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A comparison of cardiovascular risk scores in native and migrant South Asian populations

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ABSTRACT

Background: South Asians have increased cardiovascular risk burden but little data exists comparing cardiovascular (CV) risk models in migrant and native South Asians. Our retrospective cohort study in patients presenting with first acute myocardial infarction(MI) compares the predictive value of CV risk scores in native and UK migrant South Asians.

Methods: Retrospective cohort study of 80 UK-based patients of South Asian origin admitted with first presentation MI, excluding patients with known coronary artery disease. A retrospective 10-year CV risk was calculated for each patient using four cardiovascular risk models: Framingham Risk Score($Risk_{FRS}$), World Health Organisation($Risk_{WHO}$), American College of Cardiology/American Heart Association(ACC/AHA) ($Risk_{ACC/AHA}$), and 3rd Joint British Societies'($Risk_{JBS}$). Our aim was to assess agreement between these risk scores and conduct comparative analysis with native South Asians.

Results: $Risk_{JBS}$ identified the largest proportion of migrant South Asians as 'high risk' with 65% of subjects having an estimated >20% 10-year CV risk. $Risk_{WHO}$ provided the lowest 10-year CV risk estimates for South Asian migrants, identifying 21.25% of the migrant cohort as >20% risk of major CV event. Comparative analysis with the native South Asian cohort demonstrated $Risk_{JBS}$ as the risk model most likely to identify patients as 'high'(>20%) risk(55.9%; $p = 0.224$).

Conclusions: This study represents the first analysis of predictive cardiovascular risk scores comparing migrant and native South Asian populations. Significant variation between the CV risk scores were observed, leading to inaccuracies in patient cardiovascular risk estimation. Given the growing burden of cardiovascular disease in Asian countries and different population characteristics, we highlight the need for population specific CV disease risk models whilst providing stimulus for further large-scale prospective studies.

1. Introduction

Cardiovascular disease (CVD) remains the leading cause of mortality and morbidity, with estimates that mortality will increase more than 25% by 2030 (Global et al., 2015; Laslett et al., 2012). The South Asian population (India, Pakistan, Bangladesh, Nepal, Sri Lanka) represents approximately one quarter of the world's population. South Asians are recognised to have an increased risk of premature CVD, with an age-standardised mortality around 40% (Balarajan, 1996; Reddy, 2004; Reddy & Yusuf, 1998). Through a combination of environmental and genetic factors, their enhanced susceptibility to CVD is associated with development of cardiovascular risk factors at an earlier age (Gupta & Brister, 2006; Joshi et al., 2007).

Accurate assessment of CVD risk helps to target risk reduction strategies, with the objective of reducing or preventing cardiovascular related morbidity and mortality. Multi-variant risk assessment models guide decision making through estimating the probability of cardiovascular events in asymptomatic individuals. Data from North American and European observational studies have informed these cardiovascular risk scores (Goff et al., 2013a; Hippisley-Cox et al., 2007; Wilson et al., 1998), with a paucity of data in South Asian populations (Ranganathan & Bhopal, 2006). The cardiovascular risk scores currently used in clinical practice have largely been derived from Caucasian populations. The most recent cardiovascular risk score, the 3rd Joint British Societies' risk

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calculator ($Risk_{JBS}$), represents and incorporates data from QRISK (QRESEARCH database) and QRISK2 (THIN-database), included 96% and 98% Caucasian patients respectively in their derivations and validations. Given the low proportion of South Asian patients within the QRISK and QRISK2 populations (2% and 0.7%), cardiovascular risk prediction in this cohort imprecise may be imprecise (Hippisley-Cox et al., 2008, 2010, 2017). Further research has demonstrated under-estimation of CVD risk in South Asian patients, and together with the increasing burden of cardiovascular disease in this population, we believe it is essential to develop population specific cardiovascular risk scores to improve the precision of cardiovascular risk assessment (Bhopal et al., 2005; Robson, Hippisley-Cox, & Coupland, 2012; Tillin et al., 2014). There are limited studies comparing different CVD prediction models to South Asians residing in India and in the West, with all the major cardiovascular risk models studied developed in the general Caucasian population. Similarly, there is a paucity of evidence assessing the impact of migration upon cardiovascular risk evaluation, especially direct comparisons between native and migration populations. Therefore, through our research we seek to address the gap in the knowledge of cardiovascular risk and aim to improve the accuracy of the current risk scores within ethnic populations (Bhopal et al., 2005; Cappuccio, Oakeshott, Strazzullo, & Kerry, 2002).

The primary aim of this study was to evaluate 4 recognised and validated (in the western population) cardiovascular risk models in South Asians. By retrospectively analysing the cardiovascular risk profile of South Asian patients as they presented with their first myocardial infarction (MI), we sought to assess agreement between the risk scores, had these patients presented in clinic immediately prior to their index event. Our objective was to analyse data from migrant South Asians resident in the United Kingdom (UK), then comparing this with existing data from native South Asians in India(Bansal, Kasliwal, & Trehan, 2014), with the aim of evaluating discrepancies in risk assessment between the four major cardiovascular risk models.

2. Methods

This retrospective cohort analysis included 103 patients of South Asian background presenting to the Freeman Hospital, Newcastle-upon-Tyne with acute MI, from January 2009 to January 2015. Patients identified using Patient Analysis & Tracking System (PATS, Dendrite Clinical Systems Ltd, Playhatch, UK) were only included if they had no prior history of MI or stroke, and had a comprehensive cardiovascular risk factor assessment to allow risk score calculations. Of 103 patients, 23 were excluded either for having a previously recorded acute coronary syndrome (ACS) or an incomplete dataset to enable a complete risk assessment. A total of 80 patients were followed up for a minimum of 6 months to establish post MI mortality status, with hospital records accessed to ensure comprehensive data collection.

For the purposes of the study, acute MI was defined according to the third universal definition of myocardial infarction released in 2012 by the ESC/ACCF/AHA/WHF (Thygesen et al., 2012) and patients classified as either ST-elevation MI (STEMI) or non-ST elevation MI (NSTEMI).

Patients were admitted to the coronary care unit, clinically evaluated through history and physical examination and treated in accordance with National and European Guidelines (Hamm CW BJ-Pea, 2011; Myocardial infarction wit, 2012; Steg et al., 2011; Unstable angina andM, 2011). All 80 UK-based patients underwent percutaneous coronary intervention (PCI). Data not available were length of stay in the UK, diet, exercise and socio-economic class.

Four risk scores were used to evaluate cardiovascular risk: Framingham Risk Score ($Risk_{FRS}$) (D'Agostino RB et al., 2008), World Health Organisation/International Society of Hypertension CVD risk prediction charts ($Risk_{WHO}$) (World Health Organization, 2007), American College of Cardiology/American Heart Association (ACC/AHA) pooled cohort equations ($Risk_{ACC/AHA}$) (Goff et al., 2013b), and 3rd Joint British Societies' risk calculator ($Risk_{JBS}$) (Joint British Societies', 2014). For $Risk_{WHO}$, the South-East Asian region D chart was used. Based upon individual data, a 10-year risk percentage of having a major cardiovascular event (MI or stroke) was calculated for each patient, prior to their index acute MI presentation.

Whilst all other risk scores calculate absolute values, $Risk_{WHO}$ prediction tables only provide approximate ranges for 10-year risk estimates; therefore risk categories for each model were constructed (<10%, 10–19.9%, 20–29.9%, 30–39.9%, >40%) to facilitate comparison.

Table 1 compares the various clinical and biochemical parameters included in the 4 risk models (Bansal et al., 2014).

To ensure calculation of a 10-year risk, the following adjustments were made during data input for all four risk scores: for patients aged above the specified range (see Table 1), the highest value possible was used e.g. $Risk_{FRS}$ - 74 years, with a similar strategy adapted to blood pressure and cholesterol values outside their respective reference ranges.

Data from our UK-based cohort was directly compared with a cohort of 149 resident Indian patients also presenting with acute MI. The baseline characteristics of this population are included in Table 2, with hypertension (57.7%), diabetes (46.3%), smoking (27.5%) and premature CV disease (23.5%) being the most prevalent cardiovascular risk factors. The 10-year cardiovascular risk of this population was similarly evaluated using the same four major risk algorithms and compared to

Table 1
Clinical and biochemical parameters (with applicable ranges) included in various cardiovascular risk assessment models.

Variable	FRS	JBS	ACC/AHA	WHO
Age	Yes (30–74 years)	Yes (30–84 years)	Yes (20–79 years)	Yes (35–75 years)
Gender	Yes	Yes	Yes	Yes
Ethnicity	No	Yes	Yes	No
History of diabetes	Yes	Yes	Yes	Yes
Smoking history	Yes	Yes	Yes	Yes
Family history of premature CVD	No	Yes	No	No
History of atrial fibrillation	No	Yes	No	No
History of chronic kidney disease	No	Yes	No	No
History of rheumatoid arthritis	No	Yes	No	No
History of blood pressure treatment	Yes	Yes	Yes	No
Systolic blood pressure	Yes (90–200 mmHg)	Yes (70–210 mmHg)	Yes (90–200 mmHg)	Yes (110–190 mmHg)
Body-mass index	No	Yes (20–50 kg/m^2)	No	No
Total cholesterol	Yes (100–405 mg/dl)	Yes[a]	Yes (130–320 mg/dl)	Yes (3.5–8.5 mmol/L)
HDL cholesterol	Yes (10–100 mg/dl)	Yes[a]	Yes (20–100 mg/dl)	No
Total number of risk factors included within the algorithm	7	14	9	5

**Units in brackets refers to the reference ranges considered in each algorithm.
[a] The risk calculator accepts all usually found values of total and HDL-cholesterol but when total cholesterol exceeds 7.5 mmol/L, it highlights the possibility of familial hypercholesterolemia. ACC, American College of Cardiology; AHA, American Heart Association; CVD, cardiovascular disease; FRS, Framingham risk score; HDL, high-density lipoprotein; JBS, Joint British Society; WHO, World Health Organization.

Table 2
Clinical and biochemical characteristics comparing UK resident and India resident study populations (percentages in brackets).

Parameter	UK resident (n = 80)	India resident (Hippisley-Cox et al., 2008) (n = 149)	P values
Age (years)	56.2 ± 13.1	59.4 ± 10.6	0.062
Male Gender n (%)	61 (76.3)	123 (82.6)	0.253
Hypertension n (%)	46 (57.5)	86 (57.7)	0.975
Diabetes Mellitus n (%)	30 (37.5)	69 (46.3)	0.200
Current Smokers n (%)	23 (28.8)	41 (27.5)	0.843
Family History of premature CVD n (%)	42 (52.5)	35 (23.5)	<0.05
Body-mass index (kg/m^2)	27.3 ± 4.5	24.9 ± 4.3	<0.05
Heart rate (beats/min)	74.6 ± 16.4	89 ± 17	<0.05
Systolic blood pressure (mmHg)	135.5 ± 32.1	117.2 ± 20.7	<0.05
Diastolic blood Pressure (mmHg)	75.1 ± 15.3	69.7 ± 13.7	<0.05
Types of Myocardial Infarction:			<0.05
STEMI	36 (45.0)	123 (82.6)	
Non-STEMI	44 (55.0)	26 (17.4)	
Location of myocardial infarction (STEMI) only			
Anterior wall myocardial infarction	15 (41.7)	80 (65.0)	<0.05
Others	65 (81.3)	43 (35.0)	
Thrombolysis	0	37 (24.8)	<0.05
Percutaneous or surgical coronary revascularisation	74 (92.5)	129 (86.6)	0.178
STEMI Patients undergoing PCI (%)	36 (100)	_	_
Fasting blood glucose (mg/dL)	160.1 ± 87.5	140.9 ± 44.7	0.069
Total cholesterol (mg/dL)	179.0 ± 53.0	145.2 ± 44.0	<0.05
Serum Triglycerides (mg/dL)	206.9 ± 133.2	139.3 ± 79.5	<0.05
HDL-cholesterol (mg/dL)	42.3 ± 12.9	35.1 ± 11.3	<0.05
LDL-cholesterol (mg/dL)	_	88.6 ± 35.9	_

P-values were calculated using unpaired t-test with Welch's correction and Pearson's chi-squared test.

our migrant Indian population (Bansal et al., 2014). Data was collected using LibreOffice Calc (version 6) with statistical analysis conducted using GraphPad 6 and SPSS (version 24). P-values were calculated using unpaired t-test with Welch's correction and Pearson's chi-squared test. Graphs were assembled using Minitab (version 17). Kappa analysis was conducted to compare the results of the risk calculators. Using SPSS, cardiovascular risk factors were statistically adjusted for using linear regression whilst Levene's F-test and independent samples t-test was performed to compare the two populations and determine the effect of migration upon cardiovascular risk prediction.

3. Results

3.1. Patient characteristics and CVD risk profile

Cardiovascular risk estimates were calculated for all patients, as determined by the risk factors prior to their ACS. Table 1 compares the data input variables required for each cardiovascular risk model.

We then compared our data set to those of Bansal M et al. (Bansal et al., 2014) who had performed an identical analysis in a similar patient population (i.e. those presenting with first ACS) but residing in India. Baseline characteristics of our UK-resident South Asian patients are represented in Table 2, with comparisons to the native Indian cohort.

Statistically significant differences in baseline characteristics between the UK South Asian population and the Indian population was observed, with a higher incidence of familial premature CVD (52.5% vs. 23.5%, $p < 0.05$), higher total cholesterol level (179 ± 53mg/dl) and serum triglyceride (206.9 ± 133.2mg/dL) in the UK-resident South Asians compared to resident Indians (145.2 ± 44.0mg/dl, $p < 0.05$) and (139.3 ± 79.5, $p < 0.05$) respectively. In either cohort, there were no patients who had previously been diagnosed with a stroke.

Overall, 36 (45%) patients were diagnosed with ST-elevation MI, with 42% of these being localised to the anterior wall. All patients presenting with ST-elevation MI underwent primary PCI to at least one vessel, no patients received thrombolytic therapy and none underwent surgical revascularisation. Intra-procedure systolic/diastolic BP was higher in the UK population: 135.5 ± 32.1/75.1 ± 15.3 mm Hg, compared to 117.2 ± 20.7/69.7 ± 13.7 mmHg ($p < 0.05$) in the Indian group. Mean heart rate was higher in the Indian residents (89 ± 17 vs. 74.6 ± 16.4 beats per minute, $p < 0.05$).

Two patients of the total eighty died at 6 months follow-up, however these were non-cardiovascular related deaths.

3.2. Estimated CVD risk and agreement across algorithms

As shown in Tables 2 and 3 and Fig. 1, $Risk_{WHO}$ provided the lowest risk estimates, with 62.5% of patients estimated to be having <10% 10-year cardiovascular risk, with another 16.3% having a calculated 10–19.9% risk. $Risk_{JBS}$ identified the highest proportion of patients as 'high risk' (65% of subjects with >20% 10-year cardiovascular risk). These findings concurred with those observed in the native Indian cohort (figures in brackets). Due to $Risk_{FRS}$ combining the 30–39.9% and >40% categories, a comparative analysis between cardiovascular risk scores can be made using estimated risk thresholds of less than 20% and greater than 20%, therefore provide a more efficient and equitable tool for treatment decisions, these are included in Table 3 (Fig. 2).

After $Risk_{JBS}$, $Risk_{FRS}$ was the second most likely to identify patients as 'high risk' (36.25%) using the >20% risk category. Both $Risk_{FRS}$ and $Risk_{JBS}$ demonstrated an increased ability to detect 'high cardiovascular risk' (>20%) patients, 46.3% (38.3%, $p = 0.241$) and 65% (55.9%, $p = 0.224$) respectively, when compared to data from native Indians (represented in brackets with p-values). $Risk_{ACC/AHA}$ recognised 71.3% (69.8%, $p = 0.819$) of patients as having a 'low cardiovascular risk' with estimated 10-year risk <20%. This agreed with a $Risk_{WHO}$, which identified 78.8% (86.6%, $p = 0.125$) of patients similarly as low cardiovascular risk.

Kappa analysis was also conducted to determine the inter-rater agreement between the risk algorithms for the migrant and native Indian populations. The migrant population demonstrated a range of 0.11–0.28, whilst the native population ranged from 0.01 to 0.35, with p-values <0.05, both at the lower end of agreement.

Following statistical adjustment for known cardiovascular risk factors, the CV risk scores of the native and migrant populations were compared for each of the four risk algorithms. The homogeneity of variances was tested using Levene's F test, and independent samples t-test was used to test the hypothesis that migration of South Asian patients has an impact upon their predicted cardiovascular risk score when compared to the native South Asian population. From our analysis, $Risk_{JBS}$ was the only risk score to demonstrate that migrant patients were associated with a higher mean CV risk score (mean = 23.7, SD = 23.6), compared with the native patient group (mean = 23.6, SD = 10.8, $p < 0.05$) following adjustment for all other known cardiovascular risk score included within the algorithms. Independent samples t-test was also associated with a statistically significant greater risk in the migrant population compared to the native population, with a mean difference of 10.1 (CI = 4.7–15.7) in favour of the migrant population. In contrast, the other CV risk scores, $Risk_{ACC/AHA}$, $Risk_{FRS}$ and $Risk_{WHO}$, were not associated with a statistically significant difference in cardiovascular risk scores between the migrant and native patients, therefore we were unable to reject the null hypothesis that migration does not have an impact upon CV risk score. ($Risk_{ACC/AHA}$ migrant vs. native; mean = 16.3, SD = 13.4 vs. 17.3, SD = 9.1, $p = 0.54$), ($Risk_{FRS}$ migrant vs. native; mean =

Table 3
The estimated 10-year cardiovascular risk according to the four risk assessment models inc division into two risk categories as <20% and ≥20% (figures in second columns represent data from Bansal M et al. accompanied by p-values comparing the two data sets).

Risk Category (%)	FRS			JBS			ACC/AHA			WHO		
Study	*Migrant*	*Bansal* et al.	*p-value*	*Migrant*	*Bansal* et al.	*p-value*	*Migrant*	*Bansal* et al.	*p-value*	*Migrant*	*Bansal* et al.	*p-value*
<10	**24%**	*22.8%*	$p = 0.873$	**18%**	*19.4%*	$p = 0.754$	**48%**	*38.3%*	$p = 0.176$	**63%**	*61.7%*	$p = 0.911$
10–19.9	**30%**	*38.9%*	$p = 0.179$	**18%**	*24.7%*	$p = 0.247$	**24%**	*31.5%*	$p = 0.214$	**16%**	24.8%	$p = 0.134$
20–29.9	**10%**	*13.4%*	$p = 0.451$	**20%**	*20.4%*	$p = 0.944$	**14%**	*15.4%*	$p = 0.732$	**3%**	*6.7%*	$p = 0.173$
30–39.9	**36%**	*24.8%*	$p = 0.069$	**10%**	*17.2%*	$p = 0.172$	**6%**	*5.4%*	$p = 0.784$	**6%**	*6.7%*	$p = 0.615$
>40	_	_	_	**35%**	*18.3%*	$p < 0.05$	**9%**	*9.4%*	$p = 0.872$	**13%**	*2.0%*	$p < 0.05$
<20	**54%**	*61.7%*	$p = 0.241$	**35%**	*44.1%*	$p = 0.224$	**71%**	*69.8%*	$p = 0.819$	**79%**	*86.6%*	$p = 0.125$
≥20	**46%**	*38.3%*	$p = 0.241$	**65%**	*55.9%*	$p = 0.224$	**29%**	*30.2%*	$p = 0.819$	**21%**	*13.4%*	$p = 0.125$

Pearson's chi-squared test was used to calculate p-values.

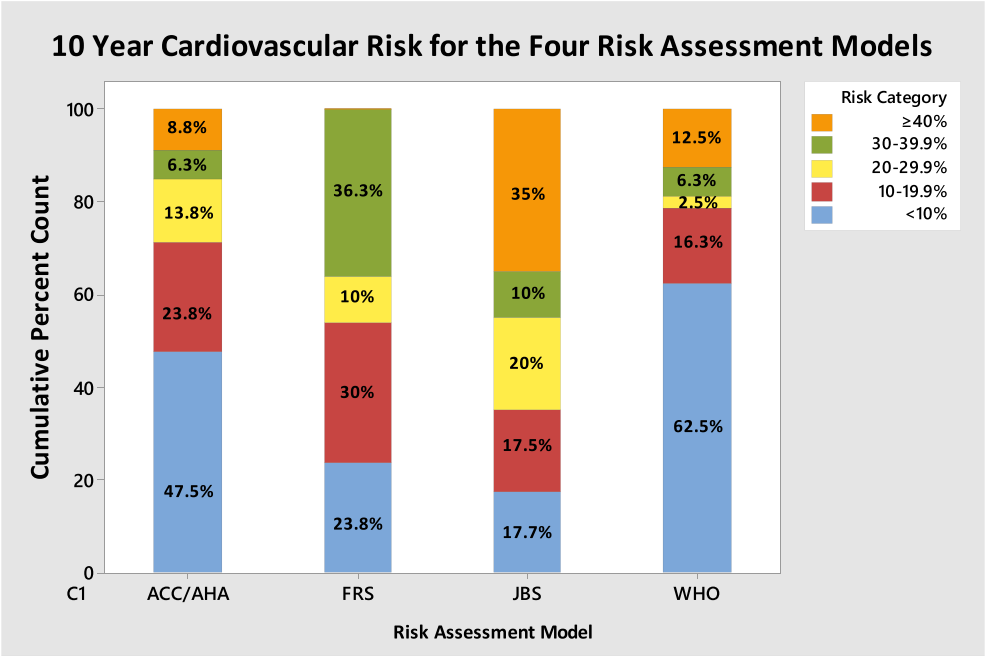

Fig. 1. Four risk assessment models with estimated 10-year risk assessment models. Two categories for FRS combined (30–39.9% and 40% or more), as risk score does not provide values above 30% 10-year risk. Framingham Risk Score (FRS); Joint British Society (JBS); American College of Cardiology/American Heart Association (ACC/AHA); World Health Organisation (WHO).

2.6, SD = 1.05 vs. 2.4, SD = 0.8, p = 0.22), ($Risk_{WHO}$ migrant vs. native; mean = 1.9, SD = 1.1 vs. 1.6, SD = 0.7, p = 0.07).

4. Discussion

The South Asian population is recognised for its predisposition to premature cardiovascular disease and propensity to exhibit multiple cardiovascular risk factors (Gupta & Brister, 2006; Joshi et al., 2007). Accurate cardiovascular risk estimation is essential given the importance of decision making for initiating preventative treatment strategies. Earlier comparative studies evaluating some cardiovascular risk calculators have highlighted their poor performance when analysing ethnic groups, whilst discrepancies between risk scoring models in Caucasian populations strongly emphasise the need for direct comparative studies and prospective validation studies to improve CV risk prediction (Collins & Altman, 2010; Siontis, Tzoulaki, Siontis, & Ioannidis, 2012; Tillin et al., 2014). The results of our research demonstrate significant variability between the four risk prediction models when estimating 10-year cardiovascular risk, confirming the challenges when identifying patients with high cardiovascular risk in the South Asian population.

$Risk_{JBS}$ identified the highest proportion of UK-based South Asian patients as having high cardiovascular risk (65%), whilst $Risk_{ACC/AHA}$ and $Risk_{WHO}$ using the same patient population, identified only 28.7% and 21.3% respectively as high risk. Importantly, this large variability between risk prediction models is supported by results of Bansal and co-workers who reported similar findings through their identical analysis of a native South Asian population. Bansal M et al. also demonstrated that $Risk_{JBS}$ recognised a higher proportion of 'high cardiovascular risk' South Asian patients when compared to $Risk_{WHO}$ and $Risk_{ACC/AHA}$, which reclassified a significant proportion of the same patients as low risk. With poor agreement between the individual risk scores, this will lead to potential inaccuracies in cardiovascular risk estimation if different risk scores are utilised, with relative under or overestimation of risk prediction. This could lead to major inconsistencies in healthcare advice and influence treatment decisions, in a population already recognised as having a high prevalence of premature onset CVD.

There is recognition of a shortage of cardiovascular cohort studies in South Asian populations, particularly prospective studies (Ranganathan & Bhopal, 2006). Results from Kanjilala et al. concluded that despite a patient cohort with perceived high cardiovascular risk, only 5.3% were classified according to $Risk_{FRS}$ as 'high risk' (Kanjilal et al., 2008). The other risk scores utilised in the study, SCORE and JBS, identified less than 5% of patients as high risk, which appears to significantly underestimate 10-year cardiovascular risk in a population acknowledged as

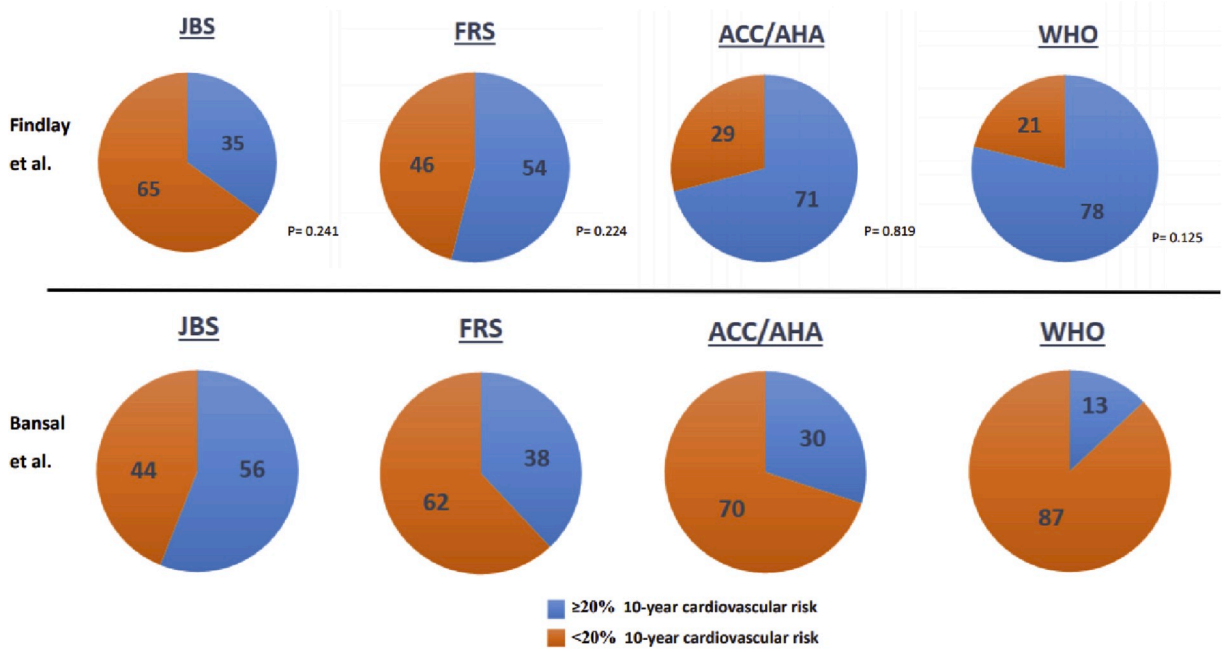

Fig. 2. Estimated cardiovascular risk divided into <20% and ≥20% categories extrapolated from Table 3: Framingham Risk Score (FRS); Joint British Society (JBS); American College of Cardiology/American Heart Association (ACC/AHA); World Health Organisation (WHO).

having multiple cardiovascular risk factors equating to an increased CV risk burden. Despite similar research supporting the hypothesis of risk calculations underestimating overall cardiovascular risk in South Asians (Bansal, Shrivastava, Mehrotra, Agarwal, & Kasliwal, 2009; Cappuccio et al., 2002), there remains a shortage of cohort studies analysing cardiovascular risk in ethnic populations, particularly within Europe (Ranganathan & Bhopal, 2006). This may explain the poor discrimination between observed CV events and estimated CV risk in South Asian populations, with some risk models having been developed in relatively small, homogenous, white populations rather than incorporating data specifically from our target population. By contrast, $Risk_{JBS}$ was developed taking data from the QRISK2 cohort of UK-based patients, which included 320,018 in the derivation and 95,983 South Asian patients in the validation cohorts (Hippisley-Cox et al., 2008, 2010, 2017). However despite these modifications, the proportion of South Asian patients included in these large cohorts remains low with the proportion of South Asians in the QRISK cohort representing only 4.1% and 3.6% of the total population in the derivation and validation cohorts respectively (Hippisley-Cox et al., 2008, 2010, 2017). Tillin et al. underlines the caveats of these relatively small proportions, with their research evaluating the performance of QRISK 2 and Framingham risk scores in UK-based ethnic populations, which included a South Asian cohort representative of 36% of the study population (Tillin et al., 2014). Both risk scores were shown to underestimate cardiovascular risk in South Asian patients when assessing primary cardiovascular events at follow-up (Tillin et al., 2014). As neither score performed well in the ethnic groups evaluated (South Asian and African Caribbean) it challenges the accuracy of the risk scores, whilst adding complexity to the extrapolation of risk score outcomes into South Asian populations.

Despite these concerns, the accuracy of cardiovascular risk assessment continues to improve, with newer risk models demonstrating a greater ability to distinguish high and low risk patients (Hippisley-Cox et al., 2008; Rao et al., 2012). As a consequence of the changing population demographics and the increasing validation data available, newer risk models are now able to incorporate additional CV risk factors such as socio-economic status, BMI and ethnicity into their algorithms. Although none of the CV risk models used in our study originated from South Asian populations, South Asians are now being recognised within these predominantly Caucasian study cohorts. This conveys significant implications for the South Asian population, as we seek to establish the relevance of predictive CV risk scores for these patients, whilst providing the foundations to develop population specific CV risk scores, especially given their increased burden of cardiovascular risk and susceptibility to premature CV events (Krishnan, 2012).

As supported by the results of our study, South Asian patients are recognised as having greater propensity to central obesity, increased prevalence of type 2 diabetes mellitus and greater number of CV risk factors, all leading to development of cardiovascular disease at a younger age compared to their Western comparators (Joshi et al., 2007). Of the cardiovascular risk models analysed, $Risk_{JBS}$ is the only risk model to incorporate statistical adjustment specifically for South Asian subjects, therefore strengthening cardiovascular risk estimation in this ethnic population. Not only does our study emphasise the high cardiovascular risk factor burden in South Asian patients, our research provides impetus to evaluate whether long term residency enhances or detracts from an algorithm's predictive accuracy. In addition to making statistical adjustments for South Asian ethnicity, we note in our analysis that $Risk_{JBS}$ collects more data variables (e.g. atrial fibrillation, chronic kidney disease, family history) when calculating its cardiovascular risk estimate, which may further enhance the accuracy of this risk score therefore making it the strongest predictor score. To further evaluate the predictive accuracy of the four risk algorithms from our study, comparative analysis with a cohort of South Asians without cardiovascular disease is required to enable calculation of other accuracy measures such as specificity and positive predictive value. This would add to the sensitivity analysis of our data, whilst also seeking to inform how migration impacts predictive accuracy of cardiovascular risk assessment.

An estimated 10-year cardiovascular risk score >20% is classified as 'high risk', and is indication for commencing primary prevention (Tillin et al., 2014; Bansal et al., 2014). The importance of accurately assessing a patient's cardiovascular risk has prognostic benefits as early intervention can prevent development of premature CVD, with targeted prevention strategies reducing CV-related morbidity and mortality. With South Asian populations having an increased prevalence of metabolic syndrome and glucose intolerance compared to the Caucasian

population (39% vs 20%) (Ajjan, Carter, Somani, Kain, & Grant, 2007), their risk of developing premature CVD is significantly increased. One important finding between the native and UK South Asian populations in our study was the high prevalence of diabetes between the two groups compared to historical data in the Caucasian population with STEMI (Koshy, Balasubramaniam, Noman, & Zaman, 2014). A study from Barnett et al. not only demonstrated the increased prevalence of diabetes in the UK-based South Asian population, they also observed elevated triglycerides and lower HDL in this population, a finding supported by Hussain et al. (Barnett et al., 2006; Hussain, Oldenburg, Wang, Zoungas, & Tonkin, 2013) Whilst our sample size is small, prevalence of 37.5% in the UK and 46.3% in the native Asian population, compared with a diabetes prevalence of 10.5% in the Caucasian STEMI population reflects the growing burden of type 2 diabetes mellitus in South Asia. This finding in a small sample size provides pilot data for further studies of diabetes prevalence and outcomes in the native and migrant South Asian populations. This data also reaffirms the importance of accurate risk assessment and targeted prevention, with patients presenting at a younger age and with multiple CV risk factors whilst also highlighting the potential under-diagnosis of CVD in South Asians (Gupta, Singh, & Verma, 2006; Teoh, Lalondrelle, Roughton, Grocott-Mason, & Dubrey, 2007).

The results from our study show that $Risk_{JBS}$, the cardiovascular risk model which include South Asian ethnicity as a discriminant risk factor, considered a higher proportion of South Asian patients as 'high cardiovascular risk' when compared against $Risk_{FRS,}$ and $Risk_{ACC/AHA}$. One would expect $Risk_{JBS}$ to provide the most accurate cardiovascular risk estimates in this study as it most closely reflects our study cohort, having been designed for a UK-based population and importantly includes validation data for South Asian patients. Whereas other risk models which have not been validated in South Asians, have been shown to have a tendency to underestimate cardiovascular risk within this target population (Rao et al., 2012; Robson et al., 2012). Furthermore, our study compared prominent cardiovascular risk factors such hypertension, smoking and diabetes mellitus between the native and migrant South Asian populations. These major cardiovascular risk factors provide the basis for the risk calculator algorithms, and whilst there are differences detailed in Table 2, they were not statistically significant. Therefore, when comparing the estimated 10 year cardiovascular risk scores between the two populations, no significant difference between cardiovascular risk was observed except for $Risk_{JBS}$ and $Risk_{WHO}$ (Table 3) in high risk patients (risk category >40%).

$Risk_{JBS}$ would be expected to estimate cardiovascular risk more accurately than other scores given its multi-variable risk assessment, together with the continued risk score validation JBS conducts in response to changing population demographics and improved clinical outcomes (Collins & Altman, 2010). The $Risk_{JBS}$ algorithm derives from QRISK data, evaluating a large primary care population to construct the patient risk scores whilst incorporating additional CV risk factors such as family history, socioeconomic status and body mass index. $Risk_{FRS}$ and $Risk_{WHO}$ by contrast demonstrated the lowest proportion of patients to be classified as 'high cardiovascular risk. Although $Risk_{WHO}$ algorithms identify specific sub-regions, they have not evaluated cardiovascular risk for individual countries which may influence their precision of estimate cardiovascular risk estimation. Whilst it may still be useful for broad patient risk stratification, $Risk_{WHO}$ tables have not been evaluated prospectively for CV risk assessment and lacks the necessary statistical risk adjustment for validated risk factors including chronic kidney disease, family history and body mass index, which could affect its accuracy and clinical decision support (Garg et al., 2017). Moreover, $Risk_{FRS}$ derives from a small, homogenous white population, perhaps limiting its applicability to our ethnic population, with independent validation studies demonstrating QRISK and QRISK 2 (from which JBS3 originates) superior to the Framingham risk score (Collins and Altman, 2009, 2010). $Risk_{ACC/AHA}$ acknowledge within their practice guidelines the inaccuracies incurred when evaluated cardiovascular risk in ethnic populations, and whilst including statistical adjustment for Asian-American populations, their lack of validation in South Asian patients may account for discrepancies when compared to other risk scores such as $Risk_{JBS}$ (Goff et al., 2013c).

Whilst data exists demonstrating the baseline CVD risk in South Asian patients, with prevalence for coronary heart disease and stroke in South Asians males being 4.9%, compared to the general UK population 3.2%, validating our research directly against a low-risk UK-based South Asian patient cohort would strengthen our findings and enable us to fully evaluate the accuracy of the risk models studied (Brindle et al., 2006). The significant variability between the risk scores, particularly $Risk_{JBS}$ and $Risk_{ACC/AHA}$, which both provide statistical adjustment for South Asian populations, emphasises the discrepancy between the current risk scores and the potential inaccuracies of cardiovascular risk profiling. Given the growing burden of CVD in Asian countries and different population characteristics, there is an urgent need for population specific CVD risk models, which are essential to identify high risk patients and provide the basis for treatment decisions.

The results of our independent samples t-test to assess the impact of migration upon cardiovascular risk prediction established that $Risk_{JBS}$ was the only risk algorithm with a statistically significant increase in cardiovascular risk in the migrant South Asian population compared with the native population. The other risk scores demonstrated no difference in cardiovascular risk estimate between the two populations. We recognise that larger multi-site prospective observational studies, with greater ethnic representation would be required to determine the significance of these findings and provide stimulus for South Asian-based cardiovascular risk models. A comparison with the broader UK population, including patients with and without cardiovascular disease, would support a valuable sensitivity and specificity analyses to determine the predicative accuracy of the cardiovascular risk scores, therefore enhancing the results of our research.

5. Limitations

There are several limitations of our pilot study. Firstly, whilst the numbers of patients in our study is small, our findings nevertheless provide preliminary data to support further studies. Although predictive accuracy of risk scores would be best conducted through a prospective observational study design, the caveat of this is the variability in exposure to baseline characteristics and the length of study conducted.

All of our patients were UK resident but the length of time that subjects had spent in the UK was unknown. Calculated risk for South Asian patients may be influenced by time spent in the adopted country impacting upon CV risk factors which include socio-economic status, access to healthcare resources, diet and exercise.

Our study included only patients from a single centre who developed acute myocardial infarction. To better calibrate the risk scores and determine their full accuracy, opening our study to multiple cardiology centres with inclusion of a low cardiovascular risk cohort would allow calculation of sensitivity and specificity, therefore assess validity and predictive accuracy of the algorithms. This would also enable us to evaluate the impact of long-term residency upon the algorithms' predictive accuracy and analyse whether migration influences cardiovascular risk estimation.

Finally, heterogeneity in the definition of total CVD exists between the four considered risk models i.e. $Risk_{WHO}$ predicts for 10-year risk of fatal or non-fatal major cardiovascular event (myocardial infarction or stroke), whereas $Risk_{FRS}$ evaluates for 10-year risk of myocardial infarction. These differences in CVD outcomes measures could alter the sensitivity of the algorithms among ethnic populations, therefore influencing risk assessment recommendations and clinical decision making. Risk estimations may be also affected by adjustments to certain demographics falling outside the risk calculator range (e.g. age 30–74); however the closest value in these cases was used for our calculations.

6. Conclusion

Our study evaluated the agreement between four prominent cardiovascular risk scores, by retrospective analysis of patient data post myocardial infarction. The benefit to individuals, societies and healthcare systems of preventing CV events through the modification of risk factors is well known. Whilst risk scores can inform clinical decision making, the importance of applying clinical judgement to individual patients remains paramount. Our study supports the case for using South Asian specific CV risk scores, in a population where increased cardiovascular risk is recognised. This is especially relevant given the low numbers of published cohort studies that include South Asian populations, and the differences observed between estimations calculated from CV risk scores. Our study demonstrates that accurately predicting cardiovascular risk in South Asian populations remains challenging. We conclude that for UK-resident South Asian patients, marked variations exist between CV risk prediction models. Further prospective studies are required to validate our research, with impetus to include larger cohorts of South Asian patients to best support clinical decision making. The results of our study provide pilot data for further research into diabetes prevalence and cardiovascular outcomes in South Asian populations.

Contributors

AZ and MB conceived the study and methodology. SF collected the data, performed the analyses and wrote the first draft of the paper. AZ contributed to data analysis and revised the draft paper. All authors were involved with critically revising the manuscript and approving the final article.

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Ethical statement

We hereby state that all research relating to our submission of: "A comparison of cardiovascular risk scores in native and migrant South Asian populations", was conducted in adherence with the ethical conduct and standards detailed by the journal.

Data sharing statement

No additional data are available.

Declaration of competing interest

None

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