Journal of Local Global Health Perspectives

A Qatar Foundation Academic Journal

OPEN ACCESS

Research article

Prevention during the epidemiologic shift to chronic illness: a case control study of risk factors associated with cardiovascular disease in Qatar

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ABSTRACT

Background: Cardiovascular diseases (CVD) continue to be the leading cause of death worldwide. Countries in the Arabian Gulf region are prime examples of major shifts in demographic and epidemiologic profiles leading to an increased burden of chronic illness. This study estimated the association between five preventable conditions and risk factors and the development of myocardial infarction (MI) and cerebrovascular accidents (CVA) in the population of Qatar.

Methods: We conducted a case control study among patients admitted to Hamad Medical Corporation with acute MI ($n = 512$) or CVA ($n = 262$) from June 2006–June 2008. Controls ($n = 382$) were randomly selected from unrelated inpatient and outpatient departments. Data collected included socio-demographic information, medical/family history, lifestyle characteristics, and depression assessments.

Results: Over two thirds of MI and half of CVA cases were younger than 55 years, with 12% and 7%, respectively, being under age 40. Cases were predominantly males, and Qatari nationals constituted 13% of MI and 25% of CVA cases. Approximately 40% of participants were overweight and an additional 30% were obese. Diabetes was the strongest preventable risk factor for MI (adjusted odds ratio [OR] = 3.31, 95% CI 1.97–5.57) and CVA (adjusted OR = 3.67, 95% CI 2.00–6.74). Hypertension was the second major preventable risk factor for CVA (adjusted OR = 2.73, 95% CI 1.59–4.68) and an important factor for MI (adjusted OR = 1.69, 95% CI 1.05–2.72). Minimal physical activity (defined as lack of vigorous or moderate activity for at least 10 minutes in the past month) increased the risk of MI and CVA by approximately 80%, while smoking increased the risk of MI two-fold. Exploratory analyses of the determinants of CVD among Qatari nationals identified diabetes, hypertension, high cholesterol, and smoking as potential preventable risk factors, but with higher odds ratios than other groups.

Conclusions: Public health strategies to prevent MI and CVA should be based on alteration of risk factors found elsewhere in the world. However, the magnitude of these factors in Qatar suggests that the effectiveness of altering these risk factors is even more likely to have a significant impact. Designing population-level prevention interventions with awareness campaigns and supporting a culture of preventive health are critical for both Qatari nationals and the expatriate population.

Keywords: epidemiology, cardiovascular diseases, myocardial infarction, cerebrovascular diseases, Qatar, Middle East and North Africa

http://dx.doi.org/10.5339/jlghp.2013.4

Submitted: 4 February 2013
Accepted: 6 March 2013

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Cite this article as: Christos PJ, Chemaitelly H, Abu-Raddad LJ, Gehani AR, Deleu D, Mushlin AI. Prevention during the epidemiologic shift to chronic illness: a case control study of risk factors associated with cardiovascular disease in Qatar, *Journal of Local and Global Health Perspectives* 2013:4 http://dx.doi.org/10.5339/jlghp.2013.4

BACKGROUND

Cardiovascular diseases (CVD) continue to be the leading cause of death worldwide.[1] The World Health Organization (WHO) estimated CVD mortality at 17.1 million people in 2004 with 42% of these deaths attributed to coronary artery disease and 33% to stroke.[1] Mortality from CVD is predicted to reach 23.6 million people worldwide in 2030, with the largest increase occurring in the Eastern Mediterranean region.[1]

The increase in the burden of non-communicable and chronic diseases in general, and CVD occurrence in particular, is largely a manifestation of the accelerated epidemiological transition taking place in the Middle East and North Africa (MENA). This transition is driven in part by the rapidly aging populations and the high rates of urbanization and lifestyle changes.[2,3] Considerable improvements in infrastructure, sanitation, and health care services were introduced in most countries in MENA leading to a remarkable decrease in communicable diseases (from 40% in 2000 to 29% in 2010) and infant mortality, and a substantial gain in life expectancy.[3]

High-income countries in the MENA region, particularly in the Arabian Gulf region, have been witnessing major shifts in their demographic and epidemiologic profile leading to an increased burden of degenerative and chronic diseases.[4,5] Sedentary lifestyles along with reduced physical activity, and increased consumption of calories and fat rich diets have contributed to this trend.[5] Consequently, hypertension, insulin resistance, diabetes, hyperlipidemia, smoking, and metabolic syndrome, all played a role in increasing CVD incidence.[2,5,6] These changes were also accompanied by a rapid population growth and an influx of multi-ethnic workers, where in some countries such as Qatar, migrant workers constitute at least 73% of the total population.[7] As a result, these countries are challenged by a rapid increase in the incidence of cardiovascular diseases which remains unmatched by appropriate health programs.[8] A similar trend can be seen in countries of Central and Eastern Europe (CEE), as opposed to countries in North America (NA) for instance, which had already completed their epidemiological transition and have already focused their health agendas on preventing and controlling non-communicable diseases.[8]

The number of hospital admissions for coronary heart disease,[9] acute myocardial infarction,[10] stroke,[11–13] and heart failure[14] in Qatar is substantial. Although several studies have attempted to look at the characteristics of patients admitted with CVD in this nation,[9–14] these studies were based on convenience samples, and none of them involved a comparison to healthy controls. We conducted a case control study with the primary aim of estimating the association between five preventable risk factors, including diabetes, hypertension, dyslipidemia, smoking, and obesity, and the development of myocardial infarction (MI) or cerebrovascular accidents (CVA) in the population of Qatar, with its highly diverse population.

METHODS

Selection of cases and controls

Cases were recruited from Hamad Medical Corporation (HMC) in Qatar and included both Qatari nationals and non-Qatari expatriates admitted with incident MI or CVA during the period of the study. Controls were equally selected from inpatient and outpatient departments at HMC including the staff, dermatology, and orthopedic clinics. Controls were also selected from the outpatient departments at Rumailah Hospital, a part of HMC. The choice of sites for the selection of cases and controls was dictated by HMC being the main public hospital that serves the population of Qatar, and the sole health care provider fully equipped to address MI and CVA conditions. Cases and controls less than 30 years of age were excluded from the study. Controls with a history of heart disease or CVA events were similarly excluded.

Case ascertainment

MI diagnosis was ascertained by reviewing medical records for the peak troponin T and CK-MB (creatine kinase-muscle/brain type) levels for all enrolled MI cases, while CVA cases were ascertained using magnetic resonance imaging (MRI), computed tomography (CT) scans, and neurological examinations. All MI cases had detectable elevated peak troponin T values (median: 3.90 ng/ml, range: 0.03 to 63.88 ng/ml) and elevated peak CK-MB values (median: 106.45 ng/ml, range: 2.54 to 893.10 ng/ml). Enrolled CVA cases were admitted with a recent ischemic or hemorrhagic infarct as identified by MRI, CT scans, symptoms characteristic of neurological deficit (i.e., cranial nerve deficit, upper/lower extremity weakness, upper/lower extremity sensory loss, speech and/or swallowing deficit, etc.).

Data collection

Data collection took place between June 2006 and June 2008 for cases, and was extended until October 2008 for controls. It included a structured interview and a review of the patient's medical record. The patient interview and the review of the medical charts were carried out by research assistants who were employees of Weill Cornell Medical College – Qatar (WCMC–Q, the institution conducting the study). All had clinical research training and a good command of Arabic and English, and some spoke Hindi.

When possible, research assistants and patients were paired for data collection in a gender-appropriate manner, consistent with Qatari cultural norms; that is female patients being interviewed by female research assistants. Proxy respondents were interviewed in instances where cases had severe medical illnesses or severe neurological deficits (including stroke-related disabilities such as aphasia or dependence on a ventilator). Proxies were usually any adult relative designated by the study participant to represent him/her in the study.

The interview schedule required approximately 20 minutes to be completed. All interviews carried out with controls at outpatient clinics were conducted in private rooms assigned to the team. All controls participating in the study received a 100 Riyal telephone card as compensation for their time.

Sampling procedures

All inpatient cases admitted to HMC with MI or CVA between June 2006 and June 2008 were selected to potentially participate in the study. Identification of MI and CVA cases was performed by a review of the HMC hospital admission logbook, which was maintained in the HMC admission's office. Inpatients eligible for control recruitment included those who were admitted for gastrointestinal, urological, or orthopedic conditions. During each study day, a random sample of ten eligible control patients was drawn from the HMC hospital's admission logbook using a random number generator. No further attempts were made to contact control patients who were randomly selected but were not available in their rooms for the interview.

Controls recruited from the outpatient staff clinic at HMC included those who were at the clinic for sick leave requests, pre-employment screenings, follow-up visits, vaccinations, and prescription renewals. Patients were assigned numbers upon their arrival to the clinic, based on which a total of 40 patients were randomly selected at each visit. Controls recruited from outpatient dermatology and orthopedic clinics included those presenting for vitiligo, acne, alopecia, or laser treatments. The appointment lists were collected one day in advance, and 40 subjects were randomly selected for interview at each visit. Subjects who were selected to participate in the study but did not show up for their appointment were not pursued further for recruitment.

Ethical considerations

The study was approved by the Institutional Review Board of HMC and Weill Cornell Medical College in New York. Written informed consent was obtained from the physicians of eligible patients. A written informed consent was similarly collected from all study participants including proxy respondents. In some instances, a close relative such as the head of the family (husband, father, brother or son) signed the informed consent jointly with a women participant to avoid cultural sensitivities.

Study instruments

All questionnaires and consent forms were available in Arabic, English, and Hindi to minimize language barriers. Questionnaires were completed by the research assistants during the patient interview. The structured interview assessed the participant's socio-demographic background, family history, medical history, symptoms that prompted hospitalization (for cases), lifestyle characteristics (smoking, diet, and physical activity), quality of life, and depression. Indicators assessing the lifestyle characteristics were selected from a larger set of indicators contained in the National Health and Nutrition Examination Survey in the United States.[15] Questions related to alcohol consumption were specifically not selected as their inclusion is culturally inappropriate in a setting where participants were predominantly Muslim. The review of the medical record involved a collection of medical information including patient's height, weight, heart rate, blood pressure, waist circumference (if waist circumference was not available from the medical record, the research assistants measured and recorded it at the time of the interview), diagnosis, prescribed medications, results of routine blood and urine tests, patient symptoms prior to admission (for cases), results of electrocardiograms and other procedures (including cardiac catheterization, MRI scans, and CT scans) (for cases), as well as results of neurological examinations (for CVA cases). Height and weight information were used to calculate the body mass index (BMI) for all study participants.

Sample size

The sample size for this study was based on the estimated odds ratios (OR) for the association between the five hypothesized preventable risk factors (i.e., diabetes, hypertension, dyslipidemia, smoking, and obesity) and the occurrence of MI or CVA. A sample size of 400 patients with MI, 200 patients with CVA, and 400 inpatient/outpatient controls would allow for the detection of ORs ≥ 2.4 and 2.8 for MI and CVA, respectively, assuming an alpha level of 1% (two-sided test) and a power of 80%.[16] An alpha level of 1% was selected to be more conservative due to the multiplicity of hypothesized risk factors under investigation. In addition, 400 MI and 200 CVA cases would allow for the detection of an expected risk factor prevalence of 30% (among cases) with a 95% confidence interval (95% CI) width of 9% (i.e., $\pm$ 4.5%) for MI cases and 12.8% (i.e., $\pm$ 6.4%) for CVA cases.

Statistical analysis

Descriptive statistics were performed to characterize study participants. Unadjusted ORs and 95% CIs were calculated to estimate the association between the hypothesized preventable risk factors of interest (i.e., diabetes, hypertension, dyslipidemia, smoking, and obesity) and the development of MI or CVA. Similar unadjusted analyses were performed to estimate the association between socio-demographic, lifestyle, and depression variables and the development of MI or CVA. Multivariate logistic regression analyses (performed separately for MI and CVA outcomes) were carried out to examine the association between the corresponding preventable risk factors and MI or CVA, after adjusting first for age, sex, and smoking (i.e., risk factor models controlling for three covariates), and, subsequently, for all primary preventable risk factors along with other cofactors including socio-demographic, lifestyle, and depression variables. Waist circumference was used instead of BMI to assess obesity in the final multivariate models due to the high degree of collinearity between waist circumference and BMI (Pearson correlation coefficient: 0.68 among MI cases/controls and 0.62 among CVA cases/controls). The inclusion of any cofactor in the final adjusted multivariate model was determined based on whether its removal resulted in at least a 10% change in the OR confidence limits for any of the five hypothesized risk factors of interest. Exploratory descriptive and unadjusted regression analyses were also performed to examine the five hypothesized preventable risk factors for MI and CVA specifically among Qatari nationals (i.e., secondary subset analyses). All analyses were completed using SAS Version 9.2 (SAS Institute Inc., Cary, NC), SPSS Version 19.0 (SPSS Inc., Chicago, IL), and STATA Version 12.0 (StataCorp, College Station, TX).

RESULTS

From June 2006 to June 2008, a total of 1044 MI and 634 CVA cases were admitted to HMC and eligible for participation in the study, out of which 512 (49.0%) cases with MI and 262 (41.3%) cases with CVA were enrolled in the study. The main reasons for non-participation of eligible MI and CVA cases were the inability of the research team to contact the patient (19.6% and 13.7%, respectively) and the unavailability of a proxy-respondent for patients with severe medical conditions (10.5% and 29.3%, respectively). Only 12.7% of MI cases and 10.7% of CVA cases refused to participate in the study. Eligible MI and CVA cases that enrolled tended to be younger, male, and non-Qatari as compared to non-enrolled MI and CVA cases (Table 1). Comparative analyses between inpatient and outpatient controls also revealed a different socio-demographic profile. Inpatients comprised 53% of the total controls, and tended to be slightly older in age than outpatient controls (43.6 ± 10.3 vs. 41.9 ± 8.5, respectively, $P = 0.08$) and more likely to be male than outpatient controls (79.1% vs. 30.4%, respectively, $P < 0.0001$). The majority of outpatient controls were selected from HMC staff clinic (67%), while the rest were recruited from the outpatient dermatology and orthopedic clinics, or outpatient departments at Rumailah Hospital.

Table 1. Characteristics of enrolled and non-enrolled (but eligible) MI/CVA cases admitted to HMC during study period

	MI cases				CVA cases			
Demographic Characteristics	Total (N = 1044) N (%)	Enrolled (N = 512) N (%)	Not Enrolled (N = 532) N (%)	P value	Total (N = 634) N (%)	Enrolled (N = 262) N (%)	Not Enrolled (N = 372) N (%)	P value
Age at diagnosis (mean ± SD)	53.5 ± 11.0	51.8 ± 9.1	55.0 ± 12.4	<0.0001	58.0 ± 12.9	55.5 ± 10.3	59.6 ± 14.2	<0.0001
Sex				0.008				0.04
Male	930 (89.1)	470 (91.8)	460 (86.5)		488 (77.0)	213 (81.3)	275 (73.9)	
Female	114 (10.9)	42 (8.2)	72 (13.5)		146 (23.0)	49 (18.7)	97 (26.1)	
Nationality				<0.0001				0.001
Qatari	196 (18.8)	66 (12.9)	130 (24.4)		204 (32.2)	65 (24.8)	139 (37.4)	
Non-Qatari	848 (81.2)	446 (87.1)	402 (75.6)		428 (67.5)	195 (74.4)	233 (62.6)	

SD = standard deviation.

Table 2 describes the socio-demographic and lifestyle characteristics of the MI and CVA cases and controls, and provides unadjusted odds ratios and 95% CIs for the association between these factors and MI/CVA events. As expected, MI and CVA cases were more likely to be older than controls, with age >55 years (compared to age ≤55 years) strongly associated with MI (OR = 4.20, 95% CI 2.88–6.26) and CVA (OR = 7.97, 95% CI 5.27–12.29). MI and CVA cases were, respectively, 8.79 (95% CI 6.04–12.78) and 3.41 (95% CI 2.36–4.94) times more likely to be male compared to controls. CVA cases were 63% more likely to be Qatari nationals compared to controls (OR = 1.63, 95% CI 1.10–2.39). MI and CVA cases both had greater odds of having lower educational attainment as compared to controls (OR = 2.67, 95% CI 2.02–3.53 & OR = 3.30, 95% CI 2.33–4.67, respectively) (Table 2). In addition, MI cases were twice more likely than controls to have lower monthly wages (OR = 2.01, 95% CI 1.52–2.66). The majority of study participants (cases and controls) reported that they ate vegetables frequently but that they only engaged in minimal amounts of physical activity (defined as lack of vigorous or moderate activity for at least 10 minutes in the past month); however,

Table 2. Socio-demographic and lifestyle characteristics of MI and CVA cases and controls

	Controls	MI cases			CVA cases		
Primary risk factors	N = 382 N (%)	N = 512 N (%)	Unadjusted OR	95% CI	N = 262 N (%)	Unadjusted OR	95% CI
Age							
≤ 40 years	188 (50.0)	60 (11.9)	1.00	Referent	18 (7.4)	1.00	Referent
41–55 years	151 (40.2)	285 (56.7)	5.91	4.18, 8.45	113 (46.1)	7.82	4.65, 13.82
> 55 years	37 (9.8)	158 (31.4)	13.38	8.52, 21.47	114 (46.5)	32.18	17.90, 60.80
Male gender	214 (56.0)	470 (91.8)	8.79	6.04, 12.78	213 (81.3)	3.41	2.36, 4.94
Nationality (Qatari)	65 (17.0)	66 (12.9)	0.72	0.50, 1.05	65 (25.0)	1.63	1.10, 2.39
No college education	188 (49.2)	368 (72.2)	2.67	2.02, 3.53	198 (76.2)	3.30	2.33, 4.67
Monthly income < 3000 Riyals	128 (34.5)	250 (51.4)	2.01	1.52, 2.66	98 (40.7)	1.30	0.93, 1.82
Red Meat 1–3 times/day (vs. less)	25 (6.5)	46 (9.0)	1.41	0.85, 2.34	20 (7.7)	1.20	0.64, 2.20
Vegetables 1–3 times/day (vs. less)	266 (69.6)	438 (85.9)	2.65	1.91, 3.69	219 (84.6)	2.39	1.60, 3.57
Lack of vigorous activity ≥10 minutes in past month[1]	353 (92.4)	484 (94.7)	1.47	0.86, 2.53	253 (97.3)	2.97	1.28, 6.89
Lack of moderate activity ≥10 minutes in past month[2]	288 (75.4)	447 (87.5)	2.28	1.61, 3.24	222 (85.4)	1.91	1.26, 2.89
Lack of vigorous or moderate activity ≥10 minutes in past month[3]	275 (72.0)	431 (84.3)	2.10	1.51, 2.91	218 (83.9)	2.01	1.36, 3.01
Overweight (BMI 25–29.9 vs. <25)	136 (37.1)	184 (37.0)	0.80	0.58, 1.11	97 (41.3)	1.13	0.76, 1.70
Obesity (BMI ≥ 30 vs. <30)	126 (34.3)	135 (27.2)	0.71	0.53, 0.96	72 (30.6)	0.85	0.60, 1.20
Did not feel calm / peaceful last month	60 (15.7)	78 (15.3)	0.97	0.67, 1.39	40 (15.4)	0.98	0.63, 1.51
Felt downhearted / blue last month	35 (9.2)	43 (8.4)	0.91	0.57, 1.46	36 (13.9)	1.60	0.98, 2.62
History of depression	2 (0.5)	1 (0.2)	0.37	0.03, 4.13	2 (0.8)	1.46	0.20, 10.43

Some percent's are not out of 382 controls, 512 MI cases, and 262 CVA cases due to missing data.
OR = odds ratio, CI = confidence interval.
BMI = body mass index.
[1] Question: Over the past month, did you do any vigorous activity for at least 10 minutes that caused heavy sweating or large increases in breathing or heart rate? Respondents answered "no" or "yes" (referent).
[2] Question: Over the past month, did you do any moderate activity for at least 10 minutes that caused heavy sweating or large increases in breathing or heart rate? Respondents answered "no" or "yes" (referent).
[3] Lack of vigorous or moderate activity ≥10 minutes in past month was defined as patients who responded "no" to both the vigorous and moderate activity questions.

Table 3. Association between hypothesized preventable risk factors and MI and CVA

	Controls	MI cases			CVA cases		
Primary Risk Factors	N = 382 N (%)	N = 512 N (%)	Unad-justed OR	95% CI	N = 262 N (%)	Unad-justed OR	95% CI
History of diabetes	35 (9.3)	203 (40.2)	6.57	4.44, 9.71	135 (52.1)	10.64	6.96, 16.27
History of hypertension	70 (18.6)	220 (43.6)	3.39	2.47, 4.63	166 (63.8)	7.75	5.39, 11.13
History of high cholesterol	26 (6.9)	64 (12.7)	1.96	1.22, 3.15	50 (19.2)	3.21	1.94, 5.31
Smoking (ever)	112 (29.3)	304 (59.5)	3.54	2.67, 4.70	105 (40.4)	1.63	1.17, 2.28
Waist circumference (>88 cm for females or >102 cm for males)	136 (36.2)	132 (27.9)	0.68	0.51, 0.91	73 (35.1)	0.95	0.67, 1.36

Some percent's are not out of 382 controls, 512 MI cases, and 262 CVA cases due to missing data.
OR = odds ratio, CI = confidence interval.

both MI and CVA cases were more likely to eat vegetables frequently and report lack of vigorous or moderate activity for at least 10 minutes in the past month, as compared to controls (MI: ORs 2.65 [95% CI 1.91–3.69] & 2.10 [95% CI 1.51–2.91], respectively; CVA: ORs 2.39 [95% CI 1.60–3.57] & 2.01 [95% CI 1.36–3.01], respectively) (Table 2). Being overweight (defined as BMI 25–29) or obese (defined as BMI ≥ 30) was also highly prevalent among all study participants; approximately 40% were classified as overweight and an additional 30% were obese. Interestingly, and perhaps reflecting the overall amount of obesity in the population, these overweight and obesity classifications were not associated with an increased risk for MI or CVA, nor were feelings of depression or a history of depression (Table 2).

Table 3 describes the prevalence of the five hypothesized preventable risk factors in the MI/CVA cases and controls, and provides unadjusted odds ratios and 95% CIs for the association between these preventable risk factors and MI/CVA events. A history of diabetes was identified as the strongest hypothesized preventable risk factor (unadjusted) for both MI (OR = 6.57, 95% CI 4.44–9.71) and CVA (OR = 10.64, 95 CI 6.96–16.27). A history of hypertension was also identified as a strong unadjusted preventable risk factor for MI and CVA (Table 3). However, to assess the relative (and independent) importance of the five hypothesized preventable risk factors for MI and CVA, we performed multiple multivariate analyses controlling first for age, sex, and smoking, and, subsequently, including simultaneously in the model all hypothesized preventable risk factors along with significant cofactors, such as socio-demographic and lifestyle characteristics (Table 4). The first series of multivariate analyses (controlling only for age, sex, and, smoking) revealed a history of diabetes (adjusted OR = 4.01, 95% CI 2.54–6.51), a history of high cholesterol (adjusted OR = 2.81, 95% CI 1.48–5.55), past or current smoking (adjusted OR = 2.37, 95% CI 1.65–3.43), and a history of hypertension (adjusted OR = 2.34, 95% CI 1.54–3.59), as strong preventable risk factors for MI. Analogously, diagnosed diabetes (adjusted OR = 5.12, 95% CI 3.11–8.60), followed by a history of hypertension (adjusted OR = 3.59, 95% CI 2.29–5.66) and a history of high cholesterol (adjusted OR = 2.45, 95% CI 1.27–4.83), were the main preventable risk factors identified for CVA (Table 4). Adjusting for all risk factors (including socio-demographic and lifestyle factors), MI cases (compared to controls) were more likely to have a history of diabetes (adjusted OR = 3.31, 95% CI 1.97–5.57), be a previous or current smoker (adjusted OR = 2.24, 95% CI 1.49–3.37), and have a history of hypertension (adjusted OR = 1.69, 95% CI 1.05–2.72). Similarly, CVA cases (compared to controls) were more likely to have a history of diabetes (adjusted OR = 3.67, 95% CI 2.00–6.74) and a history of hypertension (adjusted OR = 2.73, 95% CI 1.59–4.68) (Table 4).

Because of the small sample size of Qatari nationals in the study (N = 66 MI cases, N = 65 CVA cases, and N = 65 controls) only exploratory (unadjusted) analyses were performed to evaluate the association between the five hypothesized preventable risk factors and MI and CVA (Table 5). Diagnosed diabetes and hypertension prevailed as very strong preventable risk factors (unadjusted), with MI and CVA Qatari cases being, respectively, 8.67 (95% CI 3.86–19.48) and 8.47 (95% CI 3.76–19.06) times more likely to have a history of diabetes, and 8.00 (95% CI 3.66–17.51) and 7.83 (95% CI 3.58–17.16) times more likely to have a history of hypertension, as compared to Qatari controls (Table 5). A history of high cholesterol was also a strong preventable risk factor (unadjusted) for MI and CVA among Qataris (OR = 2.76, 95% CI 1.18–6.45 & OR = 2.58, 95% CI 1.10–6.04, respectively), as was a history of past or current smoking (OR = 2.87, 95% CI 1.29–6.37 & OR = 2.11, 95% CI 0.93–4.76, respectively) (Table 5).

Table 4. Multivariate analyses for association between hypothesized preventable risk factors and MI/CVA, controlling for other factors

Risk factors	MI cases OR (95% CI)*	MI cases OR (95% CI)**	CVA cases OR (95% CI)*	CVA cases OR (95% CI)**
Hypothesized preventable risk factors				
History of diabetes	4.01 (2.54, 6.51)	3.31 (1.97, 5.57)	5.12 (3.11, 8.60)	3.67 (2.00, 6.74)
History of hypertension	2.34 (1.54, 3.59)	1.69 (1.05, 2.72)	3.59 (2.29, 5.66)	2.73 (1.59, 4.68)
History of high cholesterol	2.81 (1.48, 5.55)	1.90 (0.87, 4.14)	2.45 (1.27, 4.83)	1.70 (0.74, 3.91)
Smoking (ever)	2.37 (1.65, 3.43)[1]	2.24 (1.49, 3.37)	1.34 (0.86, 2.09)[1]	0.96 (0.56, 1.63)
Waist circumference (> 88 cm for females or > 102 cm for males)	1.45 (0.95, 2.25)	1.46 (0.90, 2.38)	0.96 (0.58, 1.60)	0.85 (0.47, 1.51)
Covariates in models				
Age	1.13 (1.11, 1.16)[2]	1.10 (1.07, 1.12)	1.13 (1.11, 1.16)[2]	1.09 (1.06, 1.12)
Male gender	9.10 (5.59, 15.20)[3]	11.30 (5.80, 22.00)	4.19 (2.52, 7.11)[3]	4.52 (2.22, 9.18)
Nationality (Qatari)	0.92 (0.53, 1.62)	0.64 (0.32, 1.26)	1.16 (0.66, 2.02)	0.72 (0.34, 1.53)
No college education	1.42 (0.99, 2.03)	0.95 (0.59, 1.55)	1.78 (1.16, 2.75)	1.76 (0.92, 3.36)
Monthly income < 3000 Riyals	1.39 (0.97, 2.00)	1.68 (1.02, 2.77)	1.48 (0.95, 2.33)	1.32 (0.66, 2.63)
Red meat 1–3 times/day (vs. less)	1.14 (0.61, 2.19)	1.12 (0.57, 2.23)	0.77 (0.35, 1.67)	0.47 (0.18, 1.22)
Vegetables 1–3 times/ day (vs. less)	2.61 (1.73, 3.95)	3.05 (1.91, 4.88)	2.19 (1.34, 3.63)	2.45 (1.33, 4.52)
Lack of vigorous or moderate activity ≥ 10 minutes in past month[4]	1.98 (1.31, 3.01)	1.83 (1.13, 2.96)	1.76 (1.08, 2.92)	1.86 (1.00, 3.45)

*Adjusted for age, sex, and smoking.
**Adjusted for all risk factors.
OR = odds ratio, CI = confidence interval.
[1] Adjusted for age and sex.
[2] Adjusted for sex and smoking.
[3] Adjusted for age and smoking.
[4] Lack of vigorous or moderate activity ≥ 10 minutes in past month was defined as patients who responded "no" to both the vigorous and moderate activity questions (see Table 2).

DISCUSSION

Our study revealed that diabetes was the largest preventable risk factor for MI and CVA among the highly diverse population of Qatar. Hypertension was the second most important preventable risk factor for CVA and an important factor for MI. Minimal engagement in physical activity was a risk factor for both MI and CVA, while smoking was associated with an increased risk of MI but not CVA (Table 4). Our exploratory analyses for the hypothesized preventable risk factors in the sub-group of Qatari nationals suggested similar trends, but higher odds ratios, and identified diabetes, hypertension, elevated total cholesterol, and smoking as preventable risk factors for MI and CVA.

Our findings are, in many respects, comparable to the results of the INTERHEART study, a standardized case-control study assessing the determinants of acute MI across 52 different countries around the globe (Table 6). However, the importance of diabetes as a risk factor was even higher than other countries in the region and strikingly higher than North America. This specific observation pertaining to diabetes was discussed in greater detail in a previous report of our work, which focused on the importance of diabetes in the global epidemic of cardiovascular disease.[17] Our MI cases had a

Table 5. Association between hypothesized preventable risk factors and MI and CVA events among Qatari nationals

Primary risk factors	Controls N = 65 N (%)	MI cases N = 66 N (%)	MI cases Unadjusted OR	MI cases 95% CI	CVA cases N = 65 N (%)	CVA cases Unadjusted OR	CVA cases 95% CI
History of diabetes	12 (18.8)	44 (66.7)	8.67	3.86, 19.48	43 (66.2)	8.47	3.76, 19.06
History of hypertension	16 (25.0)	48 (72.7)	8.00	3.66, 17.51	47 (72.3)	7.83	3.58, 17.16
History of high cholesterol	10 (15.6)	22 (33.9)	2.76	1.18, 6.45	21 (32.3)	2.58	1.10, 6.04
Smoking (ever)	12 (18.5)	26 (39.4)	2.87	1.29, 6.37	21 (32.3)	2.11	0.93, 4.76
Waist circumference > 88 cm for females or > 102 cm for males)	37 (56.9)	25 (42.4)	0.56	0.27, 1.13	17 (35.4)	0.42	0.19, 0.89

Some percent's are not out of 65 controls, 66 MI cases, and 65 CVA cases due to missing data.
OR = odds ratio, CI = confidence interval.

Table 6. Comparison of findings with INTERHEART study[18] for association of risk factors and MI events

Risk factor	OR (95% CI)*(NA)†[18]	OR (95% CI)*(MEC)‡ [18]	OR (95% CI)*(Qatar)
Region			
Self-reported diabetes	1.75 (0.94, 3.29)	2.92 (2.26, 3.79)	4.01 (2.54, 6.51)
Self-reported hypertension	1.58 (1.01, 2.47)	1.84 (1.45, 2.33)	2.34 (1.54, 3.59)
Dyslipidemia[1]	4.75 (1.34, 16.86)	5.33 (3.48, 8.18)	2.81 (1.48, 5.55)
Smoking	1.82 (1.14, 2.88)	2.64 (2.19, 3.19)	2.37 (1.65, 3.43)
Abdominal obesity[2]	4.68 (2.57, 8.50)	1.85 (1.43, 2.41)	1.45 (0.95, 2.25)

*All OR are adjusted for age, sex, and smoking (except OR for smoking, which is adjusted for age and sex).
†North America.
‡Middle East Crescent.
OR = odds ratio, CI = confidence interval.
[1] INTERHEART study [18]; top versus lowest quintile of ApoB/ApoA1 ratio. Qatar study; history of high cholesterol.
[2] INTERHEART study [18]; upper versus lower tertile of waist/hip ratio. Qatar study; waist circumference > 88 cm for females or > 102 cm for males.

similar socio-demographic profile to cases recruited by the INTERHEART team in Middle Eastern countries (MEC), where males comprised the majority of cases (86.0% in MEC, compared to 91.8% among the population of Qatar [Table 2] and 72.7% among Qatari nationals).[10,18] These results are also consistent with a descriptive study conducted among MI patients in Sharjah, United Arab Emirates (UAE), where males constituted 95.4% of the cases.[19] Qatar and UAE share comparable demographic characteristics and are classified among the most diversified populations in the world, with expatriates and migrant workers accounting for more than 70% of the population.[7,19] Specifically, in our study, a substantial proportion of MI cases were South-East Asian men, employed as workers, with minimal education and a low monthly income (53%), while Qataris constituted only 13% of MI cases. Moreover, most participants with MI in our study and in the INTERHEART study were 55 years of age or younger, with a large fraction being 40 years of age or younger (12.0% and 12.6%, respectively).[10,18] This prevalence of young people less than 40 years of age among MI patients is among the highest in the world and along with the striking importance of diabetes are indications of the urgency for establishing population-based awareness campaigns and prevention programs.[18] Similarly, the majority of CVA cases in Qatar were men (81.3%), with a substantial proportion of affected individuals being 55 years of age or younger (53.5%) (Table 2).

Unlike diabetes and hypertension, elevated cholesterol levels did not appear as strong of a risk factor for MI as in the INTERHEART study.[18] Differences might have risen from the use of different measures for hypercholesterolemia in the INTERHEART study, which used the ratio of apolipoproteins,[18] while our assessment was based upon a history of high total cholesterol (Table 4). Similarly, our estimate for the prevalence of elevated cholesterol among CVA patients (19.2%) (Table 3) was also less than that reported in the other Arab Gulf States which ranged between 29% in Bahrain and 61% in Kuwait.[6]

Our inquiries about potential lifestyle risk factors for MI and CVA revealed the universality of physical inactivity among study participants. Physically inactive patients were at twice the risk of developing MI and CVA in our study (Table 4). Unadjusted analyses for Qatari nationals revealed an even higher three-fold increase in the risk of MI and four-fold increase in the risk of CVA with physical inactivity (data not shown).

Interestingly, while abdominal obesity increased the risk of MI by around five times in NA and WE, and two times in MEC and CEE, abdominal obesity or an elevated BMI was not associated with MI or CVA among the population of Qatar (Table 2). The main reason may lie in the high overall prevalence of obesity conditions in Qatar.[20] Indeed, a recent cross sectional study among Qatari adults revealed that 32% are overweight and another 47% are obese.[21] These observations provide a plausible explanation for the absence of statistically significant associations between obesity and MI or CVA events; however, they do not reduce the importance of obesity as an alarming risk factor to be addressed at the national level.

An important strength of our study was the source population for cases and controls. Ideally, in the case-control design, cases and controls should be selected from the population who would have been admitted had they been diagnosed with the disease of interest (i.e., MI/CVA). A unique opportunity was afforded in this study because HMC is the sole hospital system admitting patients with acute MI or CVA in Qatar. It is, therefore, reasonable to assume that cases would have been admitted to HMC had they been diagnosed with MI or CVA and those without these conditions (controls) were from the population at risk to develop them. Therefore, our cases and controls should be representative of the population of Qatar. Furthermore, the conditions/diagnoses for which patients are seen at each of the sites selected for control recruitment, such as orthopedics and dermatology, are unlikely to be related to known or potential risk factors for MI or CVA and, thereby, constitute an appropriate control group for this study.

Our study had limitations. Although we used validated lifestyle indicators from the National Health and Nutrition Examination Survey in the United States,[15] the population of Qatar represents a setting markedly different from that of the United States. We did not formally conduct a pilot study to ascertain the validity of these lifestyle indicators in Qatar. As in all case control studies, selection bias might have been an issue if the eligible MI/CVA cases who chose not to participate in the study had a lower prevalence of risk factors compared to case patients who enrolled in the study, leading to an overestimation of the measure of association between the risk factors of interest and MI/CVA occurrence. However MI/CVA cases who did not to participate where, in fact, older, more likely to be female, and more likely to be Qatari nationals compared to MI/CVA cases who participated in the study (Table 1). Therefore, significant selection bias was unlikely in our study. The number of Qatari nationals among MI and CVA cases was small and did not allow us to carry out stratified analyses or develop multivariate models for this sub-population. However, we assessed the representativeness of our Qatari control group ($n = 65$) by comparing the prevalence of the five primary risk factors among Qatari controls to prevalence estimated for the Qatari general population (as retrieved from published cross-sectional studies) (data not shown). Despite minor differences, the broad similarity for the preventable primary risk factors in our Qatari control group and those reported for the general population from other studies, supports the validity of our findings. Furthermore, although case control studies are not optimal for establishing causality, the inclusion of only incident cases of MI and CVA helps to ensure the temporal sequence of events.

CONCLUSIONS

The risk factors and conditions leading to CVD in the population of Qatar are similar to other countries undergoing the epidemiological transition, and are demonstrably more important than in the developed world. Therefore, much of this disease burden can be alleviated by adopting healthier lifestyles, and improving the diagnosis and management of these conditions and risk factors. Up to one fourth of strokes could be prevented by treating hypertension alone,[12,22] and up to 80% of the incidence of cardiovascular events could be reduced by addressing hypertension, diabetes, and smoking.[18]

Additional research priorities should include a nationally representative large-scale community-based survey at the household level, investigating the prevalence of these key disease indicators and their associated risk factors, including diabetes. A nationally representative community-based survey would also allow the quantification of the scale of undiagnosed diabetes in Qatar, as well the prevalence of pre-diabetes. The resulting data would facilitate the establishment of evidence-informed programs and policy guidelines for better case management and prevention. Such a nationally representative study would also empower impact and cost-effectiveness analyses of health programs and interventions.

There is an urgent need for population-based public health strategies in countries undergoing the epidemiological transition like Qatar. Designing interventions with effective awareness campaigns and creating a culture of preventive health are critical for both Qatari nationals and the expatriate population.

COMPETING INTERESTS

The authors declare that they have no competing interests.

FUNDING SOURCES

This work was supported by funding to the Weill Cornell Medical College Department of Public Health from the Qatar Foundation. Dr. Paul Christos was partially supported by the following grant: Clinical Translational Science Center (CTSC) (2UL1TR000457-06) from the National Center for Research Resources, National Institutes of Health. Hiam Chemaitelly and Dr. Laith Abu-Raddad were supported by the Biostatistics, Epidemiology, and Biomathematics Research core of the Weill Cornell Medical College in Qatar.

AUTHORS' CONTRIBUTIONS

PJC participated in the design of the study, carried out the statistical analysis, provided interpretation of the data, helped to draft the manuscript, and revised the manuscript for important intellectual content. HC provided interpretation of the data, fully drafted the manuscript, and revised the manuscript for important intellectual content. LJA provided interpretation of the data, helped to draft the manuscript, and revised the manuscript for important intellectual content. ARG and DD contributed to the design of the study, helped with acquisition of the data, and revised the manuscript for important intellectual content. AIM conceived the study, participated in its design and coordination, provided interpretation of the data, helped to draft the manuscript, and revised the manuscript for important intellectual content. All authors read and approved the final manuscript.

Acknowledgements

We thank the following individuals for their contributions to study conception and design: Mark Callahan, MD, Madhu Mazumdar, PhD, Heejung Bang, PhD, Lisa Kern, MD, and Javaid I. Sheikh, MD. We thank Renee Razzano, MA, Mariam Sabbah, MPH, and Swati Srivastava, MS, for their efforts in patient recruitment, data collection, and maintenance of the study database. We thank Hala Al-Ali, Rita Habel, Ranya Shahrouri, and Nisha Lasrado, for their help with patient recruitment. We thank Naveed Akhtar, MD and Francisco Ruiz Miyares, MD, for their help in interpreting patient data provided to the research assistants. We also thank the following individuals for their assistance with various aspects of the study: Saadat Kamran, MD, Abdulbari Bener, PhD, M.S. El-Tawil, MD, Ismail Helmi, MD, Jasim Al-Suwaidi, MD, Nasser Al Ansari, MD, Hassan Al-Hail, MD, Ajayeb Dakhelallah Mohd Al-Nabet, PhD, Ronald Crystal, MD, Lofti Chouchane, PhD, Abeer Gohar, BA, and Amani Ma'ayah, MS.

REFERENCES

[1] Fact sheet on cardiovascular disease [http://www.who.int/mediacentre/factsheets/fs317/en/index.html].
[2] Aje TO, Miller M. Cardiovascular disease: A global problem extending into the developing world. *World J Cardiol*. 2009;1:3–10.
[3] Akala FA, El-Saharty S. Public-health challenges in the Middle East and North Africa. *Lancet*. 2006;367:961–964.
[4] Rosengren A, Wallentin L, Simoons M, Gitt AK, Behar S, Battler A, Hasdai D. Cardiovascular risk factors and clinical presentation in acute coronary syndromes. *Heart*. 2005;91:1141–1147.
[5] Musaiger AO. Diet and prevention of coronary heart disease in the Arab Middle East countries. *Med Princ Pract*. 2002;11(Suppl 2):9–16.
[6] Benamer HT, Grosset D. Stroke in Arab countries: a systematic literature review. *J Neurol Sci*. 2009;284:18–23.
[7] World Migration 2005. Costs and Benefits of International Migration; 2005.
[8] Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part I: general considerations, the epidemiologic transition, risk factors, and impact of urbanization. *Circulation*. 2001;104:2746–2753.
[9] Bener A, Al Suwaidi J, El-Menyar A, Gehani A. The effect of hypertension as a predictor of risk for congestive heart failure patients over a 10-year period in a newly developed country. *Blood Pressure*. 2004;13:41–46.
[10] Chaikhouni A, Chouhan L, Pomposiello C, Banna A, Mahrous F, Thomas G, al-Hassan NA, Khalifa S, Jaddan A, Bsata MW. Myocardial infarction in Qatar: the first 2515 patients. *Clin Cardiol*. 1993;16:227–230.
[11] Khan FY. Risk factors of young ischemic stroke in Qatar. *Clin Neurol Neurosurg*. 2007;109:770–773.
[12] Khan FY, Yasin M, Abu-Khattab M, El Hiday AH, Errayes M, Lotf AK, Ibrahim AS, Abbas MT, Matar I, Alsamawi M, Alhail H. Stroke in Qatar: a first prospective hospital-based study of acute stroke. *J Stroke Cerebrovasc Dis*. 2008;17:69–78.
[13] Akhtar N, Kamran SI, Deleu D, D'Souza A, Miyares F, Elsotouhy A, Al-Hail H, Mesraoua B, Own A, Salem K, Kamha A, Osman Y. Ischaemic posterior circulation stroke in State of Qatar. *Eur J Neurol*. 2009;16:1004–1009.
[14] Bener A, Al Suwaidi J, Ghaffar A. Is hypertension a predictor for heart failure? A cross cultural comparison over a 10-year period. *Eur J Heart Fail*. 2005;7:784–786.
[15] National Health and Nutrition Examination [www.cdc.gov/nchs/nhanes.htm].
[16] Elashoff JD. *Cork, Statistical Solutions*. Cork, Ireland: Statistical Solutions; 2007.
[17] Mushlin AI, Christos PJ, Abu-Raddad L, Chemaitelly H, Deleu D, Gehani AR. The importance of diabetes mellitus in the global epidemic of cardiovascular disease: the case of the state of Qatar. *Trans Am Clin Climatol Assoc*. 2012;123:193–207; discussion 207–8.
[18] Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J, Lisheng L, on behalf of the INTERHEART Study Investigators. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet*. 2004;364:937–952.
[19] Hossain MM, Kotekar ND, Dhar VK, Sunny PF. Clinical epidemiology of acute myocardial infarction in Sharjah, United Arab Emirates. *Int J Cardiol*. 1997;58:77–82.
[20] Bener A, Tewfik I. Prevalence of overweight, obesity, and associated psychological problems in Qatari's female population. *Obes Rev*. 2006;7:139–145.
[21] Bener A, Zirie M, Musallam M, Khader YS, Al-Hamaq AOAA. Prevalence of Metabolic Syndrome According to Adult Treatment Panel III and International Diabetes Federation Criteria: A Population-Based Study. *Metab Syndr Relat D*. 2009;7:221–229.
[22] Woo D, Haverbusch M, Sekar P, Kissela B, Khoury J, Schneider A, Kleindorfer D, Szaflarski J, Pancioli A, Jauch E, Moomaw C, Sauerbeck L, Gebel J, Broderick J. Effect of untreated hypertension on hemorrhagic stroke. *Stroke*. 2004;35:1703–1708.