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ORIGINAL RESEARCH

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The 10-year cardiovascular risk of physicians estimated by the Thai CV risk score and its association with current coronary artery disease: A retrospective study

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Abstract

Background and Aims: To assess the 10-year cardiovascular disease (CVD) risk among Thai physicians. The risk compared to the general population and their relationship with the current coronary artery disease (CAD) were also examined.

Methods: This retrospective study collected data of Thai physicians who underwent cardiovascular assessments between February 14, 2022, and October 31, 2022. The CVD risk was calculated using the Thai CVD risk (TCVR) score, which incorporated variables of age, gender, smoking, diabetes mellitus, blood pressure, and total cholesterol. Additional collected data included family history of CAD, weekly work hours, fiber diet, exercise, body mass index, coronary artery calcium (CAC) score, and presence of CAD. The association between the risk levels with presence of CAD and clinical features including CAC score were analyzed.

Results: Of 1225 physicians, the risk for CVD development was categorized as low in 80.0%, moderate in 11.2%, high in 4.9%, and very high in 3.9%. Among these, 33.6% were found to have higher relative risk compared to the general population of the same age and gender. The overall prevalence of CAD was 11.2%. This prevalence was escalated by risk or relative risk groups: 4.9% in low-, 33.8% in moderate-, 35.1% in high-, and 46.8% in very high-risk groups or 7.2% in lower risk, 8.0% the same risk, and 18.4% higher relative risk groups.

Conclusions: Approximately, 20% of Thai physicians in the study exhibited a moderate to very high 10-year risk of CVD. Furthermore, 33.6% of the physicians had higher risk than individuals of the same age and gender in the general population. The prevalence of CAD increased with higher CVD risk and higher relative risk.

KEYWORDS

cardiovascular diseases, coronary artery disease, physicians, risk assessment, risk factors

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1 | INTRODUCTION

Cardiovascular disease (CVD) is one of the non-communicable diseases (NCDs), which has major health impact for being the cause of all global deaths in 32% in 2019.[1] In Thailand where NCDs were reported to be the causes of mortality in up to 74% of all deaths, it was from CVDs in 23%.[2]

Several risk factors of CVDs e.g., old age, high blood pressure, high cholesterol, smoking, physical inactivity, unhealthy diet, obesity, diabetes mellitus (DM), etc. are well recognized.[1] Awareness and identification of these unfavorable features and their level of risk are important, so that the affected individuals and/or their caregivers can effectively pursue their medical consultation and intervention. The problem is that these risk factors frequently occur in common, so a method to assess these risks altogether will certainly help ones have information of the overall risk.

Several CVD risk estimation tools were developed among various populations.[3–8] The first coronary heart disease risk equation was developed in the Framingham Heart Study from the United States in 1976.[3] Many subsequent evaluating tools modified the Framingham scoring system and tested them in other populations.[4–8] These were, for examples, the Systematic Coronary Risk Evaluation model in Europe,[4] the QRISK in the United Kingdom,[5] the atherosclerotic cardiovascular disease (ASCVD) reported by and used in the American College of Cardiology/American Heart Association guideline,[7,8] and the Multi-Ethnic Study of Atherosclerosis model which incorporated the coronary artery calcium (CAC) score to the traditional risk factors.[9]

Nevertheless, these tools primarily target the Western population and may not be suitable for Asian populations who had different ethnic backgrounds, risk factor profiles, and CVD patterns. Some studies from Asia found that the Western CVD risk assessment tools would either over- or under-estimate the CVD risk of Asian populations.[10–12] Hence, a few risk scoring systems for the Asian population of each country were developed i.e., the China-PAR (Prediction for ASCVD Risk in China)[13] and the China-PAR (Prediction for ASCVD Risk in China) score.[14] These tools have been well-validated within their respective populations.[11]

In Thailand, the national authorities in collaboration with many societies also developed the Thai Cardiovascular Risk (TCVR) Score to estimate the CVD risk among the Thai population.[15] The model was first developed in 1985 using data from 3499 employees aged 35–70 years working in the Electricity Generating Authority of Thailand (EGAT) in Bangkok.[16] The model was later adjusted and validated using 2nd and 3rd EGAT cohorts comprising 2999 samples from northwestern and 2584 samples from central regions of Thailand.[16] After the validity and reliability of the TCVR score had been confirmed in many subsequent studies among the Thai population in different regions of the country,[12,17–20] the TCVR score is widely used in Thailand and is incorporated into Thai national hypertensive treatment guidelines.[21]

Doctors generally have a specific responsibility compared to other health personnel. A high responsibility added to a limited number of doctors compared to the population under their service certainly puts them at risk for illnesses or unhealthy status.[22] Some authors who reported cardiac problems among hospital personnel[23,24] also demonstrated a higher risk of CVD among physicians compared to nurses or other hospital personnel or the general population.[25] However, no studies had ever focused on CVD risk estimation or detection specifically, among doctors in Thailand.

In our other works presented elsewhere, we described general and cardiovascular health including coronary artery disease (CAD) of Thai physicians. This study focused on the 10-year prediction of risk for CVDs of Thai physicians and their relative risk compared to other Thai people of the same age and gender using the TCVR score estimator. The association between CVD risk with other clinical features and current CAD were also assessed.

2 | METHODS

This retrospective cross-sectional study collected data of Thai physicians who underwent cardiovascular assessments in the corporate social responsibility (CSR) project "Save Doctors' Heart" of our hospital. The project was conducted between February 14, 2022, and October 31, 2022, inviting Thai physicians aged 35–75 years without congenital heart diseases to have cardiac health checkups. This research received approval from the MedPark Institutional Review Board (COA-MPIRB 002/2023).

Medical services in the project included collection of data on personal health (preexisting illness), history of CAD in first- degree family members, work and health habits including weekly work hours, relative amount of fiber diet (minimal or very minimal, moderate, high), smoking, exercise, and stress (none, mild, moderate, severe). Physical examination included measurement of weight, height, blood pressure, and cardiovascular system examination. Basic hematologic, biochemical laboratory tests, non-invasive and invasive cardiac testing were performed as indicated by an individual's risk features, abnormal basic testing, and upon the discretion of the examining cardiologist. Details of these investigations were described in our work on cardiovascular health.

Inclusion criteria for this retrospective study were the physicians who participated in the "Save Doctors' Heart" project and had complete data to calculate for the 10-year CVD risk according to the TCVR.[15] The web-based TCVR estimating risk program required 5 clinical features of age, gender, smoking, presence of DM, systolic blood pressure (SBP), plus either total cholesterol (TC) level or waist circumference and height for the calculation. Exclusion criteria were those who did not have adequate cardiac investigations to assess the presence of CAD. Cardiac investigations were described in detail in our other work of cardiovascular disorder of Thai physicians which were presented elsewhere.

Data collected for the analyses included: age, gender, history of CAD in a first-degree family member, history of DM, smoking habits, weekly work hours, fiber diet, exercise, and stress. Findings from health examination in the CSR project collected were body mass index (BMI), SBP, fasting blood sugar, TC as well as other lipid profiles, CAC score, presence of CAD, and the 10-year CVD risk from the TCVR report. The presence of DM was made from personal history of DM and laboratory findings of abnormal fasting blood sugar. Dyslipidemia was defined with high levels of any lipid (TC, low-density lipoprotein cholesterol, triglycerides) or low level of

high-density lipoprotein. The CAC score was obtained from the CT Calcium Score study which measures the amount of calcified plaque and classifies the risk of CAD as: no evidence of CAD (score: 0–1), minimal evidence (score: 1–10), mild evidence (score: 11–100), moderate evidence (score: 101–400), or extensive evidence (score: >400) and grouped as no/minimal/mild or moderate/extensive evidence of CAD.[26] Data of CAD was obtained from non-invasive and/or invasive cardiac testing which were described in detail in our work on cardiovascular health presented elsewhere. Only the physicians who had been confirmed as having CAD were defined as such whereas the ones with suspicious CAD were excluded from the analysis. The 10-year CVD risk of the physicians in this study was obtained by entering data of age, gender, smoking, presence of DM, SBP, and TC level of each Thai physician in our study into the web-based TCVR program. The automatically generated 10-year CVDs risk prediction report included percentage of risk with the corresponding risk group (<10% as low, 10% to <20% as moderate, 20% to <30% as high, and >30% as very high). Of note, specific percentage of risk was given only in low-, moderate-, and high-risk groups but not in a very high-risk group which simply stated as >30%. Also reported from the program were relative risk of an individual as lower, same, or higher risk compared to Thai people of the same age and gender without risk, and advice of preventive measures.

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corporation). Continuous variables were presented as mean ± standard deviation for normally distributed data or else with median (interquartile range). Categorical variables were presented as frequency and percentage. The risk ratio of CAD according to the TCVR score group (moderate, high, very high compared to low risk) was analyzed by Chi-square test. To study the association of the 10-year prediction of risk for CVDs and clinical features, data were categorized as the followings: risk of CVD: no/low-risk group versus moderate-, high-, and very high-risk group; SBP of <120 or >120 mmHg; TC as <200 or ≥200 mg/dL; weekly work hours as <55 or >55 h; fiber diet as good (moderate/high) or fair (minimal/low); stress as none/mild or moderate/severe; exercise as low-level (<2 days/week) or high-level (>3 days/week). Group comparisons by univariable analysis were made using Student's *t*-test or Mann–Whitney *U*-test for continuous variables and Chi-square or Fisher's exact test for categorical variables, as appropriate. Clinical important features (all in the TCVR score) or significant by univariate analysis were included for a multivariate analysis by logistic regression to explore independent factors associated with the 10-year prediction of risk for CVDs. All statistical analyses were two-sided and a $p < 0.05$ was considered statistically significant.

Flow chart of the study conduct is shown in Figure S1.

3 | RESULTS

Among 1244 physicians who had participated in the "Save Doctors' Heart" project, 19 were excluded from the study: 6 did not have complete data to assess for the TCVR score and 13 did not have data on CAD. Among 1225 physicians included in the study, their median age was 45 years old (interquartile range [IQR]: 39–56 years). Slightly more than half (55.3%) were female. The number of respondents to personal data varied (Table 1). Only 0.8% smoked or ever smoked. The majority consumed a moderate to high fiber diet (80.8%) and worked <55 h per week (83.1%). Approximately 70% of the physicians had exercise ≥3 days per week and 74.2% had no or only mild stress. Family history of CAD was reported in 8.3%.

The median BMI of the physicians was 22.8 kg/m^2 (IQR: 20.53–25.41 kg/m^2). We found that slightly over one-fourth of the physicians in our study were overweight/obese (28.1%) or had DM (30.6%). The mean SBP was 118.8 ± 15.90 mmHg, with nearly half (44.3%) having a level ≥120 mmHg. The median TC was 196 mg/dL (IQR: 175–221 mg/dL), with nearly half (46.0%) having a level ≥200 mg/dL. When considering the profile of all lipids, 75% had dyslipidemia.

For CVD risk assessment, the median CAC score was 0 (IQR: 0–13.7). They were classified as having no to mild risk for CAD in

TABLE 1 Basic characteristics and health history of participants.

Characteristic features	*n*	%
Age, years (*n* = 1225)		
35–45	638	52.1
46–59	386	31.5
≥60	201	16.4
Gender (*n* = 1225)		
Female	677	55.3
Male	548	44.7
Smoking (*n* = 1180)		
No	1171	99.2
Yes	9	0.8
Fiber diet (*N* = 724)		
Fair (no or minimal)	139	19.2
Good (moderate/high)	585	80.8
Work hours per week (*n* = 703)		
<55	584	83.1
≥55	119	16.9
Exercise (*N* = 1180)		
No or 1–2 days/week	831	70.4
≥3 days/week	349	29.6
Stress (*N* = 1169)		
No to mild	867	74.2
Moderate to severe stress	302	25.8
Family history of coronary artery disease (*N* = 1168)		
No	1071	91.7
Yes	97	8.3

87.4% whereas the remaining 12.6% had moderate to extensive risk. Of 1205 physicians with one or more cardiac testing, 135 physicians (11.2%) were confirmed to have CAD. Data and details of various cardiac testing were presented elsewhere. Health findings of the physicians are shown in Table 2.

TABLE 2 Health findings of the physicians.

Health findings	*n*	%
Body mass index (*n* = 1215)		
Normal	786	64.7
Underweight	87	7.2
Overweight	286	23.5
Obese	56	4.6
Systolic blood pressure (mmHg) (*n* = 1217)		
<120 mmHg	678	55.7
≥120 mmHg	539	44.3
Diabetes mellitus[a] (*n* = 1225)		
No	850	69.4
Yes	375	30.6
Total cholesterol (mg/dL) (*n* = 1225)		
<200 mg/dL	662	54.0
≥200 mg/dL	563	46.0
Calcium score (*n* = 714)		
No evidence of CAD (0)	466	65.3
Minimal evidence of CAD (1–10)	63	8.8
Mild evidence of CAD (11–100)	95	13.3
Moderate evidence of CAD (101–400)	51	7.1
Extensive evidence of CAD (>400)	39	5.5
Coronary artery disease (*n* = 1225)		
No	1070	87.3
Yes	135	11.1
Not confirm	20	1.6

[a]Numbers of physicians with diabetes mellitus were summed from the history and current laboratory findings.

Data of age, gender, smoking, presence of DM, SBP, and TC level from 1225 physicians were entered to the web-based TCVR score program. After excluding those in the very high-risk group whose percentage of risk was not specified (only stated as >30% risk), the median (range) risk magnitude of those with low-, moderate-, and high-risk groups were 2.16% (0.49%–9.99%), 13.91% (1.37%–19.89%), and 23.44% (1.54%–29.80%), respectively. The numbers and percentages according to risk levels were: 980 (80.0%) as low risk, 137 (11.2%) as moderate risk, 60 (4.9%) as high risk, and 48 (3.9%) as very high risk.

For the relative risk compared to Thai people of the same age and gender without risk, the TCVR reported 391 of the physicians in this study (31.9%) had lower risk, 422 (34.5%) had the same risk, and 412 (33.6%) had higher risk. The frequency of higher risk (compared to other Thai people) increased sequentially according to the risk level group: 27.6% and 45.3% among those with low- or moderate-risk and 55.0% and 97.9% with high and very high-risk, respectively. Table 3 demonstrates a 10-year risk level prediction for CVDs and their relative risk compared to Thai people of the same age and gender without risk.

We studied the presence of CAD according to the TCVR score risk and relative risk levels (Table 4). We found a significant direct association between CAD and the risk or relative risk levels ($p < 0.001$ both). The highest frequency of CAD was found among the physicians in the very high-risk group (46.8%, 5.9 folds) followed by high-risk (35.1%, 4.4 folds) and moderate-risk groups (33.8%, 4.3 folds) compared to those in the low-risk group (7.9%). Likewise, CAD was highest among the physicians with a higher relative risk (18.4%, 2.6 folds) compared to those with the same risk (8.0%) and lower-risk group (7.2%).

We were aware that each feature might have a different degree of impact on the risk of CVS, so we analyzed an association or risk of each factor in the TCVR and other clinical features of the physicians with a 10-year prediction of risk for CVDs (none to low risk or moderate to extensive risk). The association of each feature and the risk are shown in Table 4. Among the indicators of CVS risk score, we found a significant direct association of older age, male gender, smoking, DM, and SBP ≥120 mmHg with moderate to extensive CVS risk by univariate analyses. We could not demonstrate a significant association of cholesterol level with the CVS risk. The other

TABLE 3 10-year cardiovascular risk and relative risk of the participating physicians estimated by Thai Cardiovascular Risk program (*N* = 1225).

	Relative risk compared to general population of the same age and gender without risk[a]		
Risk group, *n* (%)	Lower (*N* = 391, 31.9%) *n* (%[b])	Same level (*N* = 422, 34.5%) *n* (%[b])	Higher level (*N* = 412, 33.6%) *n* (%[b])
Low, *n* = 980 (80.0%)	351 (35.8)	359 (36.6)	270 (27.6)
Moderate, *n* = 137 (11.2%)	35 (25.5)	40 (29.2)	62 (45.3)
High risk, *n* = 60 (4.9%)	5 (8.3)	22 (36.7)	33 (55.0)
Very high risk, *n* = 48 (3.9%)	–	1 (2.1)	47 (97.9)

[a]Data obtained from the web-based Thai CV risk score.

[b]% Obtained according to risk group.

TABLE 4 Coronary artery disease according to the 10-year cardiovascular risk and relative risk of the participating physicians estimated by Thai Cardiovascular Risk program (*N* = 1205).

Thai CV risk by TRS score system	Presence of coronary artery disease		Risk ratio	*p*-value
	No CAD, *N* = 1070	CAD, *N* = 135		
Risk level group				<0.001
Low risk (*n* = 965)	918 (95.1)	47 (4.9)	1	
Moderate (*n* = 136)	90 (66.2)	46 (33.8)	4.3	
High risk (*n* = 57)	37 (64.9)	20 (35.1)	4.4	
Very high risk (*n* = 47)	25 (53.2)	22 (46.8)	5.9	
Relative risk compared to Thai people of the same age and gender without risk				<0.001
Lower risk (*n* = 391)	361 (92.8)	28 (7.2)	1	
Same level of risk (*n* = 422)	381 (92.0)	33 (8.0)	1.1	
Higher risk (*n* = 412)	328 (81.6)	74 (18.4)	2.6	

significant non-CVS score indicators were family history of CAD, BMI, and CAC score. Surprisingly, we found significantly higher CVDs prediction risk with those who had <55 weekly working hours, ≥3 days weekly exercise, moderate/high fiber diet, and no/mild stress.

Except for smoking and obesity, which had small numbers of participants in each subgroup and were not included in the multivariate analysis, the significant independent features which had a direct association or were risk factors for 10-year prediction of risk for CVDs were increasing age, male gender, DM, SBP >120 mmHg, and increasing BMI.

4 | DISCUSSION

The TCVR score report provides information on the 10-year prediction of risk for CVDs in terms of percentage of risk, risk level classification, relative risk compared to other Thai people of the same age and gender without risk factors, and recommendations to prevent the CVDs events.[15] So, our study analyzed the CVD risk of Thai physicians from the TCVR score reports accordingly.

Except for the very high-risk group whose score was not specified, the risk scores consecutively increased from 2.16% in low, 13.91% in moderate-, and 23.44% in high-risk group. By risk level, most of the Thai physicians in our study had low risk (80%), with the remaining having moderate (11.2%) and high- or very high-risk (8.8%). Other studies on the Thai population reported different percentages of risk levels in their studies: low-or very low-risk in 43%–96%, moderate risk in 3%–24%, and high-or very high-risk in 0.7%–8.3%.[18,27,28] The difference certainly lies in the characteristic features of the participants in each study. For example, the study of Pounavatr et al.[28] who, after excluding 25% participants who had incomplete data for risk assessment, reported a low percentage of low-risk (43%) but a high percentage of moderate- (24%), high- or very high-risk (8%) included only patients with DM and HT. Others which had only half of their participants with hypertension or DM or included hospital personnel aged <35 years old who should have fewer medical disorders reported 3.2%–5.8% were moderate-risk and only 0.7%–0.8% in high- and very high-risk.[18,27] Our study which focused on Thai physicians whose age were 35–75 years found the rates of overweight or obese at approximately 30%, DM at 31%, hypertension at 44%, and dyslipidemia (high cholesterol and other lipids) up to 75%. These risk features of physicians, like the study of Pounavatr et al.,[28] should lead to relatively high percentages of moderate-risk (11.2%) and high- or very high-risk (8.8%).

Because of the impact of age and gender on the CVS risk,[25,29,30] the TCVR score also reports the relative CVS risk compared to other Thai people of the same age and gender. Our study found that nearly one-third (33.6%) had higher relative risk. The percentages of higher risk levels sequentially increased according to the risk level: 27.6% in low-risk, 45.3% in moderate-risk, and 55.0% and up to 97.9% in high- and very high-risk, respectively (Table 3).

Slightly different from many previous studies, which simply tested the function (reliability and validity) and reported only data on future CVD risk, our study had data of actual CAD which should genuinely represent the value of the TCVR score. Other studies did not focus on this relative risk which should have some clinical values aside from the simple risk level. We studied both risk level and relative risk to explore their association with CAD. We found that CAD rate significantly increased sequentially with the increased risk and relative risk levels (Table 5). The increased risk was substantial in the physicians with very high risk that 46.8% had CAD compared to only 4.9% in those with low risk (5.9 folds). Our findings should confirm the reliability and clinical use of the TCVR scoring system to categorize an individual's risk, not only the future risk but also the current abnormality. We found only one previous study, which also reported studied the actual CVD events in 8 years among 1025 Thai participants according to the TCVR score risk group.[19] They found a good correlation between the TCVR score and CVD events in the low-risk group (0.0529 predicted and 0.0707 actual). However, there were an overestimation of the events in the moderate- (0.1522

TABLE 5 Risk of 10-year cardiovascular risk of the physicians.

Features	*n*	Risk level, *n* (%)		Crude odds ratio (95% CI)	*p*-value	Adjusted odds ratio (95% CI)	*p*-value
		No/low risk	Risk[a]				
Age, median (IQR) (*N* = 1225)		42 (39, 49)	64 (59, 68)	1.47 (1.39–1.55)	<0.001	1.97 (1.56–2.46)	<0.001
Gender (*N* = 1225)							
Female	677	609 (90.0)	68 (10.0)	1	<0.001	1	<0.001
Male	548	371 (67.7)	177 (32.3)	4.27 (3.14–5.81)		10.46 (2.62–41.66)	
Smoking (*N* = 1180)							
No	1171	944 (80.6)	227 (19.4)	1	0.015	NA	
Yes	9	4 (44.4)	5 (55.6)	5.20 (1.39–19.51)			
Diabetes mellitus[b] (*N* = 1225)							
No	850	758 (89.2)	92 (10.8)	1	<0.001	1	0.004
Yes	375	222 (59.2)	153 (40.8)	5.68 (4.21–7.66)		6.53 (1.85–23.40)	
Systolic blood pressure (*n* = 1217)							
<120 mmHg	678	635 (93.7)	43 (6.3)	1	<0.001	1	<0.001
≥120 mmHg	539	338 (62.7)	201 (37.3)	8.78 (6.16–12.52)		13.35 (3.24–55.02)	
Total Cholesterol (*n* = 1225)							
<200 mg/dL	662	525 (79.3)	137 (20.7)	1	0.510	1	0.651
>200 mg/dL	563	455 (80.8)	108 (19.2)	0.91 (0.69–1.21)		0.77 (0.24–2.41)	
Weekly working hour (*N* = 703)							
<55 h	584	467 (80.0)	117 (20.0)	1	0.002	1	
≥55 h	119	110 (92.4)	9 (7.6)	0.33 (0.16–0.66)		0.74 (0.16–3.38)	0.698
Exercise (*N* = 1180)							
≥3 days/week	349	245 (70.2)	104 (29.8)	1	<0.001	1	
No or 1–2 days/week	831	703 (84.6)	128 (15.4)	0.43 (0.32–0.58)		0.60 (0.16–2.31)	0.457
Fiber diet (*N* = 724)							
Moderate/high	585	465 (79.5)	120 (20.5)	1	0.016	1	
No/minimal	139	123 (88.5)	16 (11.5)	0.50 (0.29–0.88)		0.158 (0.024–1.040)	0.055
Stress (*N* = 1169)							
No to mild	867	675 (77.9)	192 (22.1)	1	<0.001	1	
Moderate/severe stress	302	265 (87.7)	37 (12.3)	0.49 (0.34–0.72)		0.426 (0.085–2.130)	0.299
Family history of CAD (*N* = 1168)							
No	1071	868 (81.0)	203 (19.0)	1	0.005	1	
Yes	97	67 (69.1)	30 (30.9)	1.92 (1.21–3.02)		1.750 (0.229–13.390)	0.590
Body mass index, median (IQR) (*N* = 1215)		22.5 (20.2, 25.2)	23.7 (21.4, 25.6)	1.05 (1.01–1.09)	0.011	1.211 (1.014–1.447)	0.035
Calcium score, median (IQR) (*N* = 714)		0 (0, 159.9)	22.1 (0, 156.2)	1.00 (1.00–1.00)	<0.001	1.0 (0.998–1.002)	0.866

Abbreviations: CI, confidence interval; IQR, interquartile range.

[a]Risk included moderate-, high-, and very high-risk groups.

[b]Numbers of physicians with diabetes mellitus were summed from the history and current laboratory findings.

predicted and 0.0884 actual) and high-risk groups (0.2523 predicted and 0.1364 actual) despite their inclusion of CAD and stroke as the actual events of CVD. The authors warned of these inaccurate comparisons because there were only a small number of cases (only 83) with CVS events due to a high number of censors from the migration of their population.

For clinical use to predict the CVS risk among the Thai population, additional clinical data might improve the function of the TCVR score system. Previous studies assessed the risk indicators in TCVR score and some other features to predict the 10-year prediction of risk for CVDs.[17,20] The study among 130 aboriginal Akha participants found age as the only feature with moderate association with CVD within the next 10 years whereas no association was identified with other health data of drinking, smoking, substance abuse, hypertension, diabetes, and waist size.[20] Others found age, SBP, smoking, average time to sleep at night, and health activities were significant risk factors for predicting CVD among 382 participants.[17] Different findings from each study may lie in the number of participants, the proportion of risk groups, and basic characteristics, especially risk features in each.

Our study also assessed the association of each component of the TCVR score and personal data of the physicians (weekly work hours, exercise, fiber diet, stress, family history of CAD), BMI, and CAC score with the CVD risk. By univariate analysis, we found all indicators of TCVR score (except TC) with the addition of a family history of CAD, BMI, and CAC score had a significant association with CVD risk. However, BMI was the only additional feature independently associated with risk (Table 5). We could not confirm the significant association between these features and the risk of CVD due to the small numbers of physicians in the features' subgroup resulting in wide confidence intervals in many outcomes. Future studies with a larger number of participants, especially of high and very high-risk groups, may provide a more definite answer or confirm our findings.

Our contradictory findings from univariate analyses were reverse association between higher frequency of predicted moderate/severe risk and healthy habits of less weekly working hours (<55 h), more exercise (≥3 days/week), and no to mild stress. However, these features were not significant by multivariate analysis. We proposed that the physicians with unhealthy habits may have readily modified their habits, so somehow reversed the future risk.

5 | STRENGTHS AND LIMITATIONS

Our study had some strengths. First, this was the first study in Thailand which directly focused on the 10-year prediction of risk for CVDs of Thai physicians. Second, the number of participants was quite large, so our data should be informative. Third, although being a hospital-based study, the participating physicians were from different health units and had various characteristics. So, the results from our study could be generalized. Fourth, the rate of CAD in our study was quite reliable because of the objective findings from the specific cardiac testing. This actual event readily confirmed the clinical use of the TCVR score program. Last, although the actual CVD risk in the general population were not available, the relative risk data obtained from the web-based TCVR comparing the risk of our participants to other general population should provide the information.

Nevertheless, we were aware of some limitations. First, some data were lacking or not in detail, such as other types of diet aside from the relative amount of fiber diet and the vigorousness of exercise and other physical activity. These might have resulted in an inverse relationship (although not confirmed by multivariate analysis) with the CVD risk. Second, only one spot of blood pressure measurement and blood chemistry testing were taken upon participating in the CSR project. They might not be as accurate as a repeated measurement over time, especially for those who did not have a history of preexisting conditions or treatment. Last, data collection from this cross-sectional study may have limited the ability to establish long-term trends of causal relationships between risk factors and CVD. Longitudinal studies could provide more robust evidence in this regard.

6 | PRACTICAL IMPLICATIONS

Our findings should alert all Thai physicians, especially those with high risk or higher risk than other Thai people of the same age and gender. Even the physicians with low- or moderate-risk, a substantial percentage of them had higher risk than other populations. So, we recommend that all physicians with any risk indicators should be cautious about future CVD events. A lifestyle modification of the behavioral risk should be executed as much and as soon as possible to prevent future risks. Close follow-up or regular health surveillance should be carried out for early detection of CVDs.

7 | CONCLUSIONS

Our study revealed that 80.0% of Thai physicians had low-risk, 11.2% moderate-risk, 4.9% high-risk, and 3.9% very high-risk for 10-year prediction of risk for CVD development. Compared to other Thai people of the same age and gender, 31.9% had a lower risk, 34.5% had the same risk, and 33.6% had a higher risk. A significant association was found between CAD and the risk or relative risk categorization. The higher percentages of CAD were found as the risk increased from low to high or very high, especially with those who had higher relative risk. The individuals should be aware and consider having risk assessments of their own. Every behavioral or health risk should be modified to prevent current and future risks of CVD.

AUTHOR CONTRIBUTIONS

Siriwan Tangjitgamol: conceptualization; data curation; formal analysis; funding acquisition; investigation; validation; writing—original draft; writing—review & editing. **Wasan Udayachalerm**:

conceptualization; supervision; validation; writing—review & editing. **Sureerat Panyarachun**: data curation; validation; writing—review & editing. **Chad Wanishsawad**: conceptualization; data curation; writing—review & editing. **Watcharagan Kaewwanna**: conceptualization; data curation; methodology; validation; writing—original draft; writing—review & editing. **Sumonmal Manusirivithaya**: formal analysis; methodology; validation; writing—review & editing. All authors have read and approved the final version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Relevant data of the research are available upon a reasonable request to the corresponding author. The lead author, Siriwan Tangjitgamol had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

ETHICS STATEMENT

The authors declare that all methods used in this project complied with the Helsinki Declaration. The Institutional Review Boards of the institution provided their approval for the study (COA-MPIRB 002/2023). Informed consent from individuals was waived given the retrospective nature of the study. The participants' data were de-identified, and the confidentiality of information was protected in accordance with the Helsinki Declaration, ensuring that it was solely utilized for research purposes.

TRANSPARENCY STATEMENT

The lead author Siriwan Tangjitgamol affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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