FULL LENGTH ARTICLE

Prediction of 10-year risk of hard coronary events among Saudi adults based on prevalence of heart disease risk factors

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Aim: Cardiovascular disease is becoming the lead cause of mortality and morbidity worldwide, and developing countries are the main contributors to this trend. Saudi Arabia, which is considered a rapidly developing country, faces progressive urbanization and the adoption of a westernized lifestyle, factors which contribute to the rising burden of cardiovascular disease. Our study evaluates the prevalence of coronary risk factors and predicts hard coronary artery events over 10 years in an urban Saudi cohort.

Methods: A cross-sectional observational study was conducted on a Saudi population. The study involved Saudi subjects aged more than 20 years without a history of coronary heart disease. Demographic variables and hard coronary events (HCE) risk factors were measured. Each subject's 10-year HCE risk was estimated by means of the Framingham Risk Score (FRS).

Results: A total of 4932 subjects (2215 men and 2717 women) were examined, the majority (85%) of whom were less than 40 years old. The risk of developing HCE within the next 10 years was low in 92.6% of subjects, intermediate in 3.2% and high in 4.1%. On considering diabetes as coronary heart disease (CHD) risk-equivalent, 26% of subjects were at high risk for hard coronary events in 10 years. The HCE risk progressively increased with age and was higher in men.

Conclusions: Our study, the first to estimate the 10-year risk of HCE among adults in an emerging country, determined that a significant proportion of a younger aged population is at risk for the development of hard coronary events. Public awareness programs to control risk factors are warranted.

Keywords: Cardiovascular risk factors, Coronary heart disease, Hard coronary events, Saudi Arabia

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Abbreviations and Acronyms

CVD	cardiovascular disease
ACS	acute coronary syndrome
HCE	hard coronary events
BMI	body mass index
TC	total cholesterol
HDL-C	high-density lipoprotein cholesterol
LDL-C	low-density lipoprotein cholesterol
FHS	Framingham Heart Study
CHD	coronary heart disease

Introduction

According to the World Health Organization, out of a total of 58 million deaths worldwide in 2005, 30% were due to cardiovascular diseases, mainly heart disease and stroke. The common modifiable risk factors identified were unhealthy diet, physical inactivity, tobacco use, high blood pressure and blood glucose, abnormal blood lipids, and being overweight [1].

By the year 2020, cardiovascular disease (CVD) will be the leading cause of mortality and morbidity worldwide, and developing countries will be the main contributors to this increase [2–5]. In general, developing nations continue to be relatively ill-equipped to handle this burden, and, coupled with poor literacy rates and a lack of awareness regarding disease-related symptoms and associated risk factors, the result is worse disease outcomes [6]. This is reflected in the rising rates of CVD-related hospital admissions and mortality among younger subjects, which in turn inflates disability-adjusted life-years [7,8].

Saudi Arabia, considered a rapidly developing country, faces progressive urbanization and the fast adoption of a western lifestyle, factors which contribute to the rising burden of cardiovascular disease. The SPACE Registry was the first registry in Saudi Arabia to look at patients with acute coronary syndrome (ACS) and showed that patients diagnosed with ACS in Saudi Arabia are from eight to eleven years younger than homologous patients in ACS registries in developed countries [9].

Although data on the prevalence of coronary disease risk factors in developing countries are limited, the prevalence observed is alarming. Risk stratification is therefore central to the management of heart disease. We conducted an observational study to evaluate the prevalence of coronary risk factors among the healthy Saudi population and to predict the 10-year risk of hard coronary events (HCE), defined as myocardial infarction or coronary death (see Fig. 1).

Figure 1. Age-specific distribution of risk for hard coronary events among Saudi adults (age ⩾ 20 years) without self-reported CHD. Dark ⩾ 20%; grey 10% to 20%; light grey ⩽ 10%.

Methods

Project design and patient population

A community-wide, cross-sectional, observational study was conducted on the Saudi population. The study was conducted in compliance with the Declaration of Helsinki. All subjects gave voluntary consent to participate in the study after receiving adequate information on the research aims and methods.

Saudis aged more than 20 years who had no history of coronary heart disease and who attended the 2010 cultural festival in Riyadh were included in the study. These subjects are considered representative of the various regions of Saudi Arabia, since Riyadh is the political and economic capital and is home to people from all over the kingdom.

Study objective and endpoints

The objective of the study was to estimate HCE risk at ten years on the basis of the prevalence of HCE risk factors.

Demographic variables and HCE risk factors, including hypertension, dyslipidemia, diabetes, smoking and degree of physical activity, were recorded during the interview and examination. Data were collected by means of a structured questionnaire, which was filled out by trained registered nurses and through specific tests.

Subjects who were currently smoking or had quit less than one year previously were classified as smokers. Non-smokers were classified as those who had never smoked or who had quit more than one year previously.

Height was recorded in centimeters on a calibrated height board; weight was recorded in kilograms by means of a standard calibrated weighing scale and body mass index (BMI) was calculated and expressed as kg/m^2. Obesity was defined as a BMI $\geqslant 30$.

Blood pressure and pulse rates were measured by automatic dynamap. Hypertension was defined as systolic blood pressure $\geqslant$140 mm Hg or diastolic blood pressure $\geqslant$90 mm Hg [10]. Blood pressure was measured once in each arm in sitting position at five minutes interval and the higher reading was recorded. In our study, the subject was considered hypertensive if discovered hypertensive during assessment or was diagnosed as hypertensive by a physician or taking medications for hypertension.

Diabetes was considered to be present if the subject was on treatment with insulin or oral hypoglycemic agents or had been diagnosed as diabetic by a physician.

A one-touch select device was used to check blood sugar. Total cholesterol (TC) was collected, although dyslipidemia was defined if the subject was on treatment with statins or other dyslipidemic medications or had been diagnosed by a physician.

Subjects were considered physically active if they were spending at least 150 minutes per week in moderate aerobic exercises such as walking, jogging, swimming, or cycling in the context of daily, occupational, leisure, family or community activity.

Framingham scoring method and assumptions

Each subject's 10-year HCE risk was estimated on the basis of the assumptions underlying the Framingham Risk Score (FRS) [11]. These are derived multivariable mathematical functions that assign weights to HCE risk factors such as: gender, age, blood pressure, TC, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C) and smoking behavior. Type 2 diabetes was considered to be a CHD risk equivalent; a patient with type 2 diabetes was therefore considered to be at high risk of suffering hard coronary events. Two Framingham Risk Scores were calculated – one for men and one for women – and expressed as percentages. Subjects with a 10% or lower 10-year HCE risk were classified as being at ''low risk''; those with a 10–20% risk as being at ''intermediate risk''; and those with a 20% or higher risk as being at ''high risk''. Several extreme risk factors, such as BMI > 40 kg/m^2 were not included in the prediction analysis.

Variables collected as dichotomous were inserted in the Framingham Risk Score system after categorical values had been derived by simulation methods. We set up a probability sampling method to ensure that all subjects in the study population had the same probability of being chosen for each repetition. This simulation consisted of repeatedly assigning subjects to different FHS scores with the same probability for each score. This process was implemented 100 times within each class, by gender, and for all risk factors.

Statistical analysis

Continuous variables are reported as means and standard deviations (SD) or medians (interquartile range [IQR]), as appropriate. Categorical data are reported as counts and percentages. For continuous variables, the two-sample t-test or the Wilcoxon Rank Sum test was carried out, while for categorical variables, the chi-square or Fisher's exact test was applied, as appropriate. Analysis was carried out using SAS. All statistical tests were two-sided and a p-value less than 0.05 was considered statistically significant, unless specified otherwise; p-values were rounded to 3 decimal places. If a p-value was less than 0.001, it was reported as <0.001.

Results

A total of 4932 Saudi subjects (2215 men and 2717 women) were examined. Subjects' risk

Table 1. Prevalence of risk factors among Saudis by gender: predominantly young study population with majority less than 40 years of age. Current smoking, hypertension and diabetes were statistically more significant in men, while women were statistically less involved in exercise.

	All (n = 4932) N (%)	Men (n = 2215) N (%)	Women (n = 2717) N (%)	p-value*
Risk factors used to estimate HCE risk				
Age-class				<0.001
20 Yrs–29 Yrs	2250 (46)	783 (35)	1467 (54)	
30 Yrs–39 Yrs	1948 (39)	936 (42)	1012 (37)	
40 Yrs–59 Yrs	633 (13)	463 (21)	170 (6)	
⩾60 Yrs	101 (2)	33 (2)	68 (3)	
Current smoking	1249 (25)	933 (42)	316 (12)	<0.001
Dyslipidemia	938 (19)	440 (20)	498 (18)	n.s.
Hypertension	1698 (34)	830 (38)	868 (32)	<0.001
Risk factors not used to estimate HCE risk				
Diabetes	1242 (25)	478 (22)	764 (28)	<0.001
Obesity (BMI > 30)	1342 (27)	605(27)	737(27)	n.s.
No regular exercise	4256 (86)	1652 (75)	2604 (96)	<0.001

* chi-square or Fisher's exact test.

factors are shown in Table 1. In all subjects, complete information on which to calculate their 10-year risk of HCE was available. The majority (85%) of subjects were less than 40 years old and 55% were female. Male subjects had a higher prevalence of smoking and hypertension than female subjects, and took more exercise. Conversely, females had a higher prevalence of diabetes.

The prevalence of risk factors was evaluated on comparing diabetic and non-diabetic subjects, as shown in Table 2. The prevalence of hypertension, smoking and dyslipidemia was significantly higher among diabetic subjects.

The prevalence of risk factors among age groups is shown in Table 3. Dyslipidemia and diabetes were seen to increase with age.

Table 2. Prevalence of risk factors among Saudi subjects by diabetes: prevalence of diabetes became statistically higher and significant after 30 years of age. Diabetic population had higher prevalence of smoking, dyslipidemia and hypertension with statistical significance.

	Diabetic (n = 1242) N (%)	Not Diabetic (n = 3690) N (%)	p-value*
Risk factors used to estimate HCE risk			
Gender			
Age-class			<0.001
20 Yrs–29 Yrs	308(25)	1467 (54)	
30 Yrs–39 Yrs	538(43)	1012 (37)	
40 Yrs–59 Yrs	334(27)	170 (6)	
⩾60 Yrs	62(5)	68 (3)	
Current smoking	630 (51)	619 (17)	<0.001
Dyslipidemia	820 (66)	118 (3)	<0.001
Hypertension	1145 (92)	553 (15)	<0.001
Risk factors not used to estimate HCE risk			
Obesity (BMI > 30)	342(28)	1000(27)	n.s.
No regular exercise	892 (72)	3364 (91)	<0.001

* chi-square or Fisher's exact test.

Number of risk factors

Our population had a mean of 2.3 ± 1.4 risk factors: men 2.4 ± 1.4 and women 2.3 ± 1.4 ($p < 0.001$). Overall, 55% of subjects had ⩾2 risk factors, 31% ⩾3 risk factors, and 20% had ⩾4 risk factors. The mean number of risk factors increased with age from 1.9 ± 1.2 in 20–30 year olds to 3.2 ± 1.3 in the over 60 s ($p < 0.001$).

Table 4 shows HCE risk distribution among age groups and on comparing men and women. HCE risk progressively increased with age and was higher in men.

Estimation of population at risk of hard coronary events

The risk of suffering hard coronary events (HCE) within the next 10 years, estimated as the mean of risks calculated in 100 simulation reiterations, was low in 92.6% of subjects, intermediate in 3.2% of subjects and high in 4.1% of subjects.

Impact of diabetes on the risk of hard coronary events

Since diabetes is considered to be CHD risk equivalent, we finally calculated the HCE risk by assigning the highest risk category to subjects with diabetes. The risk of suffering HCE within the next 10 years, estimated as the mean of risks

Table 3. Prevalence of risk factors among Saudi subjects in different age groups: prevalence of smoking decreases with advancing age; diabetes, hypertension and dyslipidemia increases with progression in age while obesity remains the same across all age groups.

CHARACTERISTICS	20–29 Years n = 2250 N (%)	30–39 Years n = 1948 N (%)	40–59 Years n = 633 N (%)	⩾60 Years n = 101 N (%)	P-Value*
Current smoking	707 (31)	387 (20)	143 (23)	12 (12)	<0.001
Dyslipidemia	227 (10)	380 (20)	252 (40)	79 (79)	<0.001
Hypertension	295 (13)	1064 (54)	303(47)	36 (36)	<0.001
Diabetes	308 (14)	538 (28)	334 (53)	62 (62)	<0.001
Obesity (BMI ⩾ 30)	615(27)	519(27)	180(28)	28(28)	NS
No regular exercise	1730(77)	1813(93)	616 (97)	97 (96)	<0.001

* chi-square or Fisher's exact test.

Table 4. Distribution of estimated risk for hard coronary events among Saudi adults aged ⩾ 20 years on 100 simulations: males, especially over 40 years of age, are at highest risk for the development of hard coronary events.

		10-Year Risk for Hard Coronary Heart Disease (mean (ICL-ICU))			
	N	<10%	10% to 20%	>20%	p-value*
Total	4932	92.6(92.6–92.7)	3.2(3.2–3.3)	4.1(4.0–4.1)	
Gender					<0.001
Male	2215	88.6(88.6–88.7)	4.0(3.9–4.0)	7.4(7.3–7.5)	
Female	2717	96.0(96.0–96.1)	2.6(2.5–2.7)	1.4(1.3–1.4)	
Age class					
Total					<0.001
20–30	2250	96.2(96.1–96.3)	2.0(2.0–2.1)	1.8(1.7–1.8)	
30–40	1948	94.7(94.6–94.7)	2.6(2.5–2.8)	2.7(2.7–2.8)	
40–60	633	78.7(78.4–78.9)	7.1(6.9–7.2)	14.3(14.1–14.4)	
>60	101	64.1(63.7–64.6)	18.0(17.5–18.6)	17.8(17.3–18.3)	
Male					<0.001
20–30	783	95.7(95.6–95.8)	1.6(1.5–1.7)	2.6(2.6–2.7)	
30–40	936	92.9(92.8–93.0)	2.8(2.7–2.9)	4.3(4.2–4.4)	
40–60	463	72.4(72.2–72.6)	8.1(7.9–8.3)	19.5(19.3–19.7)	
>60	33	27.2(26.5–27.9)	26.7(25.3–28.0)	46.2(44.9–47.4)	
Female					<0.001
20–30	1467	96.5(96.4–96.5)	2.2(2.1–2.3)	1.3(1.3–1.4)	
30–40	1012	96.2(96.1–96.3)	2.4(2.3–2.5)	1.4(1.4–1.5)	
40–60	170	96.0(95.8–96.2)	3.4(3.2–3.6)	0.9(0.8–1.0)	
>60	68	82.4(81.8–83.0)	12.8(12.2–13.5)	4.8(4.3–5.4)	

ICL = Interval Confidence lower; ICU = Interval Confidence upper.
* chi-square or Fisher's exact test.

calculated in 100 simulation reiterations, was low in 73.7% of subjects, intermediate in less than 1%, and high in 25.8%.

Discussion

Main study findings

Our study is the first to estimate the 10-year risk of HCE in a mostly young and healthy adult population in an emerging country.

It is well known that HCE prediction estimates are reliable when the data are concentrated in a specific population and for individuals with fewer risk factors; and these conditions do apply to our study. The high 10-year risk of HCE and the high prevalence of specific HCE risk factors, as found in our study, are alarming. Preventive health programs should therefore be implemented to control HCE risk factors, both established ones and candidate ones, such as body mass index, obesity, and the lack of regular exercise.

Comparison with previous findings

HCE risk and prevalence of risk factors

Very few data have been published on coronary heart disease (CHD) risk at 10 years. Ford et al. [12] reported that men had a higher risk than women and that the risk increased with age, as in our study. In their study, however, the percentage of subjects at high risk was lower than in ours; on including subjects with CHD risk equivalent, they recorded a value of 15.6%, as opposed to our 25.8%. The high value in our study was probably due to the high prevalence of diabetes in the Saudi population.

In the CADIS study [13], the overall prevalence of coronary artery disease was estimated at 5.5%, which is comparable to the HCE risk estimated in our study (4.1%), although the CADIS population was aged 30–70 years.

Diabetes

The prevalence of diabetes among the subjects in our study was 25%, which is significantly higher than in developed countries. In the USA [16], the percentage of adults with diabetes is 10.1%. In our data, a significant number of young subjects had diabetes and the prevalence of diabetes increased with age. These findings are alarming because diabetes is considered an ischemic heart disease equivalent and is known to cause both significant impairment of quality of life and an economic burden. Like other risk factors, it therefore demands aggressive control.

Hypertension

The variable prevalence of hypertension among the Saudi population was due to the geographical, cultural, and socioeconomic diversity of the population sample and the presence of risk factors [17,18]. In our study, the prevalence of hypertension (Table 1) was significantly higher than in prior local studies. Various risk factors, such as age, obesity, urbanization, retirement, diabetes, hypercholesterolemia, lower educational levels, physical inactivity, and higher and lower socioeconomical class have been associated with hypertension [18]. The higher prevalence of hypertension in our study is probably the result of urbanization, socio-economical class and physical inactivity. Hypertension was found to be more prevalent than in the United States, where a 30.5% prevalence of high blood pressure has been reported [15]. The considerable burden of hypertension revealed by our study is a cause for concern for health authorities and other relevant authorities. Earlier screening and detection of hypertension reduce or delay the onset of end organ damage. Non-pharmacological measures recommended by the American Heart Association to control hypertension include achieving and maintaining a healthy body weight, participating in regular leisure-time physical activity, the adoption of a healthy diet, including low salt and increased potassium intake, smoking cessation and stress management [17].

Smoking

Smoking habits vary according to gender, age, socio-economic status and education [19,20]. According to the national survey of Saudi Arabia, in 1995 about a quarter of Saudi males were smokers [16], and a much higher percentage of male university students smoked [21]. In our study, the prevalence of smoking was higher than indicated by prior published data [15], and higher among males than females (Table 1). While the prevalence of smoking in our study was higher than the 20.8% reported in the USA [15], Saudi Arabia devotes fewer resources to discouraging smoking. Smoking is considered a major risk factor for the development of coronary artery disease and may outweigh the cardio-protective benefits females enjoy during the premenopausal period. As we could not find any study which had investigated the prevalence of smoking among Saudi females, we considered our study to be the first to report the increasing trend of smoking in this population (Table 1). Effective anti-smoking media campaigns and the provision of anti-smoking clinics to support individuals who want to quit smoking may lower the prevalence of this habit.

It is well established that the leading cause of morbidity and mortality in COPD patients is cardiovascular disease [22]. In a postmortem study conducted on patients who died within 24 hours of admission for COPD exacerbation, cardiac failure was determined as the leading cause of mortality [23]. Smoking is considered a cause of COPD, and therefore smokers mandate holistic and patient centered approaches to minimize the modifiable risk of coronary artery disease and cardiac failure.

Obesity

A national survey conducted in 1995 [15] reported a higher prevalence of obesity among females than among males. Our results (Table 1), however, showed a similar prevalence among both genders. Our study also found a lower prevalence of obesity in the Saudi than in the American population (33.9%) [16], which possibly indicates an underlying genetic factor of protection against obesity. As the reduction of obesity is an important public health objective, people should be educated about the higher risk of coronary artery disease associated with obesity and offered guidance for weight reduction through non-pharmacological, pharmacological and surgical means. Indeed, since obesity and overweight are increasing in the Kingdom of Saudi Arabia, and the overall prevalence of obesity is 35.5% [24], emphasis should be placed on a healthy lifestyle incorporating a balanced diet and adequate exercise.

Dyslipidemia

We found a slight male preponderance in the prevalence of dyslipidemia (Tables 1 and 2), which proved to be higher than indicated by previously reported local data [15], and very similar to the 16% prevalence reported in the USA [16]. This trend, which may reflect the adoption of westernized eating habits and lower physical activity in the urban region, contributes to the burden of coronary artery disease.

Physical activity

The American Heart Association has focused on physical inactivity as a major modifiable risk factor for heart disease [25]. In our study, the majority of subjects did not engage in regular exercise (Tables 1 and 2) In the USA, by contrast, only 39.5% of people are reported to be physically inactive [25]. Awareness of the benefits of exercise, especially walking, should hopefully encourage people to improve their behavior.

In the USA, approximately 49% of adults have at least one major risk factor for heart disease and stroke [16]. In our study, 56% of subjects had two or more risk factors; and the mean numbers of risk factors increased with age, the highest being among subjects aged over 60 years.

Clinical implications

Coronary artery disease constitutes one of the main health problems in Saudi Arabia [13]. By the time heart problems are detected, their underlying cause (atherosclerosis) has usually quietly advanced and has likely progressed over decades. As vascular injuries accumulate in adolescence, earlier primary preventive measures are necessary [14]. Greater emphasis is therefore being placed on preventing atherosclerosis by modifying risk factors through healthy diet, exercise and avoiding smoking [14].

Efforts should be made to establish comprehensive national policies regarding cardiovascular risk factor screening, especially earlier screenings for diabetes and hypertension. The message that needs to be conveyed is that the onset of diabetes or hypertension might be delayed or prevented by aggressive action during the impaired glycemic phase or pre-hypertensive phase. Although better screening is desirable, the top priority must be prevention, which should reduce the burden on the economies of developing countries.

Coronary artery disease is regarded as a leading public health problem in terms of its economic burden [26]. The main costs are those of hospital care and drug treatment (85%), while prevention and primary care account for only 3.6% of the total cost [26]. We can reduce the prevalence of coronary artery disease by decreasing the prevalence of coronary risk factors, thus reducing the economic burden.

Our young subjects were discovered to have a sizeable burden of coronary artery disease risk factors, a finding which mandates early screening and intervention. Few subjects engaged in regular exercise, and these small numbers reflect the need for more public programs to raise awareness of the benefits of exercise. We recommend the prompt implementation of a national prevention program at the community level in order to promote a leaner and healthier community.

Limitations

The model described in the Framingham HCE prediction equation uses a categorical variable approach, suggesting that the predictability of the model is nearly the same as that of the continuous-variable approach [11]. Other risk factors collected, but not included in the Framingham risk equations, could be taken into account in evaluating risk. These include BMI or obesity and physical activity. The Framingham HCE prediction equation was never validated in the Saudi Arabian population and can be considered as a limitation.

Conclusion

Our study is the first to estimate the 10-year risk of HCE in an adult population in an emerging country. It showed that the majority (55%) of Saudi subjects had more than two risk factors and 20% had four or more risk factors. The estimated Framingham risk score was higher among male subjects and increased with age. On considering diabetes as CHD risk-equivalent, almost 26% of subjects were classified as being at high risk of suffering hard coronary events in 10 years, which is alarming.

The prevalence of cardiovascular risk factors measured in our population seems to be higher than that estimated in western countries. We believe that this is due to the effect of urbanization, a westernized lifestyle, low physical activity and, probably, a genetic influence. Public awareness programs to control risk factors are warranted.

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