The Ten-year Risk Prediction for Cardiovascular Disease in the National Population (Globorisk) of Malaysian Adults

Kamarul Imran Musa (drkamarul@usm.my)
Department of Community Medicine, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian Kelantan

Che Muhammad Nur Hidayat Che Nawi
Department of Community Medicine, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian Kelantan

Mohd. Azahadi Omar
Sector for Biostatistics & Data Repository, National Institutes of Health, Ministry of Health, 40170 Shah Alam, Selangor Darul Ehsan

Thomas Keegan
Lancaster Medical School, C039, C - Floor, Furness College, Lancaster, UK LA1 4YW

Yong Poh Yu
Redbeat Academy, AirAsia Berhad, 50470 Kuala Lumpur

Research Article

Keywords: Cardiovascular Disease, Ten-year Risk Prediction, Globorisk, Malaysia

Posted Date: November 3rd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-977091/v1

Abstract

Globorisk is a novel risk prediction model that predicts cardiovascular disease (CVD) in the national population of all world countries. Using Malaysia's risk factor levels and CVD event rates, we calculated the laboratory-based and office-based risk scores to predict the 10-year risk for fatal CVD and fatal plus non-fatal CVD for the Malaysian adult population. We analysed data from 8253 participants from the 2015 nationwide Malaysian National Health and Morbidity Survey (NHMS 2015). The average risk for the 10-year fatal and fatal plus non-fatal CVD was calculated, and participants were further grouped into four categories: Low Risk (<10% risk for CVD), High-Risk A (≥10%), High-Risk B (≥20%) and High-Risk C (≥30%). Results were reported for all participants and were then stratified by sex, race, region, and state. The average risks for laboratory-based fatal CVD, laboratory-based fatal plus non-fatal CVD and office-based fatal plus non-fatal CVD were 0.07 (SD = 0.10), 0.14 (SD = 0.12) and 0.11 (SD = 0.09), respectively. There were substantial differences in terms of the sex-, race- and state-specific Globorisk risk scores obtained.

Introduction

Cardiovascular diseases (CVDs) are the leading cause of death worldwide, with nearly 17 million deaths in 2016, 31% of the world's total [1]. The World Health Organisation (WHO)-derived aim is to reduce CVD-related premature death by 30% [2]. In Malaysia, CVD death accounted for 21.7% of all hospital deaths in 2017 [3].

CVD-related deaths could be reduced by predicting the CVD risk and subsequently mitigating the CVD risk factors. A suitable model of CVD risk prediction and a nationally representative cardiometabolic profile are needed to measure the number of people at high risk for CVD (e.g., those with a CVD risk greater than 30%). The measurement of CVD risk will help monitor progress towards the global targets for the treatment of non-communicable diseases (NCDs).

Current CVD calculators tested on populations, including Framingham, INTERHEART, SCORE, and WHO/ISH CVD, are helpful for CVD risk prediction [4–9]. However, risk predictions developed for a specific population cannot be used in other populations or the same populations later because the mean levels of CVD predictors vary across populations and over time [10–14]. Globorisk, a newly developed CVD calculator, [15] provides country-specific CVD risk scores. Globorisk provides models to estimate the 10-year risk of fatal and non-fatal CVD, and the models have been validated and calibrated using data for 182 countries [16–18].

Globorisk is the first novel, cardiovascular disease risk score that predicts the risk of heart attack or stroke in healthy individuals (those who have not yet had a heart attack or stroke) globally. It uses information on a person's country of residence, age, sex, smoking, diabetes, blood pressure, and cholesterol to predict the chance that they would have a heart attack or stroke in the next ten years (laboratory-based risk prediction). Suppose the individual does not have recent diabetes or cholesterol test. In that case, they

can use the office-based risk prediction of Globorisk, which is based on body weight and height, to generate body mass index (BMI) and use it to replace total cholesterol and diabetes instead (http://www.globorisk.org/).

There has been no local study that uses Globorisk to calculate the CVD risk among the Malaysian population. However, knowing the average risk for fatal and fatal plus non-fatal CVD and the proportion of the Malaysian population with specific risk factors for developing a CVD event in the next ten years will help public health workers, epidemiologists, and policymakers in Malaysia guide CVD control and prevention programmes.

The study aimed to provide the overall, the sex-specific, the ethnic-specific, the region-specific, and the state-specific 10-year risk for CVD among Malaysian adults. Three measures of CVD risk can be calculated using the Globorisk risk prediction model: (1) The laboratory-based 10-year risk of fatal CVD; (2) The laboratory-based 10-year risk of fatal plus non-fatal CVD; and (3) The office-based 10-year risk of fatal plus non-non-fatal CVD.

Results

The participants' characteristics

We performed CVD risk prediction on 8253 individuals aged between 40 and 84 years. The mean age for men was 53.72 years (SD = 9.32) and for women was 52.06 years (SD = 8.32). Ethnically, the sample was predominated by Malay (62%) followed by Chinese (18%), Indian (7.2%) and other ethnicities.

The geographical areas were states, the principal administrative divisions of the country, of which there are 13 states and three federal territories (WP Kuala Lumpur, WP Putrajaya, and Labuan). The proportion of the study population in the state of Selangor was the highest (12%), while Labuan had the lowest (0.2%), which was proportionate to their overall population size. The distribution of people by ethnicity between men and women was fairly equal (Table 1).

Table 1

The participants' characteristics. [a] Other ethnicities comprised of other Malaysian minorities such as Sikh, Baba, Chitty, Eurasian and non-citizens. [b] Other Bumiputera comprised of more than 40 indigenous ethnicities that reside in both Peninsular and Borneo, Malaysia.

Characteristic	Overall (n = 8253)	Women (n = 4170)	Men (n = 4083)
Age, mean (SD), years	52.88 (8.87)	52.06 (8.32)	53.72 (9.32)
Ethnic			
Chinese	1496 (18%)	736 (18%)	760 (19%)
Indian	591 (7.2%)	320 (7.7%)	271 (6.6%)
Malay	5149 (62%)	2608 (63%)	2541 (62%)
Others [a]	357 (4.3%)	167 (4.0%)	190 (4.7%)
Others Bumis [b]	660 (8.0%)	339 (8.1%)	321 (7.9%)
State			
Johor	751 (9.1%)	382 (9.2%)	369 (9.0%)
Kedah	561 (6.8%)	285 (6.8%)	276 (6.8%)
Kelantan	516 (6.3%)	258 (6.2%)	258 (6.3%)
Labuan	15 (0.2%)	6 (0.1%)	9 (0.2%)
Melaka	447 (5.4%)	252 (6.0%)	195 (4.8%)
Negeri Sembilan	568 (6.9%)	318 (7.6%)	250 (6.1%)
Pahang	497 (6.0%)	227 (5.4%)	270 (6.6%)
Penang	629 (7.6%)	332 (8.0%)	297 (7.3%)
Perak	650 (7.9%)	327 (7.8%)	323 (7.9%)
Perlis	624 (7.6%)	310 (7.4%)	314 (7.7%)
Sabah	593 (7.2%)	297 (7.1%)	296 (7.2%)
Sarawak	506 (6.1%)	252 (6.0%)	254 (6.2%)
Selangor	970 (12%)	468 (11%)	502 (12%)
Terengganu	526 (6.4%)	257 (6.2%)	269 (6.6%)
WP Kuala Lumpur	278 (3.4%)	145 (3.5%)	133 (3.3%)
WP Putrajaya	122 (1.5%)	54 (1.3%)	68 (1.7%)

Characteristic	Overall (n = 8253)	Women (n = 4170)	Men (n = 4083)
Smoking Status, yes	1741 (21%)	41 (1.0%)	1700 (42%)
Diabetes Status, yes	2350 (28%)	1219 (29%)	1131 (28%)
Systolic Blood Pressure, mean (SD), mm Hg	135.31 (23.17)	135.65 (23.74)	134.97 (22.58)
Total Cholesterol, mean (SD), mmol/L	5.18 (2.86)	5.41 (2.82)	4.94 (2.89)
Body Mass Index, mean (SD), kg/m^2	26.61 (4.94)	27.33 (5.23)	25.87 (4.51)

In terms of cardiovascular risk factors, men had a higher prevalence of smoking (42%) than women (1%). The prevalence of diabetes was equivalent between sexes; 28% for men and 29% for women. The overall mean for systolic blood pressure was 135.65 mm Hg, (SD = 23.74), for total cholesterol 5.41 mmol (SD = 2.82) and BMI 27.33 kg/m^2 (SD = 5.23). These values were higher in women compared with men (Table 1).

The 10-year CVD risk prediction score at the national level

Table 2 shows that the average risk laboratory-based mean (SD) 10-year risk of fatal CVD, the laboratory-based mean 10-year risk of fatal plus non-fatal CVD, and the office-based mean 10-year risk of fatal plus non-fatal CVD were 0.07 (SD = 0.10), 0.14 (SD = 0.12) and 0.11 (SD = 0.09), respectively. The CVD risk for women appears to be lower than that of the men: mean 10-year risk of fatal CVD = 0.05 (SD = 0.09), laboratory-based mean 10-year risk of fatal plus non-fatal CVD = 0.11 (SD = 0.12) and office-based mean 10-year risk of fatal plus non-fatal CVD = 0.08 (SD = 0.09). The CVD risk categories (calculated from Globorisk risk prediction), showed that more men had high CVD risk scores for all Globorisk predicted risk. For example, their 10-year risk of fatal CVD was 30%, the laboratory-based 10-year risk of fatal plus non-fatal CVD was 73%, and the office-based ten-year risk of fatal plus non-fatal CVD was 72%.

Table 2
The overall and sex-specific 10-year CVD risk

Prediction	Overall (n = 8253)	Female (n = 4170)	Male (n = 4083)
Mean probability of 10-year fatal CVD (SD)	0.07 (0.10)	0.05 (0.09)	0.08 (0.10)
Categories			
Low Risk <10%	6392 (77%)	3,515 (84%)	2877 (70%)
High Risk A ≥10%	1123 (14%)	381 (9.1%)	742 (18%)
High Risk B ≥20%	411 (5.0%)	148 (3.5%)	263 (6.4%)
High Risk C ≥30%	327 (4.0%)	126 (3.0%)	201 (4.9%)
Mean of 10-year fatal plus non-fatal laboratory CVD (SD)	0.14 (0.12)	0.11 (0.12)	0.17 (0.12)
Categories			
Low Risk <10%	3732 (45%)	2617 (63%)	1115 (27%)
High Risk A ≥10%	2502 (30%)	884 (21%)	1618 (40%)
High Risk B ≥20%	1117 (14%)	329 (7.9%)	788 (19%)
High Risk C ≥30%	902 (11%)	340 (8.2%)	562 (14%)
Mean of 10-year fatal plus non-fatal office CVD (SD)	0.11 (0.09)	0.08 (0.09)	0.14 (0.08)
Categories			
Low Risk <10%	4205 (51%)	3072 (74%)	1133 (28%)
High Risk A ≥10%	2724 (33%)	764 (18%)	1960 (48%)
High Risk B ≥20%	920 (11%)	187 (4.5%)	733 (18%)
High Risk C ≥30%	404 (4.9%)	147 (3.5%)	257 (6.3%)

Table 3 depicts the CVD risk for different ethnicities in Malaysia. The Malays had the highest Globorisk risk prediction compared with their counterparts – the mean of 10-year risk of fatal CVD = 0.07 (SD = 0.10), the mean of laboratory-based 10-year risk of fatal plus non-fatal CVD = 0.15 (SD = 0.13), and the mean of office-based 10-year risk of fatal plus non-fatal CVD = 0.12 (SD = 0.09). Malays also had the largest percentage of high CVD risk scores in all Globorisk outcomes compared with other ethnicities. Their 10-year risk of fatal CVD was 25%, the laboratory-based 10-year risk of fatal plus non-fatal CVD was 58%, and the office-based 10-year risk of fatal plus non-fatal CVD was 51%.

Table 3
The ethnicity-specific 10-year CVD risk

Prediction	Chinese (n = 1496)	Indian (n = 591)	Malay (n = 5,149)	Others [a] (n = 357)	Others Bumis [b] (n = 660)
Mean of lab-based fatal CVD (SD)	0.06 (0.09)	0.06 (0.09)	0.07 (0.10)	0.04 (0.06)	0.05 (0.07)
Categories					
Low Risk <10%	1,214 (81%)	469 (79%)	3,846 (75%)	310 (87%)	553 (84%)
High Risk A ≥10%	166 (11%)	71 (12%)	773 (15%)	36 (10%)	77 (12%)
High Risk B ≥20%	60 (4.0%)	25 (4.2%)	299 (5.8%)	5 (1.4%)	22 (3.3%)
High Risk C ≥30%	56 (3.7%)	26 (4.4%)	231 (4.5%)	6 (1.7%)	8 (1.2%)
Mean of lab-based fatal plus non-fatal laboratory CVD (SD)	0.12 (0.11)	0.13 (0.12)	0.15 (0.13)	0.11 (0.10)	0.11 (0.10)
Categories					
Low Risk <10%	760 (51%)	275 (47%)	2,161 (42%)	196 (55%)	340 (52%)
High Risk A ≥10%	446 (30%)	174 (29%)	1,573 (31%)	99 (28%)	210 (32%)
High Risk B ≥20%	168 (11%)	79 (13%)	756 (15%)	42 (12%)	72 (11%)
High Risk C ≥30%	122 (8.2%)	63 (11%)	659 (13%)	20 (5.6%)	38 (5.8%)
Mean of office-based fatal plus non-fatal office CVD (SD)	0.11 (0.09)	0.10 (0.09)	0.12 (0.09)	0.09 (0.07)	0.10 (0.08)
Categories					
Low Risk <10%	779 (52%)	335 (57%)	2,512 (49%)	222 (62%)	357 (54%)
High Risk A ≥10%	500 (33%)	176 (30%)	1,723 (33%)	111 (31%)	214 (32%)
High Risk B ≥20%	156 (10%)	48 (8.1%)	642 (12%)	15 (4.2%)	59 (8.9%)

Prediction	Chinese (n = 1496)	Indian (n = 591)	Malay (n = 5,149)	Others [a] (n = 357)	Others Bumis [b] (n = 660)
High Risk C ≥30%	61 (4.1%)	32 (5.4%)	272 (5.3%)	9 (2.5%)	30 (4.5%)

In Table 4, we present the region-specific CVD risk based on the Globorisk risk prediction. It shows that the Northern region of Malaysia had the highest CVD risk scores compared with other regions in terms of mean (10-year risk of fatal Globorisk = 0.08 [SD = 0.11], laboratory-based 10-year risk of fatal plus non-fatal CVD = 0.15 [SD = 0.13] and office-based 10-year risk of fatal plus non-fatal CVD = 0.12 [SD = 0.10]) and category (10-year fatal Globorisk = 27%, laboratory-based 10-year risk for CVD = 58% and office-based 10-year risk for fatal plus non-fatal CVD = 53%).

Table 4
The region-specific 10-year CVD risk

Prediction	Centre (n = 1370)	East Cost (n = 1539)	Northern (n = 2464)	Sabah (n = 608)	Sarawak (n = 506)	Southern (n = 1766)
Mean of lab-based fatal CVD (SD)	0.05 (0.08)	0.07 (0.09)	0.08 (0.11)	0.05 (0.08)	0.06 (0.08)	0.07 (0.10)
Categories						
Low Risk <10%	1131 (83%)	1195 (78%)	1800 (73%)	503 (83%)	418 (83%)	1345 (76%)
High Risk A ≥10%	157 (11%)	208 (14%)	372 (15%)	73 (12%)	54 (11%)	259 (15%)
High Risk B ≥20%	37 (2.7%)	74 (4.8%)	170 (6.9%)	21 (3.5%)	23 (4.5%)	86 (4.9%)
High Risk C ≥30%	45 (3.3%)	62 (4.0%)	122 (5.0%)	11 (1.8%)	11 (2.2%)	76 (4.3%)
Mean of lab-based fatal plus non-fatal CVD (SD)	0.12 (0.11)	0.14 (0.12)	0.15 (0.13)	0.11 (0.10)	0.12 (0.11)	0.14 (0.13)
Categories						
Low Risk <10%	712 (52%)	655 (43%)	1028 (42%)	311 (51%)	257 (51%)	769 (44%)
High Risk A ≥10%	383 (28%)	517 (34%)	718 (29%)	187 (31%)	153 (30%)	544 (31%)
High Risk B ≥20%	163 (12%)	208 (14%)	372 (15%)	70 (12%)	57 (11%)	247 (14%)
High Risk C ≥30%	112 (8.2%)	159 (10%)	346 (14%)	40 (6.6%)	39 (7.7%)	206 (12%)
Mean of office-based fatal plus Non-fatal CVD (SD)	0.10 (0.08)	0.11 (0.09)	0.12 (0.10)	0.10 (0.08)	0.10 (0.08)	0.11 (0.09)
Categories						
Low Risk <10%	774 (56%)	780 (51%)	1168 (47%)	329 (54%)	265 (52%)	889 (50%)
High Risk A ≥10%	441 (32%)	515 (33%)	801 (33%)	196 (32%)	171 (34%)	600 (34%)
High Risk B ≥20%	108 (7.9%)	176 (11%)	336 (14%)	55 (9.0%)	47 (9.3%)	198 (11%)

Prediction	Centre (n = 1370)	East Cost (n = 1539)	Northern (n = 2464)	Sabah (n = 608)	Sarawak (n = 506)	Southern (n = 1766)
High Risk C ≥30%	47 (3.4%)	68 (4.4%)	159 (6.5%)	28 (4.6%)	23 (4.5%)	79 (4.5%)

The states in the Northern region (Perlis, Kedah, Penang and Perak) showed the highest proportion of high CVD risk for all Globorisk scores than the other states (see Figure 2). All related details regarding state-specific Globorisk risk predictions are available in Table 5.

Table 5
State-Specific Ten-year Globorisk Scores for Malaysians

Characteristic	n	Ten-year fatal categorical Globorisk		Ten-year laboratory categorical Globorisk		Ten-year office categorical Globorisk	
		Low risk	High risk	Low risk	High risk	Low risk	High risk
Johor	729	706 (97%)	23 (3%)	652 (89%)	77 (11%)	700 (96%)	29 (4%)
Kedah	521	492 (94.4%)	29 (5.6%)	435 (83%)	86 (17%)	492 (94.4%)	29 (5.6%)
Kelantan	513	484 (94.3%)	29 (5.7%)	451 (88%)	62 (12%)	489 (95.3%)	24 (4.7%)
Labuan	15	15 (100%)	0 (0%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)
Melaka	416	397 (95.4%)	19 (4.6%)	370 (89%)	46 (11%)	400 (96.2%)	16 (3.8%)
Negeri Sembilan	544	513 (94.3%)	31 (5.7%)	472 (87%)	72 (13%)	515 (95%)	29 (5%)
Pahang	482	466 (97%)	16 (3%)	441 (91.5%)	41 (8.5%)	463 (96%)	19 (4%)
Penang	602	573 (95.2%)	29 (4.8%)	538 (89%)	64 (11%)	565 (94%)	37 (6%)
Perak	636	608 (96%)	28 (4%)	559 (88%)	77 (12%)	593 (93.2%)	43 (6.8%)
Perlis	618	590 (95.5%)	28 (4.5%)	535 (87%)	83 (13%)	588 (95%)	30 (5%)
Sabah	571	561 (98.2%)	10 (1.8%)	535 (94%)	36 (6%)	546 (96%)	25 (4%)
Sarawak	501	490 (98%)	11 (2%)	465 (93%)	36 (7%)	482 (96.2%)	19 (3.8%)
Selangor	922	886 (96%)	36 (4%)	844 (91.5%)	78 (8.5%)	891 (96.6%)	31 (3.4%)
Terengganu	515	501 (97.3%)	14 (2.7%)	472 (91.7%)	43 (8.3%)	502 (97%)	13 (3%)
WP Kuala Lumpur	270	264 (98%)	6 (2%)	250 (93%)	20 (7%)	264 (98%)	6 (2%)
WP Putrajaya	122	122 (100%)	0 (0%)	114 (93.4%)	8 (6.6%)	121 (99.2%)	1 (0.8%)

Discussion

From our analysis, the population-based data for 8253 adults across Malaysia showed variations in the estimated 10-year CVD risk scores. The overall CVD risk for the Malaysian population is higher than Japan, South Korea, Spain, and Denmark [16]. Common comorbidities in diabetes, hypertension, hypercholesterolemia, obesity, and smoking are prevalent in Malaysia [19]. In fact, a substantial increase in those common CVD risk factors was observed in data from the NHMS conducted among Malaysians [18,20]. The increase in these CVD risk factors could be attributed to the sedentary lifestyle pattern common among Malaysians [21–23].

Men have higher CVD risk scores than women in Malaysia. This result is in line with previous studies that have found similar results [4,7,24]. For the 10-year risk of fatal CVD, our findings for men and women with a high-risk CVD risk score (See Table 2) were lower than those of South Korea (men: 7.0%, women: 7.0%) and China (men: 33.0%, women: 28.0%) [16]. As for the laboratory-based 10-year risk of fatal and non-fatal CVD, our high-risk CVD scores among men and women were higher than those in South Korea (men: 0.3%, women: 0.5%) and China (men: 10.3%, women: 9.2%) [17].

The Malaysian sex-specific high-risk for the office-based 10-year risk of fatal plus non-fatal CVD was higher than South Korea (men: 0.1%, women: 0.1%) but was substantially lower than China (men: 8.8%, women: 6.5%) [17]. In general, in all comparisons, the men had higher high-risk CVD risk scores than women; in this study, it was specifically because men had higher baseline risk factors of CVD compared with women, particularly regarding the smoking rate. In addition, the constellation of smoking with other risk factors increases the CVD risk score and the risk of CVD events in the foreseeable future [25–27]. In particular, smoking is associated with increased oxidative stress, thus predisposing individuals to smoke to develop cardiovascular diseases [28,29].

Meanwhile, the comparison between ethnicities in Malaysia showed that Malays have the highest CVD risk in all the CVD risk groups (see Table 3). This finding was consistent with previous studies showing that the high 10-year CVD risk among Malays was due to higher baseline CVD risk factors, such as diabetes, hypertension, hypercholesterolemia, and smoking [4,5]. The prominent CVD risk factors among Malays were possibly due to a high unawareness of having NCDs and poor health-seeking behavior [30–32]. Eating foods high in saturated fat, trans fat, salt, and sugar are also associated with a high risk of CVD. Previous studies conducted among Malaysians showed that Malays had poor eating habits associated with the risk of developing CVD [33,34].

Regarding the region-specific analysis, the Northern region, which comprises the states of Penang, Kedah, Perlis, and Perak, have the highest CVD risk scores compared with their counterparts (see Table 4 and Figure 2). The highest proportion of individuals with high CVD risk in the Northern region is due to a high proportion of 4 common CVD risk factors: diabetes, hypertension, hypercholesterolemia, and smoking, as evidenced in the NHMS 2015 and its corresponding cross-sectional study [20,35].

Estimating 10-year fatal and fatal plus non-fatal laboratory and office CVD risk scores reveals a comparable estimate for low and high CVD risk scores. This finding is in line with previous research that showed that 80% of adults were comparably classified into low and high CVD risk by laboratory and office risk scores [36]. Thus, the office Globorisk risk score allows for risk prediction in settings where there is no access to laboratory testing, such as during community screening and home care visits, which subsequently reduces the cost of laboratory testing.

Our study has several strengths and limitations. To the best of our knowledge, this study is the first of its kind in Malaysia that used the Globorisk risk prediction model to estimate CVD risk. Our study also used large data from the 2015 NHMS, which is representative of the Malaysian adult population. Given that national CVD incidence data are not available for Malaysia, the Globorisk risk prediction estimates fatal and non-fatal CVD rates using national ischaemic heart disease and stroke death rates from the WHO. Globorisk risk prediction also predicts the 10-year CVD risk; however, 10-year risks underestimate lifetime risk and might therefore lead to undertreatment, especially in younger individuals.

Conclusion

The 10-year risk for fatal and fatal plus non-fatal CVD based on the Globorisk risk prediction model shows substantial differences in the average CVD risk and CVD risk categories for sex, ethnicity, region, and state. Malaysian men, Malays and those living in the Northern region have a higher CVD risk than their counterparts. The results of this study are representative of the Malaysian adult population and would be useful for the control and prevention of CVD in Malaysia.

Methods

Survey data source and variables

the Institute of Public Health (IPH), Ministry of Health, Malaysia, conducted the National Health and Morbidity Survey in 2015 (NHMS 2015). The NHMS 2015 survey was a nationwide population-based cross-sectional survey, and the dataset from the survey was representative of cardiometabolic risk factor profiles of the general Malaysian population. IPH is the keeper of the dataset, and they provided the NHMS 2015 data to us after we had obtained permission from the Director of IPH, Ministry of Health, Malaysia. The NHMS 2015 dataset did not contain any identifiable variable, and we did not take additional data from the participants. The same datasets have been analysed in a few studies, and their results have been published elsewhere [37,38]. The dataset is not publicly available but can be requested from IPH, Ministry of Health Malaysia at this link http://iku.gov.my/nhms .

Further information of the NHMS 2015, including the methodology used, is available from this link https://www.moh.gov.my/moh/resources/nhmsreport2015vol2.pdf. Briefly, diabetes status was characterised as fasting blood glucose (finger-prick sample) tested using the CardioChek portable blood

test device with a value of more than 7.1 mmol/L or recorded use of oral hypoglycaemic agents or insulin injection.

Hypertension was defined as a blood pressure measurement using Omron's digital automated blood pressure monitor model HEM-907 with a value of systolic blood pressure and/or diastolic blood pressure greater than or equal to 140 mm Hg and/or 90 mm Hg, respectively. Meanwhile, hypercholesterolemia was defined as a total cholesterol level (finger-prick sample) tested using the portable CardioChek blood test device. Smoking status was defined as whether the participant was currently smoking.

Selection of participants

The NMHS 2015 dataset contains data on 29,460 participants (14,225 men and 15,235 women). Participants were eligible if older than 40 years of age in 2015 and with no prior history of major cardiovascular diseases (ischaemic heart disease or stroke). We excluded participants if their data were incomplete for the calculation of the 10-year CVD risk.

We excluded data from 10,142 male and 11,065 female participants because they were younger than 40 years or had missing data for all the Globorisk risk prediction model (age, systolic blood pressure, total cholesterol level, history of diabetes mellitus, and smoking status). Ultimately, 4083 men and 4170 women were eligible for inclusion in the study because they met the Globorisk risk prediction model (Figure 1).

The Globorisk risk prediction model to calculate 10-year CVD risk

The Globorisk risk prediction model is based on an analysis of baseline CVD risk factors. It produces a population's cardiovascular disease risk in a specific year (linked to each year in which the data were collected). The model has a set of coefficients, usually hazard ratios (specific to a population), each of which quantifies the risk factor's proportional impact on the risk of cardiovascular disease.

To estimate the coefficients for the baseline CVD risk factors in the prediction equation, the Globorisk team pooled individual-level data from eight prospective cohorts - Atherosclerosis Risk in Communities, Cardiovascular Health Study, Framingham Heart Study original cohort, Framingham Heart Study offspring cohort, Honolulu Heart Program, Multiple Risk Factor Intervention Trial, Puerto Rico Heart Health Program and Women's Health Initiative Clinical Trial [16,17].

For Globorisk risk prediction to calculate country-specific fatal and non-fatal CVD, it needs data on CVD event rates in each 5-year age group and by sex, and the mean risk factor levels for the country. After replacing the values of sex, age, smoking status, systolic blood pressure, diabetes status, and total cholesterol level in the Globorisk risk prediction, it will return three primary outcomes: (1) the laboratory-based mean 10-year risk of fatal CVD; (2) the laboratory-based mean 10-year risk of fatal plus non-fatal CVD; and (3) the office-based mean 10-year risk of fatal plus non-fatal CVD [16,17]. The fatal plus non-fatal

Globorisk risk scores are the probability of future fatal or non-fatal CVD events relative to the fatal CVD events in the initial recalibration process for each country, respectively.

The laboratory-based 10-year risk of fatal CVD

This score is the 10-year risk for fatal cardiovascular disease only. Although fatal and non-fatal cardiovascular disease are important for clinical and public health applications, national data for average death rates are more reliable than those for disease incidence, even in high-income countries [16]. The laboratory-based 10-year risk of fatal and non-fatal CVD Globorisk risk score is calculated from 6 variables: sex, age, smoking status, systolic blood pressure, diabetes status and total cholesterol level [16,17].

The laboratory-based 10-year risk of fatal plus non-fatal CVD

The laboratory-based 10-year risk of fatal and non-fatal CVD Globorisk risk score is calculated from same 6 variables: sex, age, smoking status, systolic blood pressure, diabetes status and total cholesterol level [17]. This calculation allows for the estimation of specific CVD risk using readily available population-wide survey data in most middle- and high-income countries.

The office-based 10-year risk of fatal plus non-non-fatal CVD

The office-based 10-year risk of fatal and non-non-fatal CVD Globorisk risk score is calculated from 5 variables: sex, age, smoking status, systolic blood pressure and BMI (diabetes status and total cholesterol are replaced with BMI) [17]. BMI has a strong association with diabetes status and total cholesterol and acts as a proxy to increased body weight, blood glucose and serum cholesterol [17,39]. The modification estimates CVD risk score in an economically poor resource setting in which laboratory facilities are limited.

Statistical methods

Categorical variables are presented using frequencies (n) and percentages (%). Meanwhile, continuous variables are presented using means (SD) for normally distributed data and medians (interquartile range) for skewed data. We calculated the CVD risk scores for each eligible participant. CVD risk scores are typically classified into various categories. For this paper, we divided them into 4 categories: a low risk for future CVD (if the CVD risk score was <10%) and 3 high-risk CVD categories (if CVD risk is equal to or greater than 10%, 20% and 30%) [2,40,41]. An analysis was performed for overall risk and by sex, race, region, and state in Malaysia. All the statistical analyses were performed using R software version 3.6.1 [42] and the **gtsummary**, **summarytools** and **ggplot2** packages [43–45] in RStudio IDE.

Declarations

Ethical approval

This study was performed in accordance with the principles of the Helsinki Declaration. Ethical approval to perform the study was obtained from the Human Research and Ethics Committee, Universiti Sains Malaysia USM/JEPeM/19100607, and the Medical Research and Ethics Committee of the National Institute of Health, Ministry of Health Malaysia NMRR-19-3061-51277 (IIR).

Acknowledgements

The authors would like to thank the Director General of Health Malaysia for permission to publish this paper. We would also like to say thank you to Associate Professor Dr Goodarz Danaei for providing us the Stata codes for running the Globorisk risk prediction model and the CVD event rates in each 5-year age group and by sex and the mean risk factors level for Malaysia.

Author contributions

Che Muhammad Nur Hidayat Che Nawi and Kamarul Imran Musa contributed to the conception and design of the study. Che Muhammad Nur Hidayat Che Nawi, Kamarul Imran Musa and Mohd. Azahadi Omar contributed to the acquisition, analysis, and interpretation of the data for research. Che Muhammad Nur Hidayat Che Nawi drafted the manuscript. Kamarul Imran Musa and Thomas Keegan acted as epidemiological and statistics advisers. Yong Poh Yu contributed to the development of interactive shiny dashboard to ease the reader understanding. All authors reviewed the manuscript objectively, gave final approval and agreed to be responsible for all aspects of the research ensuring reliability and precision.

Funding

We would like to thank the Universiti Sains Malaysia for funding this study through the Research University Grant (Probability of Cardiovascular Disease and Assessing the Predictive Effect of Job Stress on CVD Risk: A Study Among Healthcare Providers Using the Framingham and Globorisk Scores, 1001/PPSP/8012359).

Competing interest

The authors declare no competing interests.

Additional information

We have developed a dashboard that provides an interactive approach for readers to view the results from this paper. The dashboard also includes results that not available in this paper due to the constraint of the space. The dashboard is available at https://kim-usm.shinyapps.io/Globorisk4Malaysia/.

References

1 Roth, G. A. *et al.* Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet***392**, 1736-1788, doi:https://doi.org/10.1016/S0140-6736(18)32203-7 (2018).

2 WHO. Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013-2020. Report No. 9241506237, (Geneva, Switzerland, 2013).

3 Ministry of Health Malaysia. Annual Report 2017. (Kuala Lumpur, Malaysia, 2017).

4 Borhanuddin, B. *et al.* 10-year cardiovascular disease risk estimation based on lipid profile-based and BMI-based Framingham risk scores across multiple sociodemographic characteristics: The Malaysian Cohort Project. *ScientificWorldJournal***2018**, 2979206, doi:https://doi.org/10.1155/2018/2979206 (2018).

5 Chia, Y. C., Gray, S. Y., Ching, S. M., Lim, H. M. & Chinna, K. Validation of the Framingham general cardiovascular risk score in a multiethnic Asian population: a retrospective cohort study. *BMJ Open***5**, e007324, doi:http://dx.doi.org/10.1136/bmjopen-2014-007324 (2015).

6 Noor Hassim, I., Norazman, M. R., Diana, M., Khairul Hazdi, Y. & Rosnah, I. Cardiovascular risk assessment between urban and rural population in Malaysia. *Med J Malaysia***71**, 331-337 (2016).

7 Selvarajah, S. *et al.* Comparison of the Framingham Risk Score, SCORE and WHO/ISH cardiovascular risk prediction models in an Asian population. *Int J Cardiol***176**, 211-218, doi:https://doi.org/10.1016/j.ijcard.2014.07.066 (2014).

8 Su, T. T. *et al.* Prediction of cardiovascular disease risk among low-income urban dwellers in metropolitan Kuala Lumpur, Malaysia. *Biomed Res Int***2015**, 516984, doi:https://doi.org/10.1155/2015/516984 (2015).

9 Yew, S. Q., Chia, Y. C. & Theodorakis, M. Assessing 10-Year cardiovascular disease risk in Malaysians with type 2 diabetes mellitus: Framingham cardiovascular versus United Kingdom prospective diabetes study equations. *Asia Pac J Public Health***31**, 622-632, doi:https://doi.org/10.1177%2F1010539519873487 (2019).

10 Cook, N. R. *et al.* Comparison of the Framingham and Reynolds Risk scores for global cardiovascular risk prediction in the multiethnic Women's Health Initiative. *Circulation***125**, 1711-1748, doi:https://doi.org/10.1161/CIRCULATIONAHA.111.075929 (2012).

11 Chia, Y. C. Review of tools of cardiovascular disease risk stratification: interpretation, customisation and application in clinical practice. *Singapore Med J***52**, 116-123 (2011).

12 Liu, J. *et al.* Predictive value for the Chinese population of the Framingham CHD risk assessment tool compared with the Chinese multi-provincial cohort study. *JAMA***291**, 2591-2599, doi:10.1001/jama.291.21.2591 (2004).

13 Brindle, P. *et al.* Predictive accuracy of the Framingham coronary risk score in British men:prospective cohort study. *BMJ***327**, 1267, doi:https://doi.org/10.1136/bmj.327.7426.1267 (2003).

14 Menotti, A., Lanti, M., Puddu, P. E. & Kromhout, D. Coronary heart disease incidence in northern and southern European populations: a reanalysis of the seven countries study for a European coronary risk chart. *Heart***84**, 238-244, doi:http://dx.doi.org/10.1136/heart.84.3.238 (2000).

15 Harvard T. H. Chan School of Public Health. *Globorisk*, <http://www.globorisk.org/> (2016).

16 Hajifathalian, K. *et al.* A novel risk score to predict cardiovascular disease risk in national populations (Globorisk): a pooled analysis of prospective cohorts and health examination surveys. *Lancet Diabetes Endocrinol***3**, 339-355, doi:https://doi.org/10.1016/S2213-8587(15)00081-9 (2015).

17 Ueda, P. *et al.* Laboratory-based and office-based risk scores and charts to predict 10-year risk of cardiovascular disease in 182 countries: a pooled analysis of prospective cohorts and health surveys. *Lancet Diabetes Endocrinol***5**, 196-213, doi:https://doi.org/10.1016/S2213-8587(17)30015-3 (2017).

18 AMM. Primary & Secondary Prevention of Cardiovascular Disease 2017. (Putrajaya, Malaysia, 2017).

19 Ghazali, S. M. *et al.* Sociodemographic factors associated with multiple cardiovascular risk factors among Malaysian adults. *BMC Public Health***15**, 68, doi:10.1186/s12889-015-1432-z (2015).

20 Institute for Public Health. National Health and Morbidity Survey: Non-communicable diseases, risk factors & other health problems. (Kuala Lumpur, Malaysia, 2015).

21 Chan, Y. Y. *et al.* Physical activity and overweight/obesity among Malaysian adults: findings from the 2015 National Health and morbidity survey (NHMS). *BMC Public Health***17**, 733, doi:10.1186/s12889-017-4772-z (2017).

22 Gan, W. Y., Mohamed, S. F. & Law, L. S. Unhealthy Lifestyle Associated with Higher Intake of Sugar-Sweetened Beverages among Malaysian School-Aged Adolescents. *Int J Environ Res Public Health***16**, 2785, doi:10.3390/ijerph16152785 (2019).

23 Mohammadi, S. *et al.* Dietary and physical activity patterns related to cardio-metabolic health among Malaysian adolescents: a systematic review. *BMC Public Health***19**, 251, doi:10.1186/s12889-019-6557-z (2019).

24 Metcalf, P. A., Wells, S. & Jackson, R. T. Assessing 10-year coronary heart disease risk in people with Type 2 diabetes mellitus: Framingham versus United Kingdom Prospective Diabetes Study. *Journal of Diabetes Mellitus***Vol.04No.01**, 7, doi:10.4236/jdm.2014.41003 (2014).

25 Hazreen, M. A. *et al.* An exploratory study on risk factors for chronic non-communicable diseases among adolescents in Malaysia: overview of the Malaysian Health and Adolescents Longitudinal Research Team study (The MyHeART study). *BMC Public Health***14 Suppl 3**, S6, doi:https://doi.org/10.1186/1471-2458-14-S3-S6 (2014).

26 Russell, S. *et al.* The burden of non-communicable diseases and their related risk factors in the country of Georgia, 2015. *BMC Public Health***19**, 479, doi:https://doi.org/10.1186/s12889-019-6785-2 (2019).

27 Mohamed, M., Winn, T., Rampal, G. L., Abdul Rashid, A. & Mustaffa, B. A prelimenary result of the cardiovascular risk factors intervention study (Pikom Study): Diabetes mellitus, hypertension and their associated factors. *Malays J Med Sci***12**, 20-25 (2005).

28 Khan, N. A. *et al.* Systemic biomarkers of inflammation, oxidative stress and tissue injury and repair among waterpipe, cigarette and dual tobacco smokers. *Tobacco Control***29**, s102-s109, doi:http://dx.doi.org/10.1136/tobaccocontrol-2019-054958 (2020).

29 Uchmanowicz, I. in *Frailty and Cardiovascular Diseases : Research into an Elderly Population* (ed Nicola Veronese) 65-77 (Springer International Publishing, 2020).

30 Amal, N. M., Paramesarvathy, R., Tee, G. H., Gurpreet, K. & Karuthan, C. Prevalence of chronic illness and health seeking behaviour in Malaysian population: Results from the Third National Health Morbidity Survey (NHMS III) 2006. *Med J Malaysia***66**, 36-41 (2011).

31 Man, R. E. K. *et al.* Prevalence, determinants and association of unawareness of diabetes, hypertension and hypercholesterolemia with poor disease control in a multi-ethnic Asian population without cardiovascular disease. *Popul Health Metr***17**, 17, doi:https://doi.org/10.1186/s12963-019-0197-5 (2019).

32 Muda, W. A., Kuate, D., Jalil, R. A., Nik, W. S. & Awang, S. A. Self-perception and quality of life among overweight and obese rural housewives in Kelantan, Malaysia. *Health Qual Life Outcomes***13**, 19, doi:https://doi.org/10.1186/s12955-015-0210-z (2015).

33 Lee, H., Aman, A., Kamaruddin, K., Ali, A. & Yusof, H. Ethnic differences on cardiovascular disease risk and quality of life in Selangor. *Food Research***4**, 1272-1286, doi:https://doi.org/10.26656/fr.2017.4(4).035 (2020).

34 Shyam, S. *et al.* Association between dietary patterns and overweight risk among Malaysian adults: evidence from nationally representative surveys. *Public Health Nutrition***23**, 319-328, doi:https://doi.org/10.1017/S1368980019001861 (2020).

35 Nuur Amalina, A. G., Jamaiyah, H. & Selvarajah, S. Geographical variation of cardiovascular risk factors in Malaysia. *Med J Malaysia***67**, 31-38 (2012).

36 Gaziano, T. A. *et al.* Comparison of nonblood-based and blood-based total CV risk scores in global populations. *Global heart***11**, 37-46. e32 (2016).

37 Ariaratnam, S. *et al.* Prevalence of obesity and its associated risk factors among the elderly in Malaysia: Findings from The National Health and Morbidity Survey (NHMS) 2015. *Plos one***15**, e0238566 (2020).

38 Sazlina, S. G. *et al.* Cardiovascular disease risk factors among older people: Data from the National Health and Morbidity Survey 2015. *PloS one***15**, e0240826 (2020).

39 Lu, Y., Hajifathalian, K., Rimm, E. B., Ezzati, M. & Danaei, G. Mediators of the effect of body mass index on coronary heart disease: decomposing direct and indirect effects. *Epidemiology***26**, 153-162 (2015).

40 Goff, D. C. *et al.* 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Journal of the American College of Cardiology***63**, 2935-2959 (2014).

41 National Clinical Guideline, C. in *Lipid Modification: Cardiovascular Risk Assessment and the Modification of Blood Lipids for the Primary and Secondary Prevention of Cardiovascular Disease* (National Institute for Health and Care Excellence (UK) Copyright © National Clinical Guideline Centre, 2014., 2014).

42 R: A Language and Environment for Statistical Computing (Vienna, Austria, 2019).

43 gtsummary: Presentation-Ready Data Summary and Analytic Result Tables v. R package version 1.2.6 (2020).

44 ggplot2: Elegant Graphics for Data Analysis (Springer-Verlag New York, Springer-Verlag New York, 2016).

45 summarytools: Tools to Quickly and Neatly Summarize Data v. R package version 0.9.4 (2019).

Figures

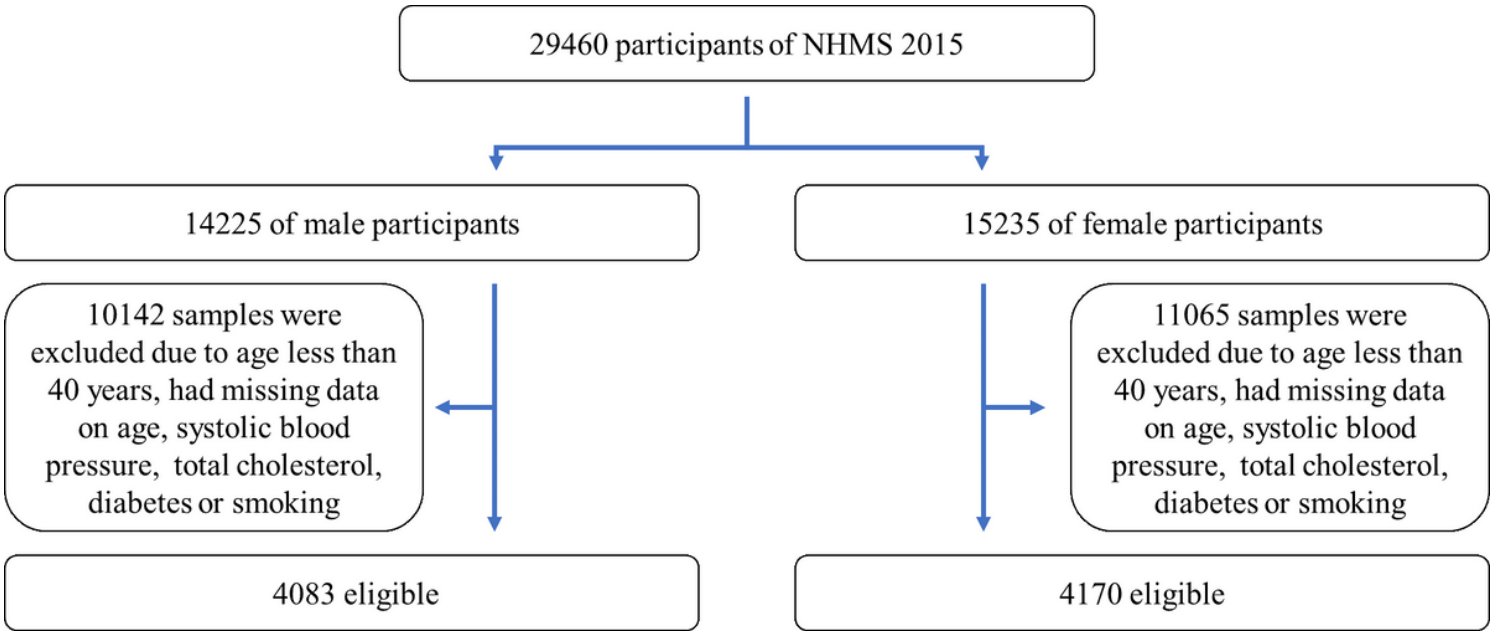

Figure 1

Study participant flow chart

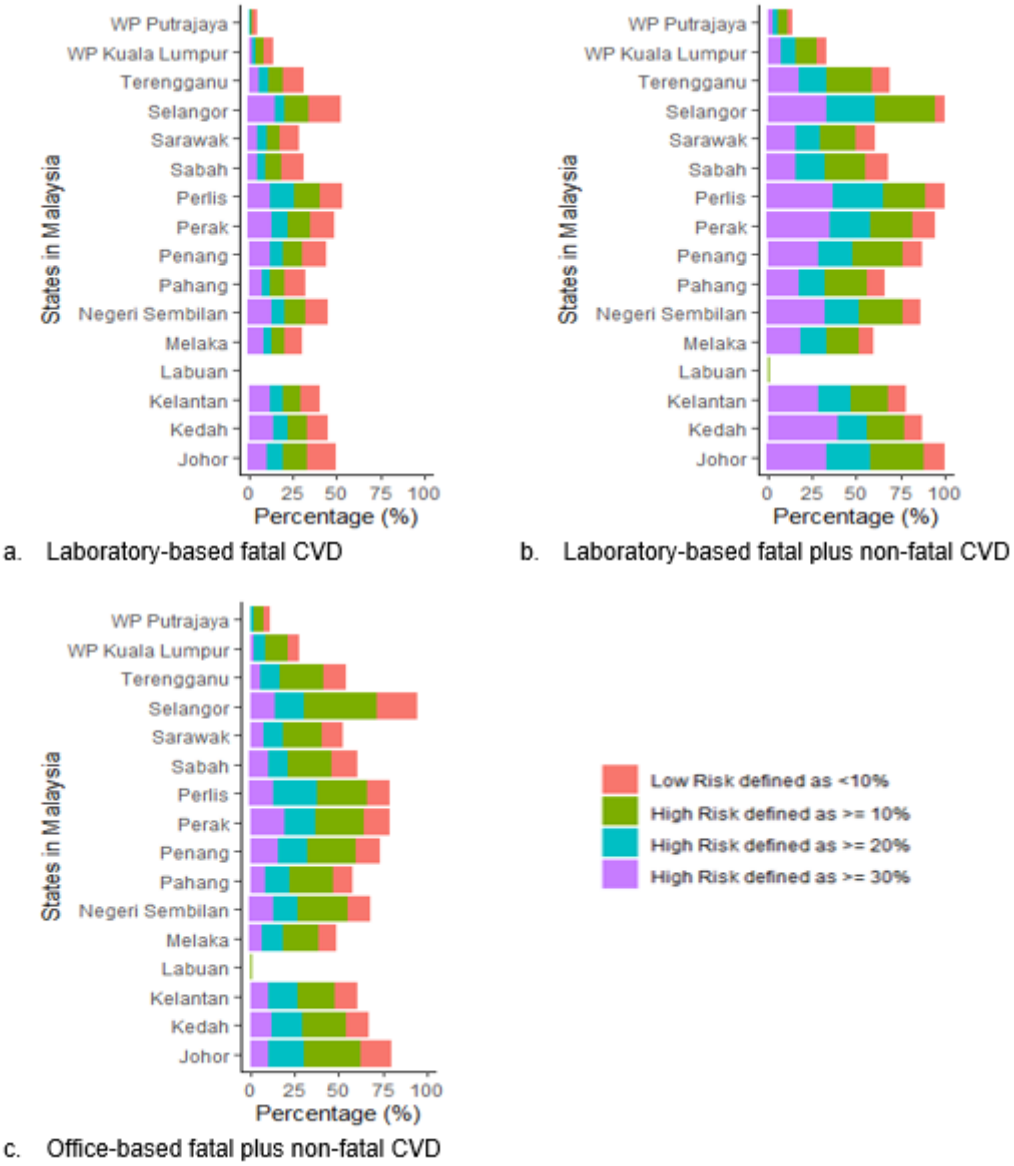

Figure 2

State-specific 10-year CVD risk. (a) The state-specific 10-year risk of laboratory-based fatal CVD; (b) The state-specific 10-year risk of laboratory-based fatal plus non-fatal CVD; (c) The state-specific 10-year risk of office-based fatal plus non-fata