RECALIBRATED SINGAPORE-MODIFIED FRAMINGHAM RISK SCORE 2023 (SG-FRS-2023)

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Background

The current recommended guidelines for coronary heart disease (CHD) risk screening in Singapore are based on the locally recalibrated Framingham-based NCEP ATP III models (1), hereafter referred to as the SG-ATP III model. The SG-ATP III model uses predictors such as age, smoking history, blood pressure, and blood lipids to predict the 10-year risk of CHD using sex- and ethnic-specific models. The SG-ATP III model was previously recalibrated using data from the Singapore Cardiovascular Cohort Study (SCCS) with baseline recruitment between 1982 and 1995 and linkage to national registries in December 2004 (2). A recent study on the global cardiovascular disease (CVD) incidence trends revealed that the global CVD incidence has been on a descending trend since 1996 (3), which highlighted the need to re-evaluate the predictive performance of the SG-ATP III model using a more recent dataset. In this study, we evaluated the discrimination and calibration of the SG-ATP III model using data from the Singapore Multi-Ethnic Cohort Phase 1 (MEC1). We also recalibrated the model and evaluated the discrimination and calibration of the recalibrated SG-ATP III model in MEC1.

For ease of reference, this will be referred to as the Singapore-modified Framingham Risk Score 2023 (SG-RFS-2023), as named in the MOH Clinical Practice Guidelines 2011 for cardiovascular screening, as it was thought to be more familiar to local clinicians.

Methodology

Study population

MEC1 is a population-based cohort study that was set up to study how genetics, lifestyle, and environmental factors influence chronic disease risk. Details of the MEC1 study have been reported previously (4). Briefly, between 2004 and 2010, 14,465 male and female adult Singapore residents were recruited with disproportionate sampling stratified by ethnicity to ensure a good representation of the three major ethnic groups in Singapore—Chinese, Malay, and Indian. Participants completed an interviewer administered questionnaire that included questions on socio-demographic variables, lifestyle variables, and personal medical history, and were subsequently invited to physical examination at a study site where measurements such as blood pressure and blood lipids were measured. For the present analysis, we excluded participants who did not give consent to record linkage (n = 1,355), participants with stroke or heart diseases at baseline (n = 304), participants who did not complete the interview or attend the physical examination at baseline (n = 2556), participants with ethnicity other than Chinese, Malay, or Indian (n = 30), participants with missing data (n = 44), and participants with a baseline age of <20 or >79 (n = 22). We further excluded participants with type 2 diabetes at baseline (based on self-reported physician diagnosis, fasting glucose > 7.0 mmol/L, or HbA1c > 6.5% at baseline) (n = 1446) as the SG-ATP III model was

designed for CHD risk assessment among individuals without type 2 diabetes (1). After exclusion, data from 8,708 participants remained for the analysis.

Ascertainment of outcome

The main outcome of interest is the incidence of coronary heart disease (CHD), which is defined as non-fatal acute myocardial infarction mortality and ischemic heart disease mortality (ICD-10 I20-I25). We ascertained CHD incidence through record linkage in December 2017 with the National Registry of Diseases Office (NRDO), which identifies CHD incident cases through hospital in-patient discharge summaries from all public healthcare institutions, medical claims from the Ministry of Health, and the death registry from the Ministry of Home Affairs. The follow-up duration was calculated from the date of recruitment to the date of the first CHD event or end of follow-up, and individuals who did not experience any CHD event by the end of follow-up were censored.

Statistical analysis

Discrimination and calibration of the original SG-ATP III model

The parameters needed to estimate the predicted risk for an individual using the original SG-ATP III model are: (1) the average 10-year survival in the population, (2) the coefficient for each risk factor, (3) the means of the risk factors, and (4) the values of each risk factor for that individual. The coefficients and means of the risk factors were obtained from the original Framingham-based NCEP ATP III model (1). The sex- and ethnic-specific 10-year average survival were previously estimated using the Kaplan-Meier estimator from SCCS. The predicted 10-year CHD risk is calculated using **Equation 1**:

$$1 - S_{10,SCCS}^{\exp \sum \beta_{FHS}(x_{individual} - \bar{x}_{FHS})} \quad (1)$$

where,

$S_{10,\mathrm{SCCS}}$ is the average 10-year survival estimated previously from SCCS
β_{FHS} are the beta coefficients from the original Framingham-based ATPIII model
$x_{\mathrm{individual}}$ are the values of the risk factors of an individual
$\bar{x}_{\mathrm{FHS}}$ are the means of the risk factors from the original Framingham-based ATPIII model

Discrimination refers to the ability of the model to differentiate those at a higher risk compared to those at a lower risk. We assessed discrimination using the concordance index (C-index), which represents the probability of allocating a higher risk score to an individual with a shorter time-to-event out of two randomly selected individual. C-index < 0.6 suggests poor discrimination, C-index 0.60—0.75 suggests possibly helpful discrimination, and C-index > 0.75 suggests clearly useful discrimination (5).

Calibration refers to how accurate the model is in estimating the absolute risk of event (5). We assessed calibration using the calibration slope, calibration-in-the-large (CIL), and deviance (6). The calibration slope is a measure of the spread of estimated risk and has a target value of 1 (7). The CIL is the measure of overall calibration with a target value of 0. CIL below 0 suggest an overestimation of risk, while values above 0 suggest an underestimation of risk (7). The deviance is a measure of the overall goodness-of-fit of the model, where high deviance (P < 0.005) suggests poor fit (6). We also compared the observed risk against predicted risk in quintiles of predicted risk using bar plots.

Recalibration of SG-ATPIII model

We recalibrated the SG-ATPIII model using the same method that was used to recalibrate the original SG-ATP III model, based on a published method (10). It involves the replacement of the previously estimated sex- and ethnic-specific average 10-year survival in SCCS (1982 to 2004) with the newly estimated average 10-year survival in MEC1 (2004 to 2018) to account for the differences in average CHD risk that may have changed over time (**Equation 2**). After recalibration, we assessed the discrimination and calibration of the recalibrated SG-ATP III in MEC1.

$$1 - S_{10,MEC1}^{\exp \sum \beta_{FHS}(x_{individual} - \bar{x}_{FHS})} \quad (2)$$

where,

$S_{10,MEC1}$ is the average 10-year survival estimated from MEC1
β_{FHS} are the beta coefficients from the original Framingham-based ATPIII model
$x_{individual}$ are the values of the risk factors of an individual
$\bar{x}_{FHS}$ are the means of the risk factors from the original Framingham-based ATPIII model

Translation to a simplified point-based scoring system

To facilitate the use of the SG-ATP III model in practice, we translated the recalibrated SG-ATP III equations to a point-based scoring system according to the method detailed by Sullivan et al. (9). The point-based scoring system would allow an individual to estimate their 10-year risk of CHD by summing the scores for each risk factor and comparing the total score against the accompanying score sheet.

Sensitivity analyses

We performed a second round of recalibration of the SG-ATP III model with a less stringent exclusion criteria for type 2 diabetes. Participants were retained for the second round of recalibration analysis if they did not report a prior diagnosis of type 2 diabetes, regardless of their fasting blood glucose or HbA1c levels at baseline.

Results

The baseline characteristics of participants are shown in **Table 1**. Participants were male (42.1%) and female (57.9%) adults with a mean age of 44.0 (± SD 12.5) years. The ethnic composition was 48% Chinese, 26% Malay, and 25% Indian. Over a mean follow-up duration of 10.2 (± SD 2.2) years, we documented 154 incident CHD cases.

Table 1. Baseline characteristics of participants in the Singapore Multi-Ethnic Cohort Phase 1.

Characteristic	Chinese	Malay	Indian	All
n	4206 (48.3%)	2273 (26.1%)	2229 (25.6%)	8708 (100%)
Male	1844 (43.8%)	925 (40.7%)	899 (40.3%)	3668 (42.1%)
Age, years	45.3 ± 12.5	42.7 ± 12.3	42.7 ± 12.4	44.0 ± 12.5
Smoker	456 (10.8%)	535 (23.5%)	378 (17.0%)	1369 (15.7%)
Hypertension	586 (13.9%)	242 (10.6%)	271 (12.2%)	1099 (12.6%)
SBP, mmHg	125 ± 19.5	126 ± 19.7	121 ± 20.0	124 ± 19.8
TC, mmol/L	5.21 ± 0.917	5.45 ± 1.00	5.16 ± 0.948	5.26 ± 0.955
HDL, mmol/L	1.44 ± 0.367	1.25 ± 0.325	1.13 ± 0.316	1.31 ± 0.367
Follow-up duration, years	10.7 ± 2.24	9.80 ± 1.85	9.57 ± 1.97	10.2 ± 2.14

Numbers are counts (percentage) or mean ± SD

Discrimination and calibration of the original SG-ATP III model

The parameters (coefficients, means of risk factors, and average 10-year survival) for the SG-ATPIII model are shown in **Table 2**.

The discrimination and calibration statistics for the SG-ATPIII model in MEC1 are shown in **Table 3**. The C-index ranged from 0.737 (95% CI 0.412 to 0.915) for Malay females to 0.943 (0.635 to 0.994) for Chinese females. The calibration of the SG-ATP III model in MEC1 was poor. Although the 95% confidence intervals for the calibration slope in all sex and ethnic groups included the target value of 1, there was an overestimation of risk across all sex and ethnic groups (CIL < 0, P < 0.05). In particular, the number of predicted events were more than 2 times the observed number of events among females. The goodness-of-fit of the models were poor across all sex and ethnic groups as indicated by the high deviance (P < 0.05).

Table 2. Coefficients and baseline 10-year survival from the SG-ATPIII model and recalibrated SG-ATPIII model.

	Male		Female	
Predictor	**Coefficient[1]**	**Means[1]**	**Coefficient[1]**	**Means[1]**
Ln(age)	52.01	3.89	31.76	3.92
Ln(TC)	20.01	5.34	22.47	5.36
Ln(HDL)	-0.91	3.77	-1.19	4.01
Ln(SBP)	1.31	4.86	2.55	4.84
Hypertension treatment if SBP>120	0.24	0.12	0.42	0.14
Smoker	12.1	0.34	13.08	0.32
Ln(age)*Ln(TC)	-4.61	20.81	-5.06	21.06
Ln(age)*Smoker	-2.84	1.29	-3.00	1.25
Ln(age)*Ln(age)	-2.93	15.21	NA	NA
	10-year average survival		**10-year average survival**	
Model	**Original[2]**	**Recalibrated[3]**	**Original[2]**	**Recalibrated[3]**
Chinese	0.9614	0.9750	0.9892	0.9954
Malay	0.9503	0.9593	0.9800	0.9919
Indian	0.9128	0.9425	0.9675	0.9885

[1]The coefficients and means of the risk factors were obtained from the original Framingham-based NCEP ATP III model.
[2]The sex- and ethnic-specific 10-year average survival were estimated using the Kaplan-Meier estimator from the Singapore Cardiovascular Cohort Study with baseline recruitment between 1982 and 1995 and record linkage in December 2004
[3]The sex- and ethnic-specific 10-year average survival were estimated using the Kaplan-Meier estimator from the Singapore Multi-Ethnic Cohort Phase 1 with baseline recruitment between 2004 and 2010 and record linkage in December 2017.
Abbreviations: TC, total cholesterol; HDL, high density lipoprotein cholesterol; SBP, systolic blood pressure

Table 3. Discrimination and calibration of the SG-ATP III model for predicting 10-year CHD risk in the Singapore Multi-Ethnic Cohort Phase 1.

	Male			Female		
Metric	**Chinese**	**Malay**	**Indian**	**Chinese**	**Malay**	**Indian**
C-index	0.838	0.789	0.779	0.943	0.737	0.778
(95% CI)	(0.692, 0.923)	(0.622, 0.894)	(0.626, 0.881)	(0.635, 0.994)	(0.421, 0.915)	(0.491, 0.927)
Observed N events	42	35	44	10	10	13
Adjusted N events[1]	45.8	37.6	50.5	10.8	11.1	14.5
Predicted N events	71.2	54.5	80.2	23.8	27.0	38.9
CIL	-0.476	-0.387	-0.563	-0.808	-0.943	-1.065
(95% CI)	(-0.794, -0.188)	(-0.738, -0.073)	(-0.874, -0.282)	(-1.499, -0.246)	(-1.634, -0.381)	(-1.662, -0.566)
CIL P-value	0.002	0.022	<0.001	0.011	0.003	<0.001
Calibration slope	1.429	0.972	0.898	1.446	0.569	0.688
(95% CI)	(0.992, 1.918)	(0.598, 1.396)	(0.589, 1.250)	(0.912, 2.017)	(0.135, 1.079)	(0.314, 1.108)
Deviance	15.4	7.7	20.4	14.9	19.5	28.0
Deviance P-value	0.004	0.101	<0.001	0.005	0.001	<0.001

[1]Adjusted number of observed events using the Kaplan-Meier method to account for participants with a follow-up duration of <10 years.

Recalibrated SG-ATPIII model

We recalibrated the SG-ATPIII model by replacing the sex- and ethnic-specific average 10-year survival with the 10-year average survival from MEC1 (**Table 2**). Compared to the previously estimated average 10-year survival in SCCS (1982 to 2004), the newly estimated 10-year average survival in MEC1 (2004 to 2017) were higher across all sex and ethnic groups. For example, among Chinese males, the average probability of surviving 10 years without experiencing any CHD event increased from 0.9614 in SCCS to 0.9750 in MEC1.

After recalibration, the agreement between the predicted risks and observed risks was generally improved across quintiles of predicted risk, with the biggest improvements observed in the highest risk quintile (**Figures 1.1—1.3)**. The calibration was satisfactory across all sex and ethnic groups as indicated by the CIL (P > 0.05) and calibration slope (95% confidence intervals overlapped the target value of 1) (**Table 4**). In addition, the goodness-of-fit test was non-significant (P > 0.05) which suggested good model fit across sex and ethnicity.

To simplify the estimation of 10-year CHD risk without the need for calculators or computers, we translated the recalibrated SG-ATP III model to a point-based scoring system (**Appendix A**). This point-based scoring system would allow an individual to estimate their 10-year risk of CHD by summing the scores for each risk factor and comparing the total score against the provided score sheet. For a more precise estimation of the 10-year CHD risk, it is still recommended to use the original equation (**Equation 2**) and the parameters provided in **Table 2**.

Table 4. Discrimination and calibration of the recalibrated SG ATP III model for predicting 10-year CHD risk in the Singapore Multi-Ethnic Cohort Phase 1.

	Male			Female		
Metric	**Chinese**	**Malay**	**Indian**	**Chinese**	**Malay**	**Indian**
C-index	0.838	0.789	0.779	0.943	0.737	0.778
(95% CI)	(0.692, 0.923)	(0.622, 0.894)	(0.626, 0.881)	(0.635, 0.994)	(0.421, 0.915)	(0.491, 0.927)
Observed N events	42	35	44	10	10	13
Adjusted N events[1]	45.8	37.6	50.5	10.8	11.1	14.5
Predicted N events	46.7	45.0	54.0	10.2	11.1	14.4
CIL	-0.036	-0.182	-0.132	0.056	-0.029	-0.018
(95% CI)	(-0.355, 0.251)	(-0.533, 0.132)	(-0.442, 0.150)	(-0.635, 0.618)	(-0.720, 0.533)	(-0.616, 0.480)
CIL P-value	0.813	0.281	0.382	0.859	0.928	0.948
Calibration slope	1.429	0.972	0.898	1.446	0.569	0.688
(95% CI)	(0.992, 1.918)	(0.598, 1.396)	(0.589, 1.250)	(0.912, 2.017)	(0.135, 1.079)	(0.314, 1.108)
Deviance	4.3	3.0	4.2	6.2	7.0	6.3
Deviance P-value	0.372	0.560	0.377	0.185	0.138	0.176

[1]Adjusted number of observed events using the Kaplan-Meier method to account for participants with a follow-up duration of <10 years.

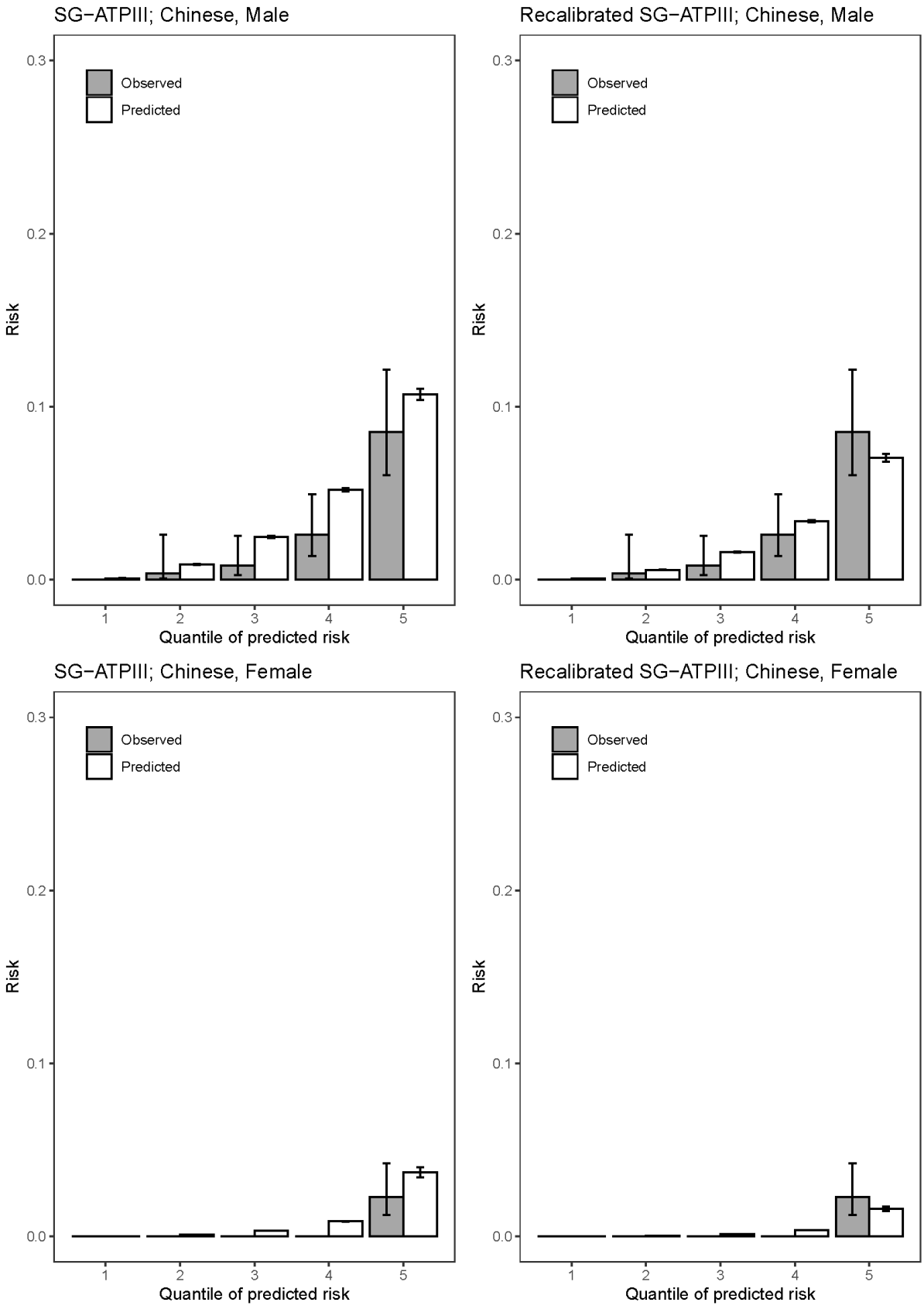

Figure 1.1 Comparison of the observed and predicted risk of the original (left) and recalibrated (right) SG-ATP III model among Chinese males (top) and females (bottom) in the Singapore Multi-Ethnic Cohort Phase 1.

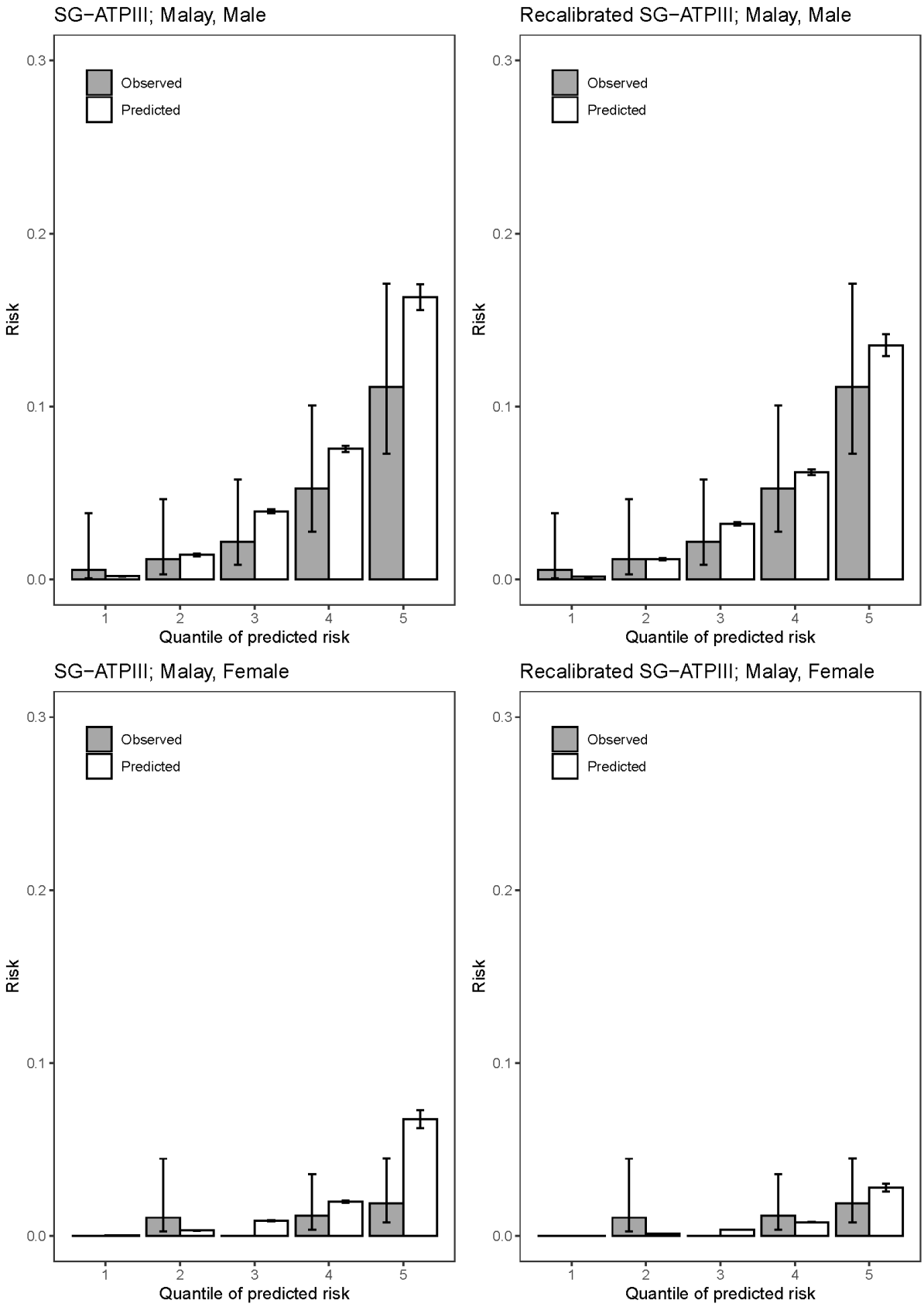

Figure 1.2 Comparison of the observed and predicted risk of the original (left) and recalibrated (right) SG-ATP III model among Malay males (top) and females (bottom) in the Singapore Multi-Ethnic Cohort Phase 1.

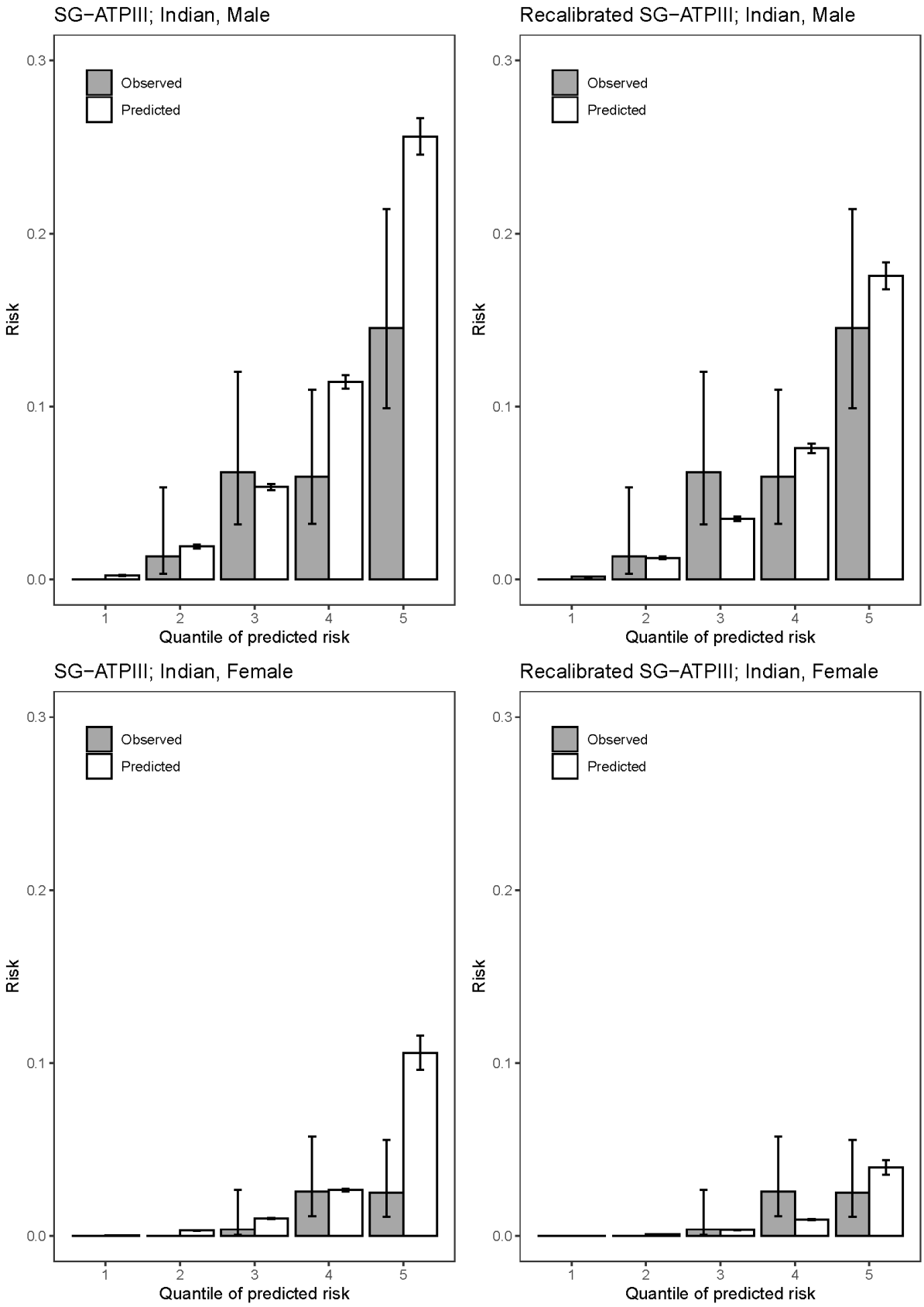

Figure 1.3 Comparison of the observed and predicted risk of the original (left) and recalibrated (right) SG-ATP III model among Indian males (top) and females (bottom) in the Singapore Multi-Ethnic Cohort Phase 1.

Sensitivity analyses

We performed a second round of recalibration using the average 10-year survival estimated in a set of participants with a less stringent exclusion criteria for type 2 diabetes—participants were retained for analysis if they did not have a prior diagnosis of type 2 diabetes regardless of their fasting blood glucose and HbA1c levels. There was an overestimation of risk among Malay males (CIL = -0.290, P = 0.037) after the second round of recalibration (**Appendix B**). A comparison of the CIL point estimates suggested poorer overall calibration (values are further away from the target value of 0) for most subgroups in the second round of recalibration when compared to the first recalibration using a more stringent exclusion of type 2 diabetes based on physician diagnosis and fasting glucose/HbA1c levels.

Summary

In this report, we evaluated the discrimination and calibration of the Framingham-based SG-ATP III model using recent data from a population-based cohort (MEC1) in Singapore. While the discrimination of the SG-ATP III model was satisfactory (C-index ranged from 0.72 to 0.94), the calibration of the model was poor. Specifically, the SG-ATP III model consistently overestimated the 10-year risk of CHD across sex and ethnicity, especially among females with a 2-fold higher predicted risk compared to the observed risk.

We recalibrated the SG-ATP III model by updating the previously estimated 10-year survival rates from SCCS (1982 to 2004) with the newly estimated 10-year survival rates from MEC1 (2004 to 2017). The improved 10-year CHD-free survival observed in MEC1 over SCCS is supported by a recent study on the global temporal trends of CVD incidence (3). In that study, the authors reported a descending trend in the global CVD incidence rate since 1996 with a more pronounced decrease observed in developed countries (3). After recalibration, the model fit was improved and there was no evidence of a misestimation of risk across all sex and ethnic groups.

We recalibrated the SG-ATP III model using the same method that was used to derive the original SG-ATP III model, following a published method (10). This method was chosen as it involves the adjustment of the baseline risk from the original Framingham-based NECP ATP III model without the need to derive a new set of coefficients. This reduces the need for further external validation of the SG-ATP III model in an independent cohort as the transportability of the Framingham CHD risk functions have been previously demonstrated in geographically and ethnically diverse populations including Japanese American, Hispanic, Native American, and Chinese populations (8,12). One potential limitation of this method is that it does not improve the discrimination of the model. However, the discrimination of the original SG-ATP III model was shown to be satisfactory across all subgroups and therefore was not the main focus of the present recalibration.

We performed sensitivity analyses to evaluate the recalibration of the SG-ATP III model based on a less stringent exclusion criteria for type 2 diabetes. In this set of analysis, we included participants that did not have a prior diagnosis of type 2 diabetes regardless of their fasting glucose or HbA1c levels. The results indicate that the less stringent exclusion criteria solely based on past diagnosis history resulted in a poorer calibration in most subgroups, with a significant overestimation of risk among Malay males. Hence, the recalibrated SG-ATP III model should only be used among individuals without type 2 diabetes, elevated fasting glucose (> 7 mmol/L), or HbA1C levels (> 6.5%). Future work is needed to identify new prediction models for CVD risk assessment among individuals with diabetes or elevated glycemic markers.

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Appendix A.

Table A1. Score sheet for the estimation of 10-year coronary heart disease risk in men.

Age	Points
20-34	-9
35-39	-4
40- 44	0
45-49	3
50-54	6
55-59	8
60-64	10
65-69	11
70-74	12
75-79	13

Allocate points based on person's age, total and HDL cholesterol levels, smoking status and systolic blood pressure. Check the total points against table A2 for estimate of that person's 10-year CHD risk.

Total Cholesterol mmol/L (mg/dL)	Points				
	Age 20-39	Age 40-49	Age 50-59	Age 60-69	Age 70-79
<4.1 (160)	0	0	0	0	0
4.1-5.1 (160-199)	4	3	2	1	0
5.2-6.1 (200-239)	7	5	3	1	0
6.2-7.2 (240-279)	9	6	4	2	1
≥7.3 (280)	11	8	5	3	1

Smoking	Points				
	Age 20-39	Age 40-49	Age 50-59	Age 60-69	Age 70-79
Non-smoker	0	0	0	0	0
Smoker	8	5	3	1	1

HDL Cholesterol mmol/L (mg/dL)	Points
≥1.6 (60)	-1
1.3-1.5 (50-59)	0
1.0-1.2 (40-49)	1
<1.0 (40)	2

Systolic BP* (mmHg)	Points	
	If untreated	If treated
<120	0	0
120-129	0	1
130-139	1	2
140-159	1	2
≥160	2	3

** BP = blood pressure*

Table A2. Score sheet for the estimation of 10-year coronary heart disease risk in men based on the original SG ATP III model and recalibrated SG-ATP III model.

Total Points	10-Year Risk (%) from the original SG-ATP III			10-Year Risk (%) from the recalibrated SG-ATP III		
	Chinese	Malay	Indian	Chinese	Malay	Indian
-5	<1%	<1%	<1%	<1%	<1%	<1%
-4	<1%	<1%	<1%	<1%	<1%	<1%
-3	<1%	<1%	<1%	<1%	<1%	<1%
-2	<1%	<1%	<1%	<1%	<1%	<1%
-1	<1%	<1%	1%	<1%	<1%	<1%
0	<1%	<1%	1%	<1%	<1%	<1%
1	<1%	1%	1%	<1%	<1%	1%
2	1%	1%	1%	<1%	1%	1%
3	1%	1%	2%	<1%	1%	1%
4	1%	1%	2%	1%	1%	1%
5	1%	1%	3%	1%	1%	2%
6	1%	2%	3%	1%	2%	2%
7	2%	2%	4%	1%	2%	3%
8	2%	3%	5%	2%	3%	4%
9	3%	4%	7%	2%	3%	5%
10	4%	5%	9%	3%	4%	6%
11	5%	6%	11%	3%	5%	7%
12	6%	8%	14%	4%	7%	10%
13	8%	11%	18%	5%	9%	12%
14	11%	13%	23%	7%	11%	15%
15	13%	17%	28%	9%	14%	19%
16	17%	21%	35%	11%	18%	24%
17	21%	27%	42%	14%	22%	30%
18				18%	28%	37%
19				23%	34%	45%
20				28%	42%	54%

Table A3. Score sheet for the estimation of 10-year coronary heart disease risk in women.

Age	Points
20-34	-7
35-39	-3
40-44	0
45-49	3
50-54	6
55-59	8
60-64	10
65-69	12
70-74	14
75-79	16

Allocate points based on person's age, total and HDL cholesterol levels, smoking status and systolic blood pressure. Check the total points against table A4 for estimate of that person's 10-year CHD risk.

Total Cholesterol mmol/L (mg/dL)	Points				
	Age 20-39	Age 40-49	Age 50-59	Age 60-69	Age 70-79
<4.1 (160)	0	0	0	0	0
4.1-5.1 (160-199)	4	3	2	1	1
5.2-6.1 (200-239)	8	6	4	2	1
6.2-7.2 (240-279)	11	8	5	3	2
≥7.3 (280)	13	10	7	4	2

Smoking	Points				
	Age 20-39	Age 40-49	Age 50-59	Age 60-69	Age 70-79
Non-smoker	0	0	0	0	0
Smoker	9	7	4	2	1

HDL Cholesterol mmol/L (mg/dL)	Points
≥1.6 (60)	-1
1.3-1.5 (50-59)	0
1.0-1.2 (40-49)	1
<1.0 (40)	2

Systolic BP* (mmHg)	Points	
	If untreated	If treated
<120	0	0
120-129	1	3
130-139	2	4
140-159	3	5
≥160	4	6

** BP = blood pressure*

Table A4. Score sheet for the estimation of 10-year coronary heart disease risk in women based on the original SG ATP III model and recalibrated SG-ATP III model.

Total Points	10-Year Risk (%) from the original SG-ATPIII			10-Year Risk (%) from the recalibrated SG-ATP III		
	Chinese	Malay	Indian	Chinese	Malay	Indian
0	<1%	<1%	<1%	<1%	<1%	<1%
1	<1%	<1%	<1%	<1%	<1%	<1%
2	<1%	<1%	<1%	<1%	<1%	<1%
3	<1%	<1%	<1%	<1%	<1%	<1%
4	<1%	<1%	<1%	<1%	<1%	<1%
5	<1%	<1%	1%	<1%	<1%	<1%
6	<1%	<1%	1%	<1%	<1%	<1%
7	<1%	1%	1%	<1%	<1%	<1%
8	<1%	1%	1%	<1%	<1%	<1%
9	1%	1%	2%	<1%	<1%	1%
10	1%	1%	2%	<1%	1%	1%
11	1%	2%	3%	<1%	1%	1%
12	1%	2%	3%	<1%	1%	1%
13	1%	3%	4%	1%	1%	2%
14	2%	4%	6%	1%	1%	2%
15	3%	5%	7%	1%	2%	3%
16	3%	6%	10%	1%	2%	3%
17	4%	8%	12%	2%	3%	4%
18	5%	10%	16%	2%	4%	6%
19	7%	13%	20%	3%	5%	7%
20	9%	16%	25%	4%	7%	10%
21	12%	20%	31%	5%	9%	12%
22	15%	26%	39%	7%	11%	16%
23	19%	32%	47%	8%	14%	20%
24	24%	40%	56%	11%	18%	25%
25	30%	48%	66%	14%	23%	31%
26				18%	29%	39%
27				22%	36%	47%

Appendix B.

Table B1. Discrimination and calibration of the recalibrated SG-ATP III model based on with the inclusion of participants with elevated fasting glucose (> 7.0 mmol/L) or HbA1C (> 6.5%) levels without a prior diagnosis of type 2 diabetes.

	Male			Female		
Metric	**Chinese**	**Malay**	**Indian**	**Chinese**	**Malay**	**Indian**
C-index	0.830	0.766	0.760	0.941	0.757	0.779
(95% CI)	(0.691, 0.914)	(0.629, 0.863)	(0.619, 0.860)	(0.651, 0.993)	(0.460, 0.919)	(0.509, 0.923)
Observed N events	47	52	52	11	12	15
Adjusted N events[1]	51.4	56.4	60.1	11.8	14.1	17.6
Predicted N events	53.2	73.2	69.3	11.7	16.0	17.5
CIL	-0.055	-0.290	-0.215	0.015	-0.212	-0.072
(95% CI)	(-0.355, 0.218)	(-0.575, -0.030)	(-0.500, 0.045)	(-0.640, 0.553)	(-0.837, 0.305)	(-0.624, 0.395)
CIL P-value	0.706	0.037	0.121	0.959	0.462	0.782
Calibration slope	1.349	0.851	0.855	1.435	0.726	0.745
(95% CI)	(0.948, 1.795)	(0.560, 1.177)	(0.568, 1.177)	(0.916, 1.991)	(0.295, 1.215)	(0.381, 1.147)
Deviance	4.4	6.7	5.5	6.9	4.4	6.4
Deviance P-value	0.361	0.151	0.240	0.142	0.360	0.173

[1]Adjusted number of observed events using the Kaplan-Meier method to account for participants with a follow-up duration of <10 years.