Original Article

Coronary Artery Disease Preventive Behaviors among Thai Community-Dwelling Older Adults with Chronic Illnesses and Associated Factors: A Cross-Sectional Study

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Abstract

Background: Coronary artery disease (CAD) is a major health burden among community-dwelling older adults with chronic illnesses. Preventive behaviors, such as healthy diet, physical activity, smoking avoidance, and medication adherence, are important for reducing CAD risk. However, limited health literacy and health information access may affect engagement in preventive behaviors. This study aimed to investigate the factors associated with CAD preventive behaviors among Thai community-dwelling older adults with chronic illnesses.

Methods: This cross-sectional study was conducted from August to October 2025 among 130 community-dwelling older adults with chronic illnesses in Selaphum District, Roi Et Province, Thailand. Participants were selected using multi-stage sampling. Data were collected using questionnaires on demographic characteristics, CAD knowledge, perceptions of CAD prevention, health literacy, and CAD preventive behaviors. Data were analyzed using multiple linear regression with SPSS 26 software. Statistical significance was set at $P<0.05$.

Results: The mean overall score of CAD preventive behaviors was 2.89±0.49. Multiple linear regression analysis showed that health literacy (B=0.44, 95% CI [0.33,0.56], $P<0.001$), perceived benefits (B=0.30, 95% CI [0.05,0.56], P=0.020), family history of non-communicable diseases (B=2.23, 95% CI [0.39,4.08], P=0.018), and female (B=−2.67, 95% CI [−5.09,−0.25], P=0.031) were significantly associated with CAD preventive behaviors.

Conclusion: Older adults with chronic illnesses demonstrated high levels of CAD preventive behaviors. Health literacy, perceived benefits, family history of non-communicable diseases, and female sex were significantly associated with CAD preventive behaviors. Interventions should prioritize improving health literacy and tailoring strategies to the needs of older women.

Keywords: Chronic illnesses; coronary artery disease; Health literacy; Older adults

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Introduction

Coronary artery disease (CAD) is caused by narrowing or blockage of the coronary arteries due to atherosclerotic plaque formation, which reduces blood flow to the myocardium and may result in angina, myocardial infarction, or sudden cardiac death.[1] Cardiovascular diseases remain the leading global cause of death, accounting for approximately 19.8 million deaths in 2022, representing 32% of all deaths worldwide.[2] More than three-quarters of these deaths occur in low- and middle-income countries.[2] CAD accounts for a substantial proportion of premature deaths related to noncommunicable diseases worldwide.[2] In Thailand, ischemic heart disease remains a major cause of mortality, with the age-standardized mortality rate reaching 26.9 per 100,000 population in 2021.[3] Cardiovascular diseases continue to impose a substantial public health burden, particularly among older adults and individuals with chronic illnesses.[3]

Thailand's transition into a complete-aged society has led to a rapid increase in the older population. Age-related cardiovascular changes, particularly arterial stiffness and vascular aging, substantially increase the risk of CAD among older adults.[4] Many older adults also live with chronic conditions such as diabetes mellitus, hypertension, and hyperlipidemia, which are major risk factors for CAD.[4, 5] Multimorbidity further complicates health status and increases the need for continuous self-care among older adults with cardiovascular conditions.[5] Moreover, many community-dwelling older adults experience limitations in health literacy, access to health information, preventive resources, and healthcare services, which may hinder their ability to recognize health risks and engage in disease prevention.[6] These challenges highlight community-dwelling older adults with chronic illnesses as a priority population for CAD prevention and emphasize the need for targeted research and tailored health-promotion interventions.

Preventive behaviors for CAD refer to actions aimed at reducing the risk of developing the disease.[2] These behaviors include maintaining a healthy diet, engaging in regular physical activity, managing stress, avoiding smoking and secondhand smoke, limiting alcohol consumption, adhering to medications, and attending regular health screenings.[2, 7] Such lifestyle behaviors are effective in reducing cardiovascular risk and improving cardiovascular outcomes among individuals with chronic conditions.[7] Adherence to these preventive behaviors has also been associated with reduced cardiovascular morbidity and mortality.[7] Previous studies conducted in Thailand have demonstrated that higher health literacy is associated with better self-care and health-related behaviors among older adults, including those with chronic illnesses.[8-10] Recent studies based on the Health Belief Model (HBM)[11] have shown that health beliefs, including perceived susceptibility, perceived severity, perceived benefits, and perceived barriers, are associated with preventive health behaviors related to cardiovascular disease and other noncommunicable diseases.[12-14] Inadequate health beliefs may reduce older adults' ability to recognize health risks and engage in preventive behaviors.[12, 13] However, evidence specifically focusing on CAD preventive behaviors among Thai community-dwelling older adults with chronic illnesses remains limited. Furthermore, health literacy and health beliefs may be associated with engagement in health-related behaviors among Thai older adults with chronic illnesses.[8-10, 13]

Therefore, understanding these factors is essential for developing effective and sustainable interventions to promote CAD preventive behaviors among older adults.

Despite the growing burden of CAD among older adults, evidence regarding preventive behaviors among community-dwelling older adults with chronic illnesses, particularly in rural settings, remains limited. To the best of our knowledge, there is no study that has simultaneously examined health literacy, health beliefs, and sociodemographic factors associated with CAD preventive behaviors

among Thai community-dwelling older adults with chronic illnesses. Previous studies have generally examined these factors separately.[8-10, 13] Therefore, this study aimed to identify factors associated with CAD preventive behaviors among community-dwelling older adults with chronic illnesses.

Materials and Methods

This cross-sectional study was conducted from August to October 2025. The study sample consisted of 130 community-dwelling older adults with chronic illnesses residing in Selaphum District, Roi Et Province, northeastern Thailand. The area is predominantly rural, and hypertension and diabetes are common among older adults receiving care through subdistrict health-promoting hospitals.

The inclusion criteria were as follows: being aged 60 years or older, of either sex; being cognitively intact and able to communicate, indicated by a Six-Item Cognitive Impairment Test (6 CIT) score of 0–7, which reflects no cognitive impairment;[15] having been diagnosed by a physician with diabetes mellitus, hypertension, CAD, or cerebrovascular disease according to ICD-10 codes; and not being homebound or bedridden. The exclusion criterion was inability to complete the questionnaire.

The sample size was determined using G*Power based on a linear multiple regression analysis. The effect size was informed by previous research,[12] which reported an R^2 of 0.12 (corresponding to $f^2=0.136$), indicating a medium effect. Accordingly, an effect size of $f^2=0.15$ was adopted in line with established criteria.[16] With 10 independent variables, a significance level of $\alpha=0.05$, and a power of 0.80, the required sample size was calculated to be 112 participants. To further enhance the stability of the multiple regression model, we applied an additional criterion,[17] whereby the minimum required sample size was calculated using the formula $N \geq 50+8k$, where k represents the number of independent variables. With 10 independent variables, the minimum required sample size was 130 participants. Multi-stage sampling was employed, including cluster random sampling to select subdistricts and villages, followed by simple random sampling from the registry of older adults with chronic illnesses, with proportional allocation based on village population. Eligible participants were identified from the registry of older adults with chronic illnesses maintained by subdistrict health-promoting hospitals. The research team contacted eligible participants and invited them to attend the subdistrict health-promoting hospitals, where information about the study was provided and voluntary participation was requested. All eligible participants who were invited agreed to participate in the study, resulting in a response rate of 100%. Data were collected face-to-face using structured questionnaires at subdistrict health-promoting hospitals. After obtaining written informed consent, we assessed the participants for eligibility using the 6 CIT. Eligible participants then completed the questionnaires independently, with assistance from the research team provided when needed.

The 6 CIT, Thai version, translated and psychometrically tested by Areeue and Youngcharoen was used to determine the participants' eligibility.[15] The instrument comprises six items across three cognitive domains: orientation (three items assessing time, month, and year), attention (two items requiring backward counting from 20 to 0 and reciting the months in reverse order from December to January), and memory (one item assessing the recall of five pieces of information: first name, surname, house number, street, and province). The 6 CIT is not a Likert-type scale; items are scored according to response accuracy and the number of errors. For the orientation items, correct responses are scored 0, whereas incorrect responses are scored 3 points for time and month and 4 points for year. For each attention item, a correct response is scored 0, one error 2 points, and more than one error 4 points. For the memory item, scores of 0, 2, 4, 6, 8, and 10 correspond to zero, one, two, three, four, and five errors, respectively. The total score ranges from 0 to 28, with higher scores indicating greater cognitive impairment. Scores of 0–7 indicate no cognitive impairment, whereas scores of 8 or

higher indicate possible cognitive impairment. The Thai version of the 6 CIT demonstrated acceptable psychometric properties, with criterion validity supported by a significant negative correlation with the Thai version of the Mini-Cog.[18] Test–retest reliability showed good stability over time, as reported previously.[15] Demographic characteristics were collected using a questionnaire including age, sex, marital status, educational level, diagnosed comorbidities, and family history of non-communicable diseases.

The CAD Knowledge Questionnaire was developed by researchers based on previous studies and World Health Organization (WHO) guidelines.[2, 7] The questionnaire consists of 15 items covering causes and risk factors, signs and symptoms, and preventive practices related to CAD. Items were scored as 1 (correct) or 0 (incorrect), with total scores ranging from 0–15. The total scores were interpreted using cut-off criteria reported in a previous study[19] and classified as high (80–100%; 12–15), moderate (60–79%; 9–11), and low (<60%; 0–8). Face validity was assessed for clarity and relevance of the items. Content validity was evaluated by a panel of three experts in geriatric and community health nursing using the Item Content Validity Index (I-CVI) and Scale Content Validity Index (S-CVI/Ave). After revision based on expert recommendations, all items achieved an I-CVI of 1.00, with an overall S-CVI/Ave of 1.00.

The questionnaire items were developed and conceptually mapped according to WHO guidelines and the conceptual framework for CAD prevention.[2] Internal consistency reliability assessed using KR-20 was 0.78.

The Perceptions of CAD Prevention Questionnaire was developed by reviewing previous studies on this topic and based on the HBM.[11, 13] The questionnaire consists of 22 items across five dimensions: perceived susceptibility (5 items), perceived severity (2 items), perceived benefits (6 items), perceived barriers (3 items), and self-efficacy (6 items). Items are rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Mean scores for each domain were calculated by averaging the corresponding item scores, yielding possible mean scores ranging from 1 to 5. These mean scores were interpreted using interval criteria reported in a previous study and classified as low (1.00–2.33), moderate (2.34–3.66), and high (3.67–5.00).[13] Face validity was assessed to ensure clarity and relevance of the items, and content validity was evaluated by a panel of three experts in geriatric and community health nursing using the I-CVI and the S-CVI/Ave. After revision based on expert recommendations, all items achieved an I-CVI of 1.00, with an overall S-CVI/Ave of 1.00. Construct validity was assessed using exploratory factor analysis (EFA). The five-factor solution explained 70.51% of the total variance. The Kaiser–Meyer–Olkin (KMO) measure was 0.895, and Bartlett's test of sphericity was significant ($P<0.001$). Internal consistency reliability assessed using Cronbach's alpha was 0.82.

The Health Literacy Questionnaire was developed by reviewing previous studies on this topic and based on the conceptual framework proposed by Sorensen et al.[8, 20] The questionnaire consists of 15 items covering four skills: access, understanding, appraisal, and application. Items are rated on a 5-point Likert scale ranging from 1 (unable to perform) to 5 (very easy to perform). Total scores range from 15 to 75 and were converted to percentages and classified as high (>80%; 60–75 points), moderate (60–79%; 45–59 points), and low (<60%; 15–44 points) according to criteria reported in previous research.[21] Health literacy was analyzed as an overall construct using the total score rather than domain-specific scores. Face validity was assessed to ensure clarity and relevance of the items, and content validity was evaluated by a panel of three experts in geriatric and community health nursing using the I-CVI and the S-CVI/Ave. After revision based on expert recommendations, all items achieved an I-CVI of 1.00, with an overall S-CVI/Ave of 1.00. Construct validity was assessed using EFA. The four-factor solution explained 75.73% of the total variance. The KMO measure was 0.885, and Bartlett's test of sphericity was significant

(P<0.001). Internal consistency reliability assessed using Cronbach's alpha was 0.94.

The CAD Preventive Behavior Questionnaire was developed by reviewing previous studies on this topic and the WHO guidelines.[2, 7] The questionnaire consists of 14 items across six domains: dietary behaviors, physical activity, stress management, smoking avoidance, alcohol avoidance, and medication adherence with regular health check-ups. Items are scored on a 5-point Likert scale ranging from 0 (never practiced) to 4 (regularly practiced), yielding a possible total score ranging from 0 to 56. Mean scores for the overall preventive behaviors and each domain were calculated by averaging item scores, yielding possible mean scores ranging from 0 to 4. These mean scores were interpreted using interval criteria reported in a previous study and classified as low (0.00–1.33), moderate (1.34–2.67), and high (2.68–4.00).[13] Face validity was assessed to ensure clarity and relevance of the items, and content validity was evaluated by a panel of three experts in geriatric and community health nursing using the I-CVI and the S-CVI/Ave. After revision based on expert recommendations, all items achieved an I-CVI of 1.00, with an overall S-CVI/Ave of 1.00. Construct validity was assessed using EFA. The Six-factor solution explained 58.93% of the total variance. The KMO measure was 0.683, and Bartlett's test of sphericity was significant (P<0.001). Internal consistency reliability assessed using Cronbach's alpha was 0.75.

Data were analyzed using IBM SPSS Statistics version 26. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were used to summarize the data. Independent t-tests were used to compare the mean scores between the two groups, whereas one-way analysis of variance (ANOVA) was used for comparisons among three or more groups. Multiple linear regression analysis was performed to identify the factors associated with CAD preventive behaviors. The statistical significance was set at P<0.05.

This study received ethical approval from the Research Ethics Committee of Roi Et Rajabhat University, Thailand (Approval No. 104/2568, July 29, 2025). Participants' rights and welfare were protected, written informed consent was obtained prior to participation, and all data were kept confidential and used solely for research purposes. Participation was voluntary and posed no risk or harm to the participants.

Results

Socio-demographic characteristics showed that most participants were female 107(82.30%), aged 70–79 years 57(43.80%), married 60(46.20%), and had completed primary education 123(94.60%). Participants with one comorbidity accounted for 55(42.30%), while 57(43.80%) had a family history of non-communicable diseases. CAD preventive behaviors did not differ significantly across demographic characteristics (P>0.05) although participants with a family history of non-communicable diseases showed slightly higher scores (Table 1).

Overall, CAD preventive behavior mean score was 2.89±0.49 and in high level. By domain, dietary behaviors, physical activity, and smoking avoidance or avoidance of secondhand smoke were at moderate levels, whereas stress management and sleep behaviors, alcohol avoidance, and medication adherence and regular follow-up appointments were at high levels. CAD knowledge mean score was 13.12±2.56 and at a high level. Perceptions related to CAD prevention were at high levels across all five dimensions, including perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and self-efficacy for CAD prevention. Health literacy mean score was 60.29±8.68 and at a high level (Table 2).

Multiple linear regression analysis was used; it was found that health literacy, perceived benefits, family history of non-communicable diseases, and female sex were significant factors associated with CAD preventive behaviors (P<0.05). Health literacy showed the strongest association. The regression model explained 44.0% of the variance in CAD preventive behaviors (Table 3).

Table 1: Socio-demographic characteristics and their association with the coronary artery disease prevention behaviors (N=130)

Characteristics	N (%)	Coronary artery disease prevention behaviors total score Mean±SD	P-value
Age (years)			
60-69 years	31 (23.80)	40.90±6.97	0.91*
70-79 years	57 (43.80)	40.46±6.52	
≥80 years	42 (32.40)	40.24±7.13	
Sex			
Male	23 (17.70)	41.00±5.90	0.69**
Female	107 (82.30)	40.38±7.02	
Marital status			
Single	7 (5.40)	36.57±5.19	0.10*
Married	60 (46.20)	39.35±7.05	
Widowed	54 (41.40)	41.76±6.16	
Divorced	8 (6.20)	43.50±8.79	
Separated	1 (0.80)	44.00±NA[a]	
Educational level			
Primary education	123(94.60)	40.54±6.87	0.86*
Lower secondary education	2 (1.50)	42.00±11.31	
Upper secondary education	3 (2.40)	37.33±5.50	
Bachelor's degree	2 (1.50)	40.50±4.95	
Number of comorbidities			
1	55 (42.30)	40.35±7.47	0.93*
2	49 (37.70)	40.78±6.43	
≥3	26 (20.00)	40.27±6.32	
Family history of non-communicable diseases			
Yes	57 (43.80)	41.54±7.47	0.12**
No	73 (56.20)	39.67±6.20	

*One-way ANOVA;**Independent t-test; [a]NA: Not applicable

Table 2: Means and standard deviations of coronary artery disease (CAD) prevention behaviors, CAD knowledge, perceptions of CAD prevention and health literacy (N=130)

Variables	Mean±SD	Level
CAD[a] Preventive behavior domain		
Dietary behaviors	2.59±0.64	Moderate
Physical activity	2.42±1.33	Moderate
Stress management and sleep behaviors	3.09±0.77	High
Smoking avoidance or avoidance of secondhand smoke	2.58±1.26	Moderate
Alcohol avoidance	3.24±1.26	High
Medication adherence and regular follow-up appointments	3.54±0.79	High
Overall score	2.89±0.49	High
CAD knowledge	13.12±2.56	High
Perceptions of CAD Prevention		
Perceived susceptibility to CAD	4.27±0.67	High
Perceived severity of CAD	4.49±0.68	High
Perceived benefits of CAD prevention	4.44±0.65	High
Perceived barriers to CAD prevention	3.84±1.24	High
Self-efficacy for CAD prevention	4.30±0.69	High
Health literacy	60.29±8.68	High

[a]CAD: Coronary artery disease

Table 3: Factors associated with coronary artery disease preventive behaviors using multiple linear regression analysis

Variables	B[a]	S.E.[b]	Beta[C]	t	95% CI		P value
					Lower	Upper	
Constant	6.87	3.84		1.79	−0.74	14.48	0.076
Health literacy	0.44	0.06	0.56	7.68	0.33	0.56	<0.001
Perceived benefits	0.30	0.13	0.17	2.36	0.05	0.56	0.020
Family history of non-communicable diseases	2.23	0.93	0.16	2.40	0.39	4.08	0.018
Not family history	Ref.						
Female	-2.67	1.22	-0.150	-2.19	-5.09	-0.25	0.031
Male	Ref.						
R^2=0.440, R^2_{adj}=0.422, F=24.56, P<0.001							

[a]B: unstandardized regression coefficient; [b] SE: standard error; [c] Beta: standardized regression coefficient

Discussion

The findings indicated that community-dwelling older adults with chronic illnesses demonstrated a high overall level of CAD preventive behaviors. This suggests that most older adults were aware of the importance of maintaining their health and engaged in appropriate practices to prevent CAD. When examining specific behavioral domains, the highest scores were observed in medication adherence with regular follow-up, alcohol avoidance, stress management, and adequate sleep. These behaviors are generally easier to maintain and require less physical effort, making them more feasible for older adults. In contrast, physical activity was at a moderate level and lower than other domains. This is consistent with previous evidence showing that physical limitations, fear of falling or injury, and chronic conditions significantly hinder adequate physical activity among older adults.[22–24]

Health literacy was most strongly associated with CAD preventive behaviors in the present study. This finding suggests that older adults who can effectively access, understand, appraise, and apply health information are more likely to engage in appropriate cardiovascular disease preventive behaviors. Health literacy may help older adults better understand health information, navigate healthcare services, and make informed health decisions in daily life, particularly among those managing chronic illnesses.[25] The present findings are consistent with previous studies reporting that higher levels of health literacy are associated with healthier behaviors, greater use of preventive services, medication adherence, and better overall health outcomes among older adults.[8, 10, 26]

Perceived benefits, one of the dimensions of the Perceptions of CAD Prevention based on HBM, was the second strongest factor associated with CAD preventive behaviors. As described in HBM, perceived benefits reflect the belief that engaging in specific health behaviors will produce positive outcomes.[27] When older adults recognize the clear advantages of behaviors such as physical activity, dietary control, regular check-ups, and medication adherence, they are more likely to engage in these practices consistently.

Previous studies have similarly reported associations between perceived benefits and physical activity, as well as between perceived benefits and preventive behaviors.[14, 28, 29] In Thailand, many older adults face limitations related to income, access to services, and family support, which may reduce the perceived importance of health benefits and weaken their influence on behavior. These findings highlight the need to strengthen health education and communication strategies to enhance awareness of the benefits of self-care among older adults living in the community.

A family history of non-communicable diseases was significantly associated with CAD preventive behaviors in the present study. Older adults with a family history of

non-communicable diseases were more likely to engage in CAD preventive behaviors. This may be because exposure to illness within the family increases awareness of disease severity and susceptibility, thereby motivating individuals to adopt healthier behaviors. These findings are consistent with HBM, in which cues to action can enhance perceived risk and motivate behavior change.[27] Family illness may serve as such a cue to action by increasing awareness of health risks. The present finding is also consistent with previous research reporting an association between family history and preventive health behaviors.[30] Nevertheless, family history may still serve as an important trigger for preventive action among older adults. These findings highlight the value of incorporating family health history into counseling and health education to strengthen risk perception and promote sustained engagement in preventive practices among older adults.

Female sex was negatively associated with CAD preventive behaviors, indicating that older women were less likely than men to engage in preventive practices. This finding is consistent with previous evidence, which reported that women often face barriers to healthcare access and tend to underestimate their cardiovascular risk.[31] Supporting this, additional research has suggested that family responsibilities and domestic workload may limit women's time and resources for engaging in health-related activities.[32] However, this result contrasts with findings from another study, which reported higher levels of preventive behaviors among adult women in a different cultural context, partly attributed to lower smoking rates and their central role in family health care.[14] The discrepancy may reflect differences in age and cultural context, as middle-aged women generally have greater functional capacity and health-related roles than older adults with chronic conditions. Overall, the association between female sex and CAD preventive behaviors may vary across populations and sociocultural contexts. These findings highlight the importance of developing tailored health-promotion strategies for older women that consider social roles, caregiving demands, and time constraints.

The findings suggested that personal characteristics, such as age and CAD knowledge, along with several HBM components, showed no significant association with CAD preventive behaviors among older adults. This suggests that health beliefs alone may be insufficient to drive preventive behaviors in this population. Age was not significantly associated with preventive behaviors because all participants were older adults with similar health risks and functional limitations, resulting in minimal variability across age groups. This is consistent with a previous study.[33] Although CAD knowledge was generally high, it was not significantly associated with preventive behaviors, likely due to the narrow range and low variability of knowledge scores. This finding is consistent with previous evidence, which noted that although older adults may possess adequate knowledge, they often struggle to translate it into practice due to physical limitations, difficulties in interpreting health information, and environmental constraints.[34, 35] Similarly, several dimensions of the perceptions of CAD Prevention based on the HBM were not significantly associated with preventive behaviors in the present study. Previous research has suggested that health beliefs may play varying roles in preventive behaviors among middle-aged and older adults with noncommunicable diseases.[36] These results highlight that, although the HBM is a widely used theoretical framework, "perceptions alone" may be insufficient to explain preventive behaviors among older adults with chronic illnesses. In the Thai context, physical limitations, financial constraints, limited access to healthcare services, and family responsibilities may play a more dominant role in shaping health behaviors than cognitive perceptions alone.

The findings of this study have important implications for community health practice.

Community-based interventions focusing on health literacy and perceived benefits of CAD prevention may help promote preventive behaviors among older adults with chronic illnesses, particularly women in rural communities. However, the geographically limited sample and cross-sectional design may limit generalizability and causal inference. In addition, some older adults required assistance during questionnaire completion, and the lengthy data collection process may have affected response accuracy.

Conclusion

Health literacy, perceived benefits, family history of non-communicable diseases, and female sex were associated with CAD preventive behaviors among older adults with chronic illnesses. These findings highlight the importance of strengthening health literacy and promoting positive perceptions toward CAD prevention in community settings. Tailored interventions addressing family health history and gender-specific needs may improve preventive behaviors among older adults. Future studies should use longitudinal and qualitative approaches in more diverse populations to better understand factors influencing preventive behaviors over time.

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Authors' Contribution

US and SP were responsible for the conceptualization and design of this study. The data collection was conducted by US, SP and TK. The data analysis and interpretation were carried out by US, SP and TK. US drafted the initial manuscript. All authors critically reviewed, revised the manuscript, and approved the final version for publication. All authors take responsibility for the integrity of the data and the accuracy of the data analysis. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Conflict of Interest

None declared

Declaration on the use of AI

AI tools were used only for language editing. All scientific content, analysis, and interpretations were generated and verified by the authors.

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