analysis was conducted for the full structural configuration using the Soper (2026) SEM Calculator (<https://www.danielsoper.com/statcalc/calculator.aspx?id=89> "Free A-priori Sample Size Calculator for Structural Equation Models"), which integrates the algorithmic frameworks established by Cohen (1988) and Westland (2010) for structural model lower bounds.

The algorithmic parameters were defined based on the model configuration: 5 latent variables, 20 observed indicators, an anticipated large structural effect size ($f^2 = 0.36$), a significance level of $\alpha = 0.05$, and a targeted statistical power level of 0.80. The mathematical lower bound required to detect the targeted structural effects was calculated to be 96 participants, while a minimum of 100 participants is required to accommodate the structural complexity of the model, resulting in a recommended minimum sample size of 100. Thus, our final active sample size of $N = 100$ meets the necessary mathematical threshold to achieve sufficient statistical power, guarantee stable parameter estimates, and prevent Type II inferential errors.

Assessment of CB-SEM Assumptions

Prior to estimating the measurement and structural models, the data were rigorously screened to assess compliance with the assumptions underlying Maximum Likelihood estimation. Univariate and multivariate normality were evaluated using skewness, kurtosis, and Mardia's coefficient. The skewness values for individual items fell within ± 1.0 , while kurtosis values were within ± 2.0 , indicating acceptable univariate normality. Mardia's multivariate kurtosis statistic was 14.774, with a critical ratio of 2.490, which remained below the threshold of 5.0 and supported the assumption of multivariate normality. The dataset was also examined for univariate outliers using standardized Z-scores with a criterion of $|Z| > 3.29$, while multivariate outliers were assessed using Mahalanobis distance at $p < 0.001$. The maximum Mahalanobis D^2 value was 32.702, which did not exceed the critical χ^2 value of 45.315 for 20 degrees of freedom; therefore, no significant multivariate outliers were identified, and all 100 observations were retained for subsequent analyses. Linearity was assessed through visual inspection of bivariate scatterplots between aggregated construct scores, which indicated approximately linear relationships among the variables. Finally, multicollinearity was evaluated using variance inflation factor (VIF) and tolerance statistics obtained from auxiliary linear regression analyses. The VIF values ranged from 1.07 to 1.51, remaining well below the commonly accepted threshold of 3.0, whereas tolerance values ranged from 0.66 to 0.94, substantially exceeding the minimum criterion of 0.10. Collectively, these findings indicated no evidence of problematic multicollinearity and supported proceeding with the CB-SEM analyses.

Psychometric and Model Fit Thresholds

To ensure consistency across the measurement and structural stages of the analysis, model evaluation was conducted according to commonly accepted criteria for

structural equation modeling. Convergent validity and construct reliability were considered adequate when standardized factor loadings exceeded 0.50, the average variance extracted (AVE) was greater than 0.50, composite reliability (CR) exceeded 0.70, and Cronbach's alpha was above 0.70. Discriminant validity was assessed using both the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) ratio. Specifically, discriminant validity was considered supported when the square root of the AVE for each construct was greater than its correlations with other constructs and all HTMT values were below the conservative threshold of 0.85. Overall model fit was evaluated using multiple goodness-of-fit indices to provide a comprehensive assessment of model adequacy, including the chi-square statistic, Chi-Square Minimum Discrepancy divided by Degrees of Freedom (CMIN/DF), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Standardized Root Mean Square Residual (SRMR), Goodness-of-Fit Index (GFI), and Adjusted Goodness-of-Fit Index (AGFI).

Measurement Model (Confirmatory Factor Analysis)

CFA was conducted to evaluate the validity and reliability of the latent constructs: PCC, understanding, engagement, satisfaction, and adherence. Each construct was specified as a reflective measurement model based on established theoretical frameworks in patient-centered communication and health behavior research.

Because each construct was measured using exactly four individual items, the CFA was executed strictly at the item level; indicators (e.g., VCOM, LIFE, PREF) represent single, observed questionnaire items, and no item parceling or composite dimension-level scores were used in the measurement model.

Structural Model Specification

The structural model was developed to examine the associations among PCC, understanding, engagement, satisfaction, and adherence.

Initial Structural Model

The initial structural model specified direct associations from PCC to all endogenous constructs:

- PCC → Understanding
- PCC → Engagement
- PCC → Satisfaction
- PCC → Adherence

This model was tested to evaluate whether direct statistical relationships existed between communication and downstream patient outcomes.

Model Evaluation and Re-specification Procedure

Following estimation of the initial structural model, model fit indices and standardized path coefficients were examined. The initial model demonstrated inadequate fit and the associations were not statistically significant. Model re-specification was subsequently conducted in a theory-driven and parsimony-oriented manner. Specifically, non-significant direct paths from PCC to engagement, satisfaction, and adherence were removed, while the direct path from PCC to understanding was retained for further evaluation based on theoretical relevance and empirical considerations. A sequential structural model was then specified in accordance with established literature on patient behavior pathways,

such that communication was posited to influence understanding, which in turn affects engagement, subsequently shaping satisfaction and ultimately adherence (Communication → Understanding → Engagement → Satisfaction → Adherence). Importantly, no modification indices were used to introduce additional structural paths during model refinement; all adjustments were grounded in theoretical justification, statistical significance of structural paths, and overall model fit indices. The final model was then compared with the initial model to assess improvements in model fit, parsimony, and explanatory structure.

Final Structural Model Evaluation

The final structural model was estimated using maximum likelihood estimation. Standardized path coefficients (β values), p-values, and explained variance (R^2) were used to assess the strength and significance of associations among constructs. Downstream associations were examined through the sequential chain of direct pathways among constructs (i.e. Communication → Understanding → Engagement → Satisfaction → Adherence). These pathways were interpreted as a cascading statistical chain of direct associations within a cross-sectional framework.

Ethical Considerations

Formal prospective Institutional Review Board (IRB) review was not sought for this study due to localized institutional research regarding non-interventional, minimal-risk surveys at the time of data collection. Administrative and institutional permissions were formally obtained from Universitas Sangga Buana and Pakuhaji Hospital to authorize institutional site access, logistical deployment, and data collection.

To maintain the highest ethical standards and safeguard participant welfare, strict protective measures were enforced throughout the research cycle. The study utilized an exclusively anonymous data-collection layout. No personally identifiable information (PII), national identification numbers, hospital medical record digits, or traceable medical histories were recorded or gathered at any stage.

To ensure absolute anonymity, participants were not required to sign their names to any consent documentation. Instead, a detailed information sheet explaining the study's precise academic purpose, the entirely voluntary nature of participation, and the absolute right to decline or withdraw at any point without impacting medical care was presented on the introductory page. Active consent was operationalized when the adult participant, being fully capable of independent decision-making, voluntarily filled out and submitted the questionnaire. All compiled data matrices remain strictly confidential, aggregated, and securely encrypted. The core ethical treatments regarding human dignity, voluntariness, and data privacy were maintained in alignment with the Declaration of Helsinki.

RESULTS OF STUDY

Respondent Characteristics

This study included 100 patients with cardiovascular disease receiving outpatient ($n = 68$) or inpatient ($n = 32$) care at Pakuhaji Regional General Hospital. The demographic characteristics of respondents are presented in Table 1. The

sample was predominantly male (56%). Most participants were aged 45–65 years (53%), followed by those aged >65 years (34%). The majority had completed secondary education (60%), and most had experienced illness duration of 1–5 years (65%). All participants (100%) reported that they received pharmacological and lifestyle/dietary modifications as their prescribed treatment regimen. The sample comprised individuals with confirmed cardiovascular diagnoses, including hypertension (42%), coronary heart disease (38%), heart failure (12%), and arrhythmias (8%).

Table 1. Demographic Characteristics of Respondents

Characteristic/ Category	Frequency	Percentage (%)
Gender		
Male	56	56
Female	44	44
Age		
18–44 years	13	13
45–65 years	53	53
> 65 years	34	34
Education		
Primary (Elementary/Junior High School)	23	23
Secondary (Senior High School)	60	60
Higher Education (Diploma/Bachelor)	17	17
Care Status		
Outpatient	68	68
Inpatient	32	32
Primary Diagnose		
Hypertension	42	42
Coronary Heart Disease	38	38
Heart Failure	12	12
Arrhythmia	8	8
Duration of Illness		
< 1 year	19	19
1–5 years	65	65
> 5 years	16	16

Distinction Among SEM Models

The SEM analysis was conducted sequentially through four complementary stages. First, the measurement model was assessed using Confirmatory Factor Analysis (CFA) to evaluate the psychometric properties of the latent constructs, including factor loadings, construct reliability, convergent validity, and discriminant validity, independently of the structural relationships among constructs. Second, an initial path model was estimated as an overidentified baseline model in which direct paths from patient-centered communication (PCC) to all downstream outcome variables were tested simultaneously. This model demonstrated poor overall fit, indicating that the direct-effects specification did not adequately represent the observed data structure. Third, the model was refined into a final sequential path model specifying the theoretically ordered associations from communication to understanding, engagement, satisfaction, and adherence. This sequential model demonstrated substantially improved fit and was therefore retained as the primary structural framework for interpreting the relationships among the study constructs. Finally, a full structural model was estimated by integrating the measurement component and the structural pathways within a unified latent-variable framework with 166 degrees of freedom. In this model, individual indicator error terms and

structural disturbance terms were estimated simultaneously, allowing the adequacy of the sequential structural relationships to be examined in conjunction with the complete measurement structure. The resulting fit indices indicated that the integrated model provided an acceptable representation of the observed data.

Measurement Model Results

The measurement model was evaluated using CFA to assess construct validity and reliability of the latent variables: PCC, understanding, engagement, satisfaction, and adherence (Figure 1). All constructs demonstrated satisfactory internal consistency, with Cronbach's alpha values ranging from 0.792 to 0.898 and composite reliability (CR) exceeding 0.70. Convergent validity was confirmed, as all AVE values were above 0.50 (see Table 2).

Discriminant validity was first evaluated using the Fornell-Larcker criterion (Table 3). Based on the evaluation, the square root of the AVE ($\sqrt{\text{AVE}}$) for each construct—positioned along the bold diagonal—exceeded any corresponding correlation coefficient with other constructs located below the diagonal. This confirms adequate empirical distinctiveness for each latent variable in the model.

The HTMT ratios are presented in a comprehensive matrix format (Table 4). All pairwise HTMT values fall well below the conservative statistical threshold of 0.85, establishing that all latent constructs are independent and distinct from one another.

Measurement Model Fit Evaluation and Factor Loadings

The CFA model demonstrated acceptable fit based on multiple indices (Table 6). The model achieved good incremental fit, including CFI = 0.974, TLI = 0.970, RMSEA = 0.040, and CMIN/DF = 1.155. Although GFI (0.844) and AGFI (0.795) were below conventional thresholds, these indices were not prioritized in interpretation due to known sensitivity to sample size and model complexity, consistent with contemporary SEM reporting recommendations. Overall, the measurement model fit was considered acceptable.

Factor loadings for all indicators exceeded 0.50 and were statistically significant ($p < 0.05$). Within the PCC construct, verbal communication demonstrated the highest loading (0.890), followed by shared decision-making (0.855), non-verbal communication (0.787), and interactive education (0.593). For adherence, medication adherence showed strong loading (0.767) and resting adherence (0.919), whereas exercise (0.575) and diet (0.544) exhibited lower, albeit acceptable, loadings, indicating that lifestyle-related indicators contribute less strongly to the adherence construct than procedural components (see table 5). These lower factor loadings provide an important empirical basis for discussing the clinical need to structurally strengthen interactive education and lifestyle-related behaviors (such as diet and exercise protocols) among cardiovascular patients.

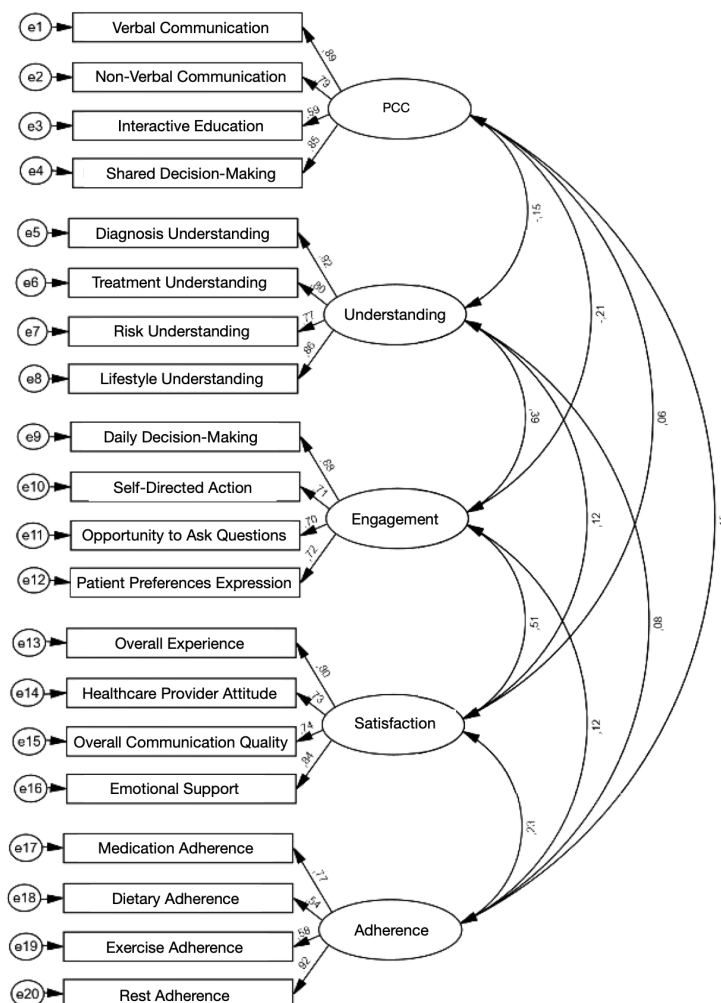


Figure 1. CFA Model of PCC, Understanding, Engagement, Satisfaction, and Adherence

Table 2. Reliability and Convergent Validity

Construct	Cronbach's Alpha	Composite Reliability (CR)	AVE
Communication	0.848	0.866	0.623
Understanding	0.898	0.904	0.703
Engagement	0.835	0.841	0.572
Satisfaction	0.857	0.862	0.610
Adherence	0.792	0.802	0.514

Table 3. Discriminant Validity Matrix (Fornell-Larcker Criterion)

Construct	Communication	Understanding	Engagement	Satisfaction	Adherence
Communication	0.789				
Understanding	-0.151	0.838			
Engagement	-0.206	0.395	0.756		
Satisfaction	0.061	0.116	0.512	0.781	
Adherence	0.147	0.084	0.122	0.226	0.717

Note: Bold values along the diagonal represent the square root of the AVE ($\sqrt{AVE}$); values below the diagonal represent inter-construct correlations.

Table 4. HTMT Ratios Matrix

Construct	Communication	Understanding	Engagement	Satisfaction	Adherence
Communication	—				
Understanding	0.151	—			
Engagement	0.207	0.395	—		
Satisfaction	0.061	0.115	0.513	—	
Adherence	0.148	0.084	0.123	0.228	—

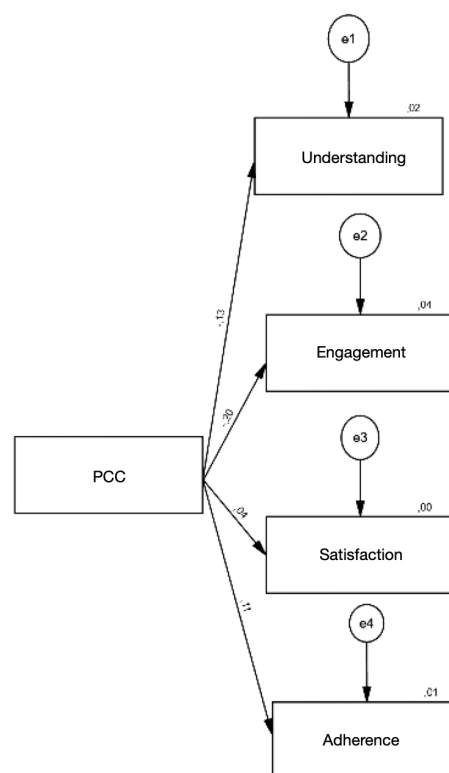
Note: Values below the diagonal represent the pairwise HTMT ratios between constructs.

Table 5. CFA Factor Loadings

Construct	Indicator	Factor Loading
PCC	SDM	0.855
	INTEDU	0.593
	NVCOM	0.787
	VCOM	0.890
Understanding	LIFE	0.862
	RISK	0.769
	THER	0.799
	DIAG	0.918
Engagement	PREF	0.719
	ASK	0.703
	INDEP	0.708
	DAILY	0.881
Satisfaction	EMO	0.842
	GEN_COM	0.741
	CARE	0.734
	EXP	0.802
Adherence	REST	0.919
	EXERCISE	0.575
	DIET	0.544
	MED	0.767

Initial Path Model

The initial path model (Figure 2) assumed direct associations between PCC and all outcome variables. This model demonstrated poor fit (RMSEA = 0.256; CFI = 0.076), and most structural relationships were not statistically supported.

**Figure 2.** Initial path model of the structural relationships between PCC, understanding, engagement, satisfaction, and adherence.

Final Path Model

The final path model (Figure 3) was refined into a sequential associative structure: Communication → Understanding → Engagement → Satisfaction → Adherence. The final path model demonstrated acceptable fit (Table 6), with CFI = 0.950, RMSEA = 0.060, and CMIN/DF = 1.354.

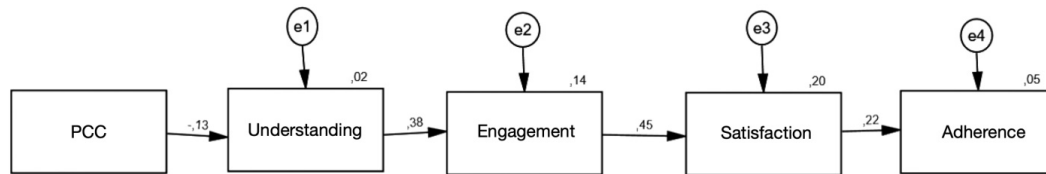


Figure 3. Final path model of the sequential relationships between PCC, understanding, engagement, satisfaction, and adherence.

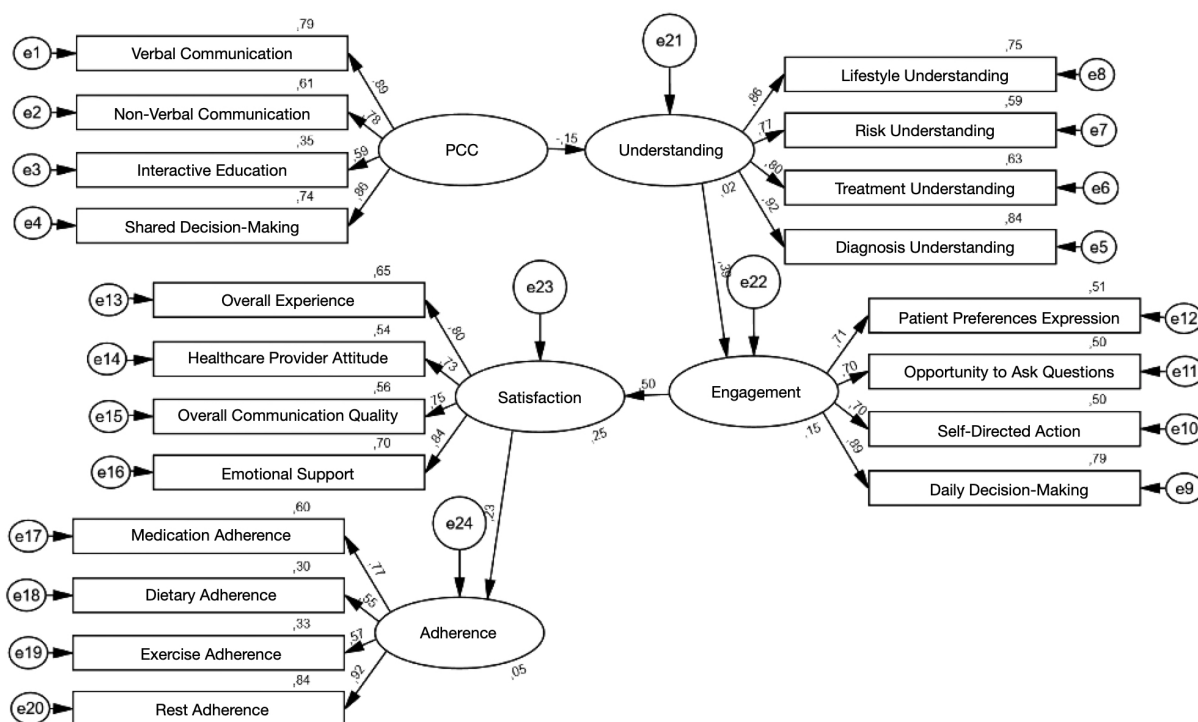


Figure 4. Full structural model of the relationships between PCC, understanding, engagement, satisfaction, and adherence.

Table 6. Goodness-of-Fit Comparison Across Models

Fit Index	CFA	Initial Path Model	Final Path Model	Full Structural Model
χ^2	184.756	45.079	8.126	191.740
df	160	6	6	166
p-value	0.088	<0.01	0.229	0.084
CMIN/DF	1.155	7.513	1.354	1.155
RMSEA	0.040	0.256	0.060	0.040
90% CI for RMSEA	[0.000, 0.063]	[0.190 -0.329]	[0.000, 0.153]	[0.000, 0.063]
CFI	0.974	0.076	0.950	0.973
TLI	0.970	-0.540	0.916	0.969
SRMR	0.068	0.171	0.060	0.080
GFI	0.844	0.844	0.970	0.838
AGFI	0.795	0.610	0.924	0.796

Note. χ^2 = Chi-square; df = degrees of freedom; CMIN/DF = Chi-square to degrees of freedom ratio; RMSEA = Root Mean Square Error of Approximation; CI = confidence interval; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; SRMR = Standardized Root Mean Square Residual; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index.

Table 7. Final Structural Model Summary

Variable Relationship	Unstandardized Estimate (B)	Standard Error (SE)	Critical Ratio (CR)	p value	95% CI	Standardized Estimate (β)	p-value	R ²
PCC→ Understanding	-0.244	0.174	-1.406	0.160	[-0.585, 0.097]	-0.155	0.160	0.024
Understanding → Engagement	0.248	0.069	3.602	<0.001	[0.113, 0.383]	0.388	<0.01	0.150
Engagement → Satisfaction	0.597	0.135	4.416	<0.001	[0.332, 0.862]	0.504	<0.01	0.254
Satisfaction → Adherence	0.183	0.093	1.968	0.049	[0.001, 0.365]	0.228	0.049	0.052

Note: β = standardized regression coefficient; $p < 0.05$ indicates statistical significance.

The standardized estimates and R² values are presented in Table 7. The final structural model indicates a pattern of sequential direct associations among the study constructs. Although PCC was not significantly associated with understanding, subsequent statistically significant direct associations were observed between understanding and engagement, engagement and satisfaction, and satisfaction and adherence. These findings indicate how the constructs are interrelated through the tested sequential SEM framework.

A central and notable finding of the full structural model is that PCC was not significantly associated with patient understanding ($\beta = -0.155$, $p = 0.160$). This critical result suggests that communication as perceived by patients may not, by itself, be sufficient to automatically enhance clinical understanding. Instead, clinical understanding appears to require distinct, targeted cognitive or educational mechanisms beyond general supportive communication.

The variance explained (R²) for the primary endogenous outcomes was relatively low, with the model accounting for 2.4% of the variance in patient understanding and 5.2% of the variance in treatment adherence. These low values are reported transparently to acknowledge that the current framework explains only a small proportion of variance in these clinical behaviors, indicating that unmeasured external variables play a substantial role.

DISCUSSION

This study identified a sequential pattern of cross-sectional statistical associations among downstream variables: understanding, engagement, satisfaction, and adherence. Crucially, PCC was not significantly associated with patient understanding ($\beta = -0.155$, $p = 0.160$). Because this initial pathway lacks statistical significance, this study cannot conclude that PCC operates as a starting trigger that flows sequentially through understanding, engagement, and satisfaction to drive adherence. Instead, the empirical data supports a model where understanding, engagement, satisfaction, and adherence are sequentially associated with each other, whereas the initial role of PCC is not statistically supported within this current framework.

Communication and Understanding in the PCC Context

The non-significant association between PCC and patient understanding represents a critical finding. It indicates that communication, as perceived and reported by patients, is insufficient on its own to automatically translate into clinical comprehension.

Several factors may explain this disconnect. First, this outcome may stem from substantial variability in patients' health literacy; individuals with low health literacy often

struggle to process health information, even when delivered within a patient-centered framework (Berkman et al., 2011; McCormack et al., 2017). Second, the result may reflect insufficiently interactive educational practices during clinical encounters, where information is delivered passively rather than checked for comprehension. Third, the frequent use of complex medical terminology by healthcare providers can create a cognitive barrier, rendering communication ineffective despite patient-centered intentions. Finally, this may point to limitations in the communication instrument used, which may capture the perceived empathy or style of the clinician rather than the cognitive clarity of the information exchanged (McCormack et al., 2017).

The current finding aligns with established health literacy frameworks (Berkman et al., 2011) and underscores that information exposure alone is insufficient for comprehension. Furthermore, within the Health Belief Model (HBM), health education only impacts behavior if it successfully alters a patient's cognitive appraisal processes, including perceived susceptibility and severity (Jones et al., 2015). Exposure to communication alone does not guarantee this cognitive shift. Similarly, patient activation theory underscores that clinical understanding is a product of active cognitive involvement and personal agency rather than passive information receipt (Hibbard & Greene, 2013).

The Sequentially Ordered Associative Pathway

Because this study relies entirely on cross-sectional data, the term "behavioral change mechanism" cannot be applied to these findings, as it is impossible to establish temporal ordering or true behavioral change over time. Instead, the tested framework represents a theoretically ordered associative pathway. Within this pathway, statistically significant concurrent associations were observed among the downstream constructs. Understanding was positively associated with engagement, engagement with satisfaction, and satisfaction with adherence. While these variables are structurally interconnected when analyzed using structural equation modeling (SEM), they must be interpreted as concurrent, static relationships rather than a dynamic, multi-stage process of behavioral change over time.

Unexplained Variance and the Role of Satisfaction

A notable attribute of the structural model is the low R² values obtained for patient understanding (2.4%) and treatment adherence (5.2%). These low values are reported transparently and indicate that the vast majority of variance in these clinical outcomes remains unexplained by the current model, highlighting the preliminary and exploratory nature of this specific model framework. In accordance with health behavior literature, it is plausible that this variance is influenced by unmeasured external factors. In cardiovascular

populations, adherence and understanding can be deeply influenced by socioeconomic status, family support structures, disease severity, medication side effects, and structural access to healthcare services (Al-Riyami & Nadar, 2026).

This context also explains why satisfaction showed only a modest association with adherence. Positive psychological and evaluative states do not automatically yield behavioral compliance, a phenomenon conceptualized as the intention-behavior gap (Sheeran & Webb, 2016; Sniehotta et al., 2005). In chronic cardiovascular disease management, long-term treatment fatigue, financial constraints, and complex daily regimens frequently disrupt the link between a patient's satisfaction with their care and their actual execution of adherence behaviors (Riegel et al., 2017).

Theoretical Implications

These findings offer nuanced insights into traditional PCC models, which frequently assume a direct relationship between clinician communication and ultimate clinical outcomes. By positioning communication as an initial variable within a broader structural model, this study suggests the potential value of evaluating intermediate cognitive and evaluative variables rather than assuming linear efficacy (Street et al., 2009).

Furthermore, these results demonstrate the utility of building a unified structural framework that accounts for multi-faceted behavioral and cognitive dimensions. By framing our results through health literacy frameworks and the Health Belief Model, these concurrent theories provide a robust lens to interpret why clinical communication alone has systemic limits in driving patient comprehension.

Specifically, while downstream components exhibit clean, sequential associations, the initial link between communication and comprehension requires a much more nuanced, multi-variable approach (Street et al., 2009). Communication frameworks cannot be divorced from patient activation theory and the intention-behavior gap, which highlight the active personal agency and the real-world socioeconomic barriers that inherently disrupt the translation of care into actual understanding and execution (Hibbard & Greene, 2013; Sniehotta et al., 2005).

Practical Implications

Because the pathway between PCC and patient understanding was non-significant, it cannot be concluded that general PCC has been demonstrated to improve patient adherence. Therefore, healthcare providers should shift focus away from generalized information delivery and toward highly targeted, interactive patient education strategies. Clinical interventions should structurally incorporate validation techniques such as the teach-back method, motivational interviewing, and structured shared decision-making protocols to directly target and verify patient comprehension (Elwyn et al., 2012; Rubak et al., 2005; Schillinger et al., 2003).

In addition, because lifestyle-related indicators (diet and exercise) demonstrated lower factor loadings than procedural components (medication and rest), clinical protocols might benefit from incorporating greater structural weight toward lifestyle counseling. These patterns suggest that providers could explore designing interactive education platforms or digital health tools that specifically foster patient engagement, as engagement may serve as a vital associative pivot connecting patient understanding to care satisfaction.

Limitations and Future Research

This study has several limitations that bound the generalizability of its conclusions. First, the cross-sectional design prevents the establishment of temporal ordering or causality; the identified pathways must be treated purely as concurrent statistical associations. Second, the use of convenience sampling limits the generalizability of these findings beyond the specific regional setting of the study. Although an a-priori power analysis confirms that our active sample size ($N = 100$) exactly meets the mathematically recommended minimum threshold required to support the model's structural complexity, this modest cohort size inevitably constrains wider extrapolation. Third, the reliance on self-reported measures introduces the potential for social desirability and response biases, particularly regarding adherence behaviors. Lastly, this study was conducted without a formal project-specific Institutional Review Board (IRB) exemption tracking number, relying instead on high-level administrative clearances. Although absolute anonymity and active informed consent were maintained to protect participants, the lack of centralized independent ethical review remains a limitation.

Future research should utilize longitudinal designs or randomized controlled trials to evaluate the actual temporal effects of communication interventions over time. Additionally, future models should explicitly incorporate unmeasured variables—such as objective health literacy scores, socioeconomic metrics, and treatment complexity—to capture the large proportion of unexplained variance highlighted by the low R^2 values in this study.

CONCLUSIONS AND RECOMMENDATION

This study highlights that while downstream variables—specifically patient understanding, engagement, satisfaction, and adherence—exhibit positive, sequential cross-sectional associations, the primary pathway from PCC to patient understanding is not statistically significant. Consequently, the assumption that general PCC automatically translates into clinical comprehension is not supported within this tested framework. Due to the cross-sectional nature of the data, these relationships must be interpreted strictly as static concurrent associations rather than causal effects. Future research should employ longitudinal, multicenter, and interventional designs to establish true temporal ordering and verify whether targeted communication strategies can actively enhance patient comprehension and adherence.

DECLARATION

Ethical Considerations

Formal prospective Institutional Review Board (IRB) review was not sought for this study due to localized institutional research regarding non-interventional, minimal-risk surveys at the time of data collection. Administrative and institutional permissions were formally obtained from Universitas Sangga Buana and Pakuhaji Hospital to authorize institutional site access, logistical deployment, and data collection.

Consent for publication

Not applicable. This manuscript does not contain any individual person's identifiable data, images, or personal information requiring consent for publication.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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During the preparation and revision of this work, the authors used Grammarly for spelling and grammar verification, and Google's Gemini to assist in structuring responses, refining paragraph transitions, and improving the phrasing of academic arguments. No generative artificial intelligence was used to create, analyze, or interpret the core empirical data or scientific conclusions of the manuscript. The authors closely reviewed and edited the final output and take full responsibility for the content and integrity of the published work.

Authors' contributions

Novita Liman: Conceptualized and designed the study, drafted the original manuscript, and supervised the overall research process. Abdul Gani Sidqi: Developed the methodology and performed the formal statistical data analysis. Taufan Nugroho: Coordinated the administrative permissions and contributed to data curation. Ayu Laili Rahmiyati: Assisted in methodology and prepared the initial draft of the discussion section. Haddan Dongoran: Critically reviewed the manuscript, provided resources, and gave final approval for the version to be published. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

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ADDITIONAL INFORMATION

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Supplementary 1. Investigator-Developed 20-Item Questionnaire Used in the Study

Response format for all items / Format pilihan jawaban untuk semua pernyataan:

- 1 = Strongly Disagree / Sangat Tidak Setuju
- 2 = Disagree / Tidak Setuju
- 3 = Neither Agree nor Disagree / Ragu-ragu (Netral)
- 4 = Agree / Setuju
- 5 = Strongly Agree / Sangat Setuju

A. Patient-Centered Communication

PCC1 – Verbal Communication (VCOM)

Tenaga kesehatan menggunakan bahasa yang sederhana dan jelas ketika menjelaskan kondisi penyakit jantung dan perawatan saya.

PCC2 – Non-verbal Communication (NVCOM)

Tenaga kesehatan menunjukkan sikap ramah, sopan, dan penuh perhatian ketika berkomunikasi dengan saya.

PCC3 – Interactive Education (INTEDU)

Tenaga kesehatan memberikan kesempatan kepada saya untuk bertanya dan memastikan bahwa saya memahami informasi yang diberikan.

PCC4 – Shared Decision-Making (SDM)

Tenaga kesehatan melibatkan saya dalam membahas pilihan dan menentukan rencana perawatan yang sesuai dengan kondisi saya.

B. Patient Understanding

U1 – Lifestyle Understanding (LIFE)

Saya memahami alasan di balik perubahan pola hidup yang dianjurkan untuk menjaga kesehatan jantung saya.

U2 – Risk Understanding (RISK)

Saya memahami tanda dan gejala yang perlu saya waspadai karena dapat menunjukkan memburuknya kondisi jantung saya.

U3 – Treatment Understanding (THER)

Saya memahami tujuan, dosis, jadwal, dan cara penggunaan obat yang diberikan untuk penyakit jantung saya.

U4 – Diagnosis Understanding (DIAG)

Saya memahami penjelasan mengenai jenis dan kondisi penyakit jantung yang saya alami.

C. Patient Engagement

E1 – Patient Preference (PREF)

Saya dapat menyampaikan kebutuhan, pilihan, dan kekhawatiran saya kepada tenaga kesehatan selama proses perawatan.

E2 – Question Asking (ASK)

Saya merasa nyaman mengajukan pertanyaan kepada tenaga kesehatan ketika ada informasi tentang penyakit atau perawatan yang belum saya pahami.

E3 – Independent Health Management (INDEP)

Saya mampu mengelola kondisi kesehatan saya di rumah hanya berdasarkan batas-batas yang diizinkan oleh tenaga kesehatan.

E4 – Daily-Life Integration (DAILY)

Saya mampu menerapkan anjuran perawatan penyakit jantung dalam kegiatan sehari-hari.

D. Patient Satisfaction

S1 – Emotional Reassurance (EMO)

Komunikasi dengan tenaga kesehatan membuat saya merasa lebih tenang dan mendapatkan dukungan ketika saya merasa khawatir terhadap penyakit jantung saya.

S2 – General Communication/Care Experience (GEN_COM)

Saya puas dengan cara tenaga kesehatan berkomunikasi dan memberikan informasi selama proses pelayanan.

S3 – Perceived Quality of Care (CARE)

Saya merasa bahwa pelayanan yang diberikan tenaga kesehatan memperhatikan kebutuhan dan kondisi saya.

S4 – Overall Care Experience (EXP)

Secara keseluruhan, saya puas dengan pengalaman pelayanan dan perawatan yang saya terima.

E. Treatment Adherence

A1 – Rest (REST)

Saya mengikuti anjuran tenaga kesehatan mengenai kebutuhan dan waktu istirahat saya.

A2 – Exercise (EXER)

Saya melakukan aktivitas fisik atau olahraga sesuai dengan anjuran tenaga kesehatan dan kondisi kesehatan saya.

A3 – Diet (DIET)

Saya mengikuti anjuran pola makan yang diberikan oleh tenaga kesehatan untuk menjaga kesehatan jantung saya.

A4 – Medication (MED)

Saya mengonsumsi obat sesuai dengan dosis dan jadwal yang dianjurkan oleh tenaga kesehatan.

Instrument Development Note

All 20 items were investigator-developed for this study to fit the Indonesian cardiovascular-care context. The item domains were structurally informed by established theoretical frameworks in health communication, functional health literacy, patient activation, and chronic disease self-care compliance. While classic literature and domain definitions (such as those underlying PaCT, S-TOFHLA, PAM-13, PSQ-18, and MMAS-8) were consulted during the conceptualization phase to ensure comprehensive construct coverage, the final questionnaire items were independently formulated by the investigators. No proprietary item wording or commercial scoring algorithms were reproduced or utilized in this instrument.

Supplementary 2

Table S1. Conceptual Mapping of the 20-Item Investigator-Developed Questionnaire

Construct	Domain/ Indicator		
PCC	VCOM	Patient-centered communication literature and clinical interaction frameworks	Investigator-developed
	NVCOM		
	INTEDU		
	SDM		
Understanding	LIFE	Functional health literacy and cognitive comprehension literature and frameworks	Investigator-developed
	RISK		
	THER		
	DIAG		
Engagement	PREF	Patient activation and chronic illness self-management literature and frameworks	Investigator-developed
	ASK		
	INDEP		
	DAILY		
Satisfaction	EMO	Multidimensional patient satisfaction and clinical care experience literature and frameworks	Investigator-developed
	GEN_COM		
	CARE		
	EXP		
Adherence	REST	Cardiovascular self-care and therapeutic regimen adherence literature and frameworks	Investigator-developed
	EXERCISE		
	DIET		
	MED		

Note: The conceptual sources listed above informed construct definition and domain selection. The final questionnaire items were independently formulated by the investigators for the Indonesian cardiovascular-care context. The questionnaire was not presented as a shortened or equivalent version of PaCT/PaCCT, S-TOFHLA, PAM-13, PSQ-18, or MMAS-8. No original proprietary item wording or scoring algorithm was reproduced in the investigator-developed questionnaire.