

Incidence of Major Cardiovascular Events in Immigrants to Ontario, Canada

The CANHEART Immigrant Study

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Background—Immigrants from ethnic minority groups represent an increasing proportion of the population in many high-income countries, but little is known about the causes and amount of variation between various immigrant groups in the incidence of major cardiovascular events.

Methods and Results—We conducted the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) Immigrant Study, a big data initiative, linking information from Citizenship and Immigration Canada's Permanent Resident database to 9 population-based health databases. A cohort of 824 662 first-generation immigrants aged 30 to 74 as of January 2002 from 8 major ethnic groups and 201 countries of birth who immigrated to Ontario, Canada between 1985 and 2000 were compared with a reference group of 5.2 million long-term residents. The overall 10-year age-standardized incidence of major cardiovascular events was 30% lower among immigrants than among long-term residents. East Asian immigrants (predominantly ethnic Chinese) had the lowest incidence overall (2.4 in males, 1.1 in females per 1000 person-years), but this increased with greater duration of stay in Canada. South Asian immigrants, including those born in Guyana, had the highest event rates (8.9 in males, 3.6 in females per 1000 person-years), along with immigrants born in Iraq and Afghanistan. Adjustment for traditional risk factors reduced but did not eliminate the differences in cardiovascular risk between various ethnic groups and long-term residents.

Conclusions—Striking differences in the incidence of cardiovascular events exist among immigrants to Canada from different ethnic backgrounds. Traditional risk factors explain a part but not all of these differences. (*Circulation*. 2015;132:1549-1559. DOI: 10.1161/CIRCULATIONAHA.115.015345.)

Key Words: cardiovascular diseases ■ emigrants and immigrants ■ ethnology ■ myocardial infarction
 ■ risk factors ■ stroke

The increasing frequency of global migration to high-income countries such as Canada has highlighted the need for more information on cardiovascular risk factors and diseases in migrant populations from different ethnic backgrounds and regions of the world.¹⁻³ Cardiovascular diseases (including stroke) are the leading cause of death globally, and many immigrants to Canada come from low- and middle-income countries, which have the greatest absolute burden of cardiovascular deaths.⁴ A systematic review of 12 studies of cardiovascular disease in immigrant populations demonstrated

that the burden of ischemic heart disease and stroke is higher in many immigrant populations in comparison with the host population in those countries.⁵ However, most previous studies have focused on one or a limited number of immigrant groups, only include data derived from death certificates or hospitalizations, and have not studied the causes of variations in cardiovascular disease burden among different immigrant groups.

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Among high-income countries, Canada is the most ethnically and culturally diverse, and represents an ideal setting in which to conduct research on cardiovascular diseases in multiethnic migrant populations.⁶ Canada has one of the highest per-capita rates of immigration of any high-income country, with ≈250 000 immigrants (0.8% of population) arriving annually from countries around the world.⁷ Of these, the greatest proportion settles in Ontario, Canada's most populous province (13 million in 2011). The Cardiovascular Health in Ambulatory Care Research Team (CANHEART) is a big data research initiative aimed at measuring and improving the cardiovascular health of all Canadians.⁸ The objectives of this CANHEART Immigrant Study were to determine the prevalence of traditional cardiovascular risk factors and the 10-year incidence rates of major cardiovascular events in a large multiethnic cohort of first-generation immigrants who immigrated to Ontario between 1985 and 2000. We sought to determine whether significant differences in cardiovascular event rates exist among immigrants from different major ethnic groups, and if so, how variations in the burden of traditional risk factors contribute to these differences.

Methods

Study Design and Population

We identified a retrospective population-based cohort of 824 662 immigrants from the Citizenship and Immigration Canada Permanent Resident database who arrived in Ontario between 1985 and 2000, were 30 to 74 years of age, and were living in Ontario as of January 1, 2002. The Citizenship and Immigration Canada Permanent Resident database contains sociodemographic information such as country of birth, mother tongue, education, and immigration class on all immigrants to Ontario since 1985. Immigrants with hospitalizations for cardiovascular events before 2002 were excluded from the study to create a primary prevention cohort. Further details about study inclusion/exclusion criteria and methods used to construct the CANHEART cohort are provided in the online-only Data Supplement and are described in detail elsewhere (www.canheart.ca).⁸ A comparison cohort of 5 200 258 long-term residents who were born in Ontario or arrived before 1985, meeting the same age, residential, and cardiovascular disease history criteria, was identified from the Ontario Registered Persons Database. We estimate that the long-term resident cohort consists predominantly of white individuals (>95%) born in (≈83%) or who migrated to Canada before 1985 (≈17%; online-only Data Supplement).

Ethnic Groups

Ethnicity has been defined as “the social group a person belongs to, and either identifies with or is identified with by others, as a result of a mix of cultural and other factors including language, diet, religion, ancestry and physical features traditionally associated with race.”⁹ It is often defined at the ethnic group level or by country of birth. In this study, we chose to categorize each immigrant into 1 of 8 major ethnic groups derived from Canada's officially recognized visible minority groups by using 2 validated algorithms that identify an immigrant's most likely ethnic background based on a combination of their country of birth, mother tongue, and surname (for Chinese and South Asians).^{10,11} These major ethnic groups were: (1) East Asian (eg, Chinese, Korean); (2) Southeast Asian (eg, Filipino, Vietnamese); (3) black, from Sub-Saharan Africa and the Caribbean; (4) West Asian/Arab, from the Middle East, West Asia, and some former republics of the USSR; (5) Latin American, from Central and South America;

(6) South Asian (eg, Pakistani, Indian, Sri Lankan); and white immigrants subdivided into those of (7) white Eastern European and (8) white Western European origin. The latter category also included immigrants from non-European countries from which most immigrants are of white-Western European origin (eg, the United States, Australia, New Zealand, and South Africa). We also conducted subgroup analyses by country of birth as a secondary approach to ethnic classification.

Data Sources and Linkage

The immigrant and long-term resident cohorts created from the Citizenship and Immigration Canada Permanent Resident database and the Ontario Registered Persons Database were linked to 9 population-based health databases using unique, encoded identifiers to obtain information on the prevalence of traditional cardiac risk factors (smoking, hypertension, diabetes mellitus, lipid levels) and cardiovascular event rates (online-only Data Supplement). Databases used to identify these risk factors and clinical events (including the relevant codes of the *International Classification of Diseases, Ninth and Tenth Revisions*) are shown in the online-only Data Supplement. Mean body mass index (BMI) and the prevalence of obesity (BMI ≥30 kg/m²) were also determined, but not used in calculation of a cardiac risk factor score (see below) because the effect of obesity on cardiovascular risk is believed to be mediated through its effect on the other traditional risk factors.¹² However, adjustment for BMI was included as a sensitivity analysis in regression analyses (see Statistical Analyses).

CANHEART Cardiac Risk Factor Score

To quantify the relative combined burden of 4 traditional modifiable cardiac risk factors (smoking, diabetes mellitus, hypertension, and hyperlipidemia) in each ethnic group, we developed a points-based cardiac risk factor score using the methods originally described by Sullivan et al¹³ in creating the points-based Framingham risk score (online-only Data Supplement). A cardiac risk factor score was calculated for each immigrant and long-term resident by assigning points based on the presence or absence of each traditional risk factor. The age-standardized mean score for each ethnic group represents the group's relative burden of risk factors with higher scores indicating a higher burden. Missing lipid and smoking data were imputed by using multiple imputation methods (online-only Data Supplement).

Outcomes

The primary study outcome of a major cardiovascular event was a composite measure defined as the incidence of hospitalization for either acute myocardial infarction (AMI), stroke, revascularization with either percutaneous coronary intervention or coronary artery bypass graft surgery, or death from ischemic heart diseases or cerebrovascular diseases (online-only Data Supplement). The ratio of AMI/stroke rates was determined to compare the relative incidence of these conditions in each group. Revascularization/AMI ratios in each group were also calculated to determine whether access to revascularization procedures was equitable across ethnic groups. To determine the impact of acculturation, we also calculated the event rate comparing immigrants who had lived in Canada for <10 years with immigrants who had lived in Canada for at least 10 years before the study period inception.

Statistical Analyses

Descriptive statistics (means, proportions) were calculated for sociodemographic and outcome variables with 95% confidence intervals. Sex-specific, age-standardized 10-year incidence rates per 1000 person-years follow-up were calculated for each ethnic group and the long-term resident cohort by using the 2006 Ontario population aged 30 to 74 as the standard population. We also conducted sex-stratified subgroup analyses by country of birth for those 29 countries with at least 5000 immigrants to

Ontario. Pearson correlation coefficients were calculated to examine the ecological association between the mean ethnic group-specific cardiac risk factor score and the ethnic group-specific incidence rate of cardiovascular events. Sex-stratified, sequential Cox proportional hazard modeling was performed to investigate differences in the primary outcome between ethnic groups and the long-term resident cohort after adjusting for individual-level differences in age, socioeconomic status measured by neighborhood income quintile, prevalence of traditional cardiovascular risk factors, and BMI (see online-only Data Supplement). Individuals who emigrated from Ontario were censored at the time of departure. Data analyses were conducted by using SAS version 9.3 (SAS Institute, Cary NC) and R software version 2.15.1, and analyzed at the Institute for Clinical Evaluative Sciences. Results are presented in order of increasing incidence of the primary outcome by ethnicity among male immigrants. This study was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre. Informed consent from Canadian Community Health Survey participants was obtained by Statistics Canada for record linkage to administrative databases.

Results

Baseline Characteristics of Immigrant Cohort

Figure 1 provides a global map showing the distribution of the 824 662 immigrants in our study population by country of birth. The map demonstrates the wide diversity of Ontario immigrants with 201 countries (and 179 mother tongues) represented, covering all inhabited continents and nearly all countries in the world. Table 1 shows baseline sociodemographic information of the immigrant cohort by ethnic group and long-term residents. At study initiation, the mean age of the immigrant cohort was 44 years and their mean duration in Canada was 8.6 years. Economic

immigrants (ie, skilled workers selected via a points system) comprised 43.0% of immigrants, 40.1% were family class immigrants (sponsored by a relative already in Canada), and 15.2% were refugees. All immigrant groups were more likely to live in low-income neighborhoods in Ontario in comparison with the long-term residents. Overall, 21.7% of immigrants were from other high-income countries, 56.9% from middle-income countries, and 21.4% from low-income countries.¹⁴

Cardiovascular Disease Risk Factors

Table 2 shows the prevalence of traditional cardiac risk factors in each ethnic group and among long-term residents. Smoking rates were lower in all female and most male ethnic groups (with the exception of white-Eastern European and West Asian/Arab males) in comparison with long-term residents. The overall prevalence of obesity and hypertension was also lower among immigrants. Black and Southeast Asian immigrants had particularly high rates of hypertension, whereas South Asian and black immigrants had the highest rates of diabetes mellitus. The total/high-density lipoprotein cholesterol ratio was highest in South Asian immigrants and lowest in East Asian and black (males only) immigrants. The mean cardiac risk factor score varied widely among ethnic groups, but was lower among immigrants overall than among long-term residents. The mean cardiac risk factor score was also lower among immigrants who left Ontario (12.1% of males, 10.4% of females) before the end of the 10-year study period (1.92 in males, 1.51 in females) than among

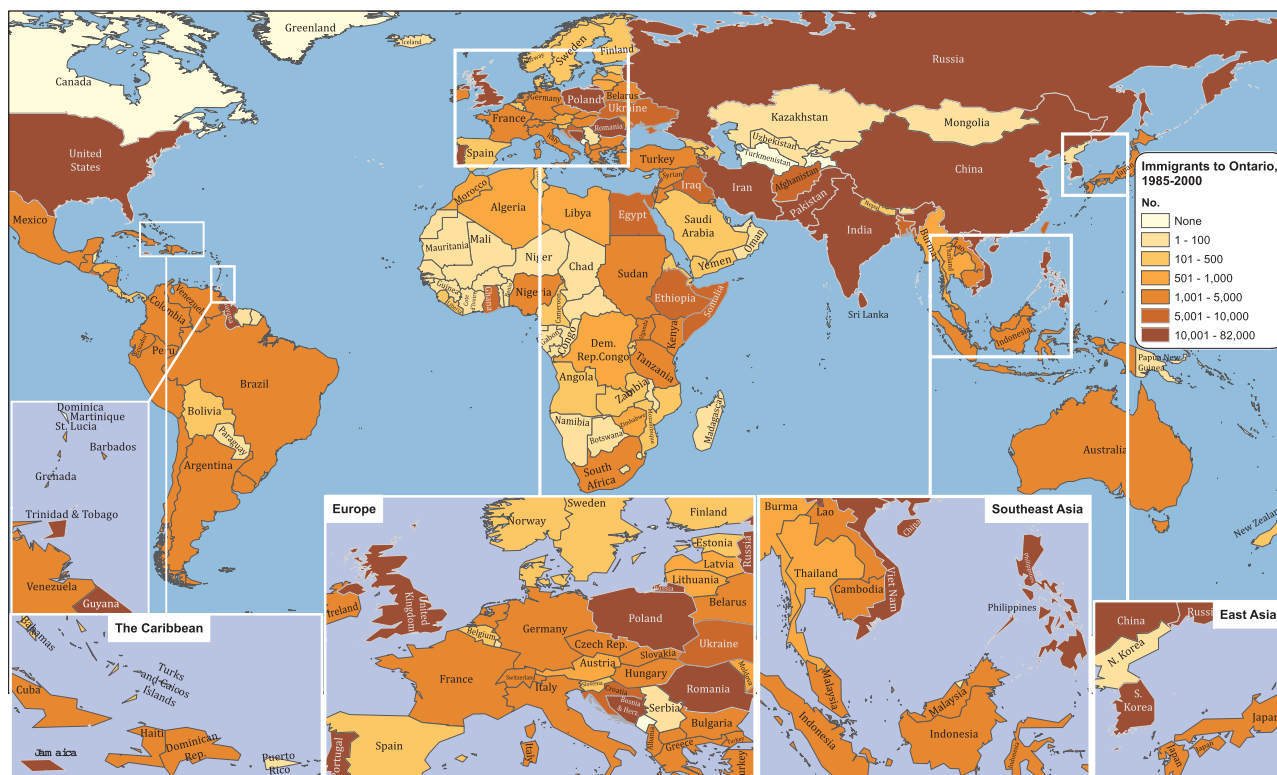


Figure 1. Countries of birth of 824 662 immigrants to Ontario, Canada (1985–2000) in the CANHEART Immigrant Study cohort.

Table 1. Baseline Characteristics of Ontario Immigrants and Long-Term Residents

Demographics	East Asian (N=174 167)	Black (N=84 914)	White-Western European (N=82 998)	Southeast Asian (N=68 239)	Latin American (N=55 173)	West Asian/Arab (N=71 770)	White-Eastern European (N=121 912)	South Asian (N=165 489)	All Immigrants (N=824 662)	Long-Term Residents (N=5 200 258)
Age on arrival, y	37.7 (11.4)	32.7 (10.0)	33.5 (10.3)	35.6 (11.1)	33.8 (10.6)	35.2 (10.7)	35.4 (9.8)	36.8 (11.7)	35.6 (11.0)	NA
Age on January 1, 2002, y	45.4 (11.6)	42.0 (9.5)	43.8 (10.1)	44.4 (10.7)	43.5 (10.3)	43.1 (10.3)	43.7 (9.5)	44.2 (11.4)	44.0 (10.7)	48.7 (11.8)
Female sex, %	52.0	50.6	50.1	60.2	48.9	42.3	49.9	46.7	49.9	52.2
Education, %										
≤12 y of schooling	47.5	64.2	49.2	46.2	61.2	46.8	30.4	52.6	48.8	
Some postsecondary	26.3	27.5	31.4	25.5	26.4	21.5	38.5	19.3	27.0	NA
Completed university	26.2	8.3	19.4	28.3	12.3	31.7	31.1	28.0	24.2	
Immigration class, %										
Economic	58.0	29.7	56.5	43.2	30.3	42.9	33.5	39.5	43.0	
Family class	34.2	52.1	42.0	46.9	46.2	27.3	29.3	47.5	40.1	NA
Refugee	3.1	17.5	0.4	9.7	22.8	28.8	36.8	12.5	15.2	
Years in Ontario (up to January 1, 2002)	8.1	9.5	10.5	8.9	9.9	8.1	8.5	7.6	8.6	NA
Low-income neighborhood, %	42.7	68.0	38.4	60.2	63.9	51.8	53.1	58.1	52.9	35.8
Country of birth income group, %										
High	43.6	19.9	92.5	0.3	0.1	5.7	0.7	3.1	21.7	
Middle	49.9	46.4	7.3	79.7	99.9	83.7	99.3	28.6	56.9	NA
Low	6.5	33.7	0.2	19.9	0	10.6	0	68.3	21.4	

Data are mean (SD) or as labeled. Values are age- and sex-standardized to the 2006 Ontario census population (except age on arrival, age on January 1, 2002, and female sex), and ordered by male ranking on the primary outcome measure (see Table 3). Education is at the time of application for immigration. Family class includes immigrants who arrived as spouses, partners, parents, grandparents, or children of a Canadian citizen or permanent resident. Economic class includes skilled workers, entrepreneurs, the self-employed, live-in caregivers, investors and their dependents (eg, spouses, parents, and children). Columns do not add up to 100% because immigrants outside these classes (eg, humanitarian and compassionate cases) are not shown (1.7% of all immigrants). Low-income neighborhood is defined as neighborhood income quintile=1 or 2, where quintile 1 has the lowest income. Country of birth income group is based on the World Bank's 2006 classification.¹⁴ NA indicates not applicable.

immigrants followed for the entire study (2.20 in males, 1.81 in females).

Ten-Year Incidence Rates of Cardiovascular Events

Overall, 19 127 events occurred over 7 674 691 person-years of follow up in the immigrant cohort (mean 9.3 years of follow-up). The overall incidence of major events was 30% lower (31% in males, 29% in female) in immigrants than in long-term residents. The age-standardized 10-year incidence rate of major cardiovascular events by ethnic group varied 4-fold with East Asian male and female immigrants at lowest risk (2.4 and 1.1 per 1000 person-years, respectively) and South Asian male and female immigrants at highest risk (8.9 and 3.6 per 1000 person-years, respectively; Table 3). The ratio of AMI/stroke events varied 3-fold across ethnic groups with East Asian, black, and Southeast Asian immigrants having relatively low ratios, indicating relatively fewer AMIs in each of these groups. The revascularization/AMI ratio was similar across ethnic groups, indicating similar access to invasive cardiac procedures.

Comparing immigrants living in Canada for <10 years versus ≥10 years, the incidence of events was similar in most ethnic groups. A notable exception was among East Asian immigrants where a 40% and 60% higher incidence was found among males and females, respectively, living in Canada for ≥10 years (Table 4).

Cardiovascular Event Rates by Country of Birth

Results from analysis of age-standardized major cardiovascular event incidence rates in the 29 countries of birth with at least 5000 immigrants to Ontario are shown in Figure 2. Greater variation in cardiovascular event rates by country of birth was observed among male immigrants than among female immigrants. In general, the cardiovascular event rate was similar among different countries of birth within each region of birth, but some exceptions were found. Immigrants born in Iraq and Afghanistan had higher event rates than those born in neighboring countries. Immigrants from these 2 countries also had among the highest mean cardiac risk factor scores (Figure 3) and relatively high proportions were refugees (61% from Iraq, 79% from

Table 2. Age-Standardized Baseline Risk Factors for Cardiovascular Disease Among Ontario Immigrants and Long-Term Residents

	East Asian	Black	White-Western European	Southeast Asian	Latin American	West Asian/Arab	White-Eastern European	South Asian	All Immigrants	Long-Term Residents
Males, n	83 535	41 907	41 434	27 159	28 176	41 407	61 096	88 161	412 875	2 484 554
Current cigarette smoker, %	23.3 (17.7–28.9)	16.0 (10.8–22.7)	24.7 (17.8–33.0)	21.1 (16.3–27.5)	26.1 (17.2–35.7)	39.4 (23.4–50.3)	32.7 (25.4–40.3)	16.5 (12.9–20.8)	24.5 (22.0–27.0)	28.7 (28.1–29.2)
Hypertension, %	14.2 (13.9–14.6)	23.2 (22.4–24.0)	14.2 (13.7–14.7)	24.9 (24.1–25.6)	18.3 (17.6–19.1)	15.8 (15.3–16.4)	15.9 (15.4–16.5)	21.4 (21.0–21.8)	17.9 (17.7–18.1)	20.6 (20.5–20.6)
Diabetes mellitus, %	6.2 (6.0–6.4)	12.3 (11.7–12.9)	4.7 (4.4–5.0)	8.8 (8.4–9.3)	9.8 (9.2–10.3)	8.5 (8.1–9.0)	4.6 (4.3–4.9)	15.0 (14.7–15.3)	8.8 (8.6–8.9)	7.3 (7.3–7.4)
Mean cholesterol, mmol/L										
Total	5.21 (5.19–5.22)	5.20 (5.17–5.22)	5.46 (5.43–5.49)	5.37 (5.34–5.39)	5.40 (5.38–5.43)	5.18 (5.16–5.20)	5.45 (5.43–5.47)	5.24 (5.22–5.25)	5.29 (5.29–5.30)	5.34 (5.34–5.34)
High-density lipoprotein	1.34 (1.34–1.35)	1.35 (1.34–1.36)	1.33 (1.32–1.34)	1.28 (1.28–1.29)	1.24 (1.23–1.25)	1.19 (1.19–1.20)	1.32 (1.31–1.32)	1.18 (1.18–1.19)	1.27 (1.27–1.28)	1.29 (1.29–1.29)
Mean total cholesterol/high-density lipoprotein ratio	4.08 (4.06–4.09)	4.07 (4.05–4.10)	4.35 (4.31–4.38)	4.38 (4.35–4.41)	4.58 (4.55–4.61)	4.58 (4.55–4.61)	4.38 (4.35–4.41)	4.62 (4.61–4.64)	4.38 (4.37–4.39)	4.38 (4.37–4.38)
Mean BMI, kg/m ²	23.5 (23.1–23.8)	25.6 (24.8–26.3)	27.5 (26.1–29.5)	25.2 (24.3–26.0)	26.9 (26.3–27.5)	26.3 (25.5–27.2)	26.6 (25.9–27.3)	25.4 (25.0–25.8)	25.6 (25.4–25.8)	27.2 (27.1–27.3)
Obesity (BMI ≥30 kg/m ²), %	2.4 (1.2–4.1)	12.4 (6.9–19.1)	14.7 (8.9–21.1)	10.6 (4.2–18.0)	15.8 (7.8–25.2)	9.5 (4.6–15.3)	16.2 (10.6–22.1)	8.6 (5.9–11.8)	10.2 (8.8–11.7)	21.5 (21.0–22.0)
Cardiac risk factor score	1.73 (1.72–1.75)	2.06 (2.03–2.09)	2.11 (2.09–2.13)	2.32 (2.30–2.35)	2.41 (2.38–2.44)	2.52 (2.50–2.54)	2.31 (2.29–2.33)	2.36 (2.35–2.37)	2.18 (2.17–2.18)	2.28 (2.28–2.29)
Females, n	90 632	43 007	41 564	41 080	26 997	30 363	60 816	77 328	411 787	2 715 704
Current cigarette smoker, %	1.7 (0.8–2.9)	2.8 (1.3–4.8)	13.3 (8.7–18.6)	4.0 (1.7–7.0)	7.9 (4.1–13.6)	19.3 (12.2–29.0)	20.9 (16.2–26.9)	2.5 (1.3–4.2)	8.6 (7.6–9.8)	23.8 (23.3–24.4)
Hypertension, %	16.2 (15.9–16.6)	31.3 (30.6–32.1)	15.9 (15.4–16.4)	25.8 (25.1–26.4)	21.7 (21.0–22.4)	17.4 (16.8–18.1)	17.9 (17.4–18.4)	21.7 (21.3–22.1)	20.3 (20.2–20.5)	21.3 (21.3–21.4)
Diabetes mellitus, %	5.8 (5.6–6.0)	13.3 (12.8–13.8)	4.4 (4.1–4.6)	8.3 (8.0–8.7)	10.2 (9.7–10.7)	7.8 (7.4–8.2)	3.6 (3.4–3.8)	13.1 (12.8–13.4)	8.2 (8.1–8.3)	6.0 (5.9–6.0)
Mean cholesterol, mmol/L										
Total	5.13 (5.12–5.14)	5.14 (5.12–5.16)	5.34 (5.31–5.36)	5.25 (5.23–5.27)	5.28 (5.26–5.30)	5.18 (5.16–5.20)	5.36 (5.35–5.38)	5.10 (5.09–5.12)	5.20 (5.19–5.20)	5.35 (5.35–5.36)
High-density lipoprotein	1.63 (1.63–1.64)	1.56 (1.56–1.57)	1.61 (1.60–1.62)	1.55 (1.54–1.56)	1.48 (1.47–1.49)	1.48 (1.47–1.49)	1.64 (1.63–1.65)	1.38 (1.38–1.38)	1.54 (1.54–1.54)	1.60 (1.60–1.60)
Mean total cholesterol/high-density lipoprotein ratio	3.31 (3.30–3.32)	3.46 (3.44–3.48)	3.52 (3.49–3.54)	3.56 (3.54–3.58)	3.76 (3.73–3.78)	3.69 (3.67–3.72)	3.46 (3.44–3.48)	3.88 (3.86–3.89)	3.57 (3.56–3.57)	3.55 (3.55–3.56)
Mean BMI, kg/m ²	22.2 (21.9–22.5)	26.7 (25.9–28.0)	26.0 (25.1–26.9)	23.8 (23.2–24.5)	26.3 (25.4–27.0)	25.8 (24.8–26.7)	25.2 (24.6–26.0)	25.2 (24.6–25.7)	24.7 (24.4–25.0)	26.0 (25.9–26.0)
Obesity (BMI ≥30 kg/m ²), %	2.5 (1.1–4.2)	23.8 (18.3–32.8)	19.6 (12.1–26.2)	6.9 (2.5–12.2)	17.6 (10.6–26.0)	15.4 (6.4–24.6)	16.4 (12.1–22.5)	10.7 (7.4–14.2)	11.3 (9.7–13.0)	18.5 (18.0–18.9)
Cardiac risk factor score	1.49 (1.48–1.50)	1.88 (1.86–1.90)	1.64 (1.62–1.66)	1.86 (1.84–1.88)	1.97 (1.94–1.99)	2.00 (1.98–2.02)	1.75 (1.73–1.76)	2.02 (2.01–2.03)	1.79 (1.78–1.80)	2.09 (2.09–2.09)

Data are mean or % with 95% confidence intervals unless otherwise stated. Smoking status is as of January 1, 2002 and is based on 8416 immigrants and 130 975 long-term residents surveyed in the 2000 to 2012 Canadian Community Health Surveys (CCHS; with the exception of white-Western and Eastern Europeans where results were calculated from a study subpopulation linkable to the CCHS; n=664 for Western Europeans and n=818 for Eastern Europeans). Lipid testing results were available for 272 399 (33%) immigrants and 1 478 632 (28%) long-term residents. The cardiac risk factor score is a measure of the traditional risk factor burden with higher scores indicating higher risk. See online-only Data Supplement for further details. BMI indicates body mass index.

Table 3. Age-Standardized Incidence of Major Cardiovascular Events by Ethnicity

	East Asian	Black	White- Western European	Southeast Asian	Latin American	West Asian/ Arab	White- Eastern European	South Asian	All Immigrants	Long-term Residents
Males, n	83 535	41 907	41 434	27 159	28 176	41 407	61 096	88 161	412 875	2 484 554
AMI	0.7 (0.6–0.8)	1.5 (1.3–1.8)	1.8 (1.6–2.0)	1.9 (1.6–2.1)	2.4 (2.1–2.7)	2.5 (2.3–2.8)	2.5 (2.3–2.7)	3.5 (3.3–3.7)	2.1 (2.0–2.1)	3.0 (2.9–3.0)
Stroke	0.7 (0.6–0.8)	1.5 (1.3–1.8)	0.9 (0.8–1.1)	1.5 (1.3–1.7)	1.3 (1.1–1.6)	0.8 (0.7–0.9)	1.3 (1.1–1.5)	1.2 (1.1–1.3)	1.0 (1.0–1.1)	1.3 (1.3–1.3)
AMI/stroke ratio	1.0 (0.9–1.2)	1.0 (0.8–1.3)	1.9 (1.6–2.4)	1.2 (1.0–1.5)	1.8 (1.5–2.3)	3.2 (2.6–4.0)	1.9 (1.7–2.3)	3.0 (2.7–3.3)	2.0 (1.9–2.1)	2.3 (2.2–2.3)
Revascularization	1.3 (1.2–1.4)	2.4 (2.1–2.6)	2.8 (2.6–3.1)	3.1 (2.8–3.4)	3.3 (3.0–3.7)	4.8 (4.5–5.1)	4.5 (4.2–4.8)	6.4 (6.1–6.6)	3.6 (3.5–3.7)	4.8 (4.8–4.9)
Revascularization/ AMI ratio	1.8 (1.6–2.1)	1.5 (1.3–1.9)	1.6 (1.4–1.8)	1.6 (1.4–1.9)	1.4 (1.2–1.6)	1.9 (1.7–2.1)	1.8 (1.6–2.0)	1.8 (1.7–1.9)	1.7 (1.7–1.8)	1.6 (1.6–1.6)
Cardiovascular death	0.4 (0.4–0.5)	0.7 (0.6–0.9)	0.8 (0.7–1.0)	0.7 (0.6–0.9)	0.7 (0.5–0.9)	0.7 (0.6–0.9)	1.2 (1.0–1.3)	1.1 (1.0–1.2)	0.8 (0.7–0.8)	1.5 (1.5–1.5)
Either AMI, stroke, revascularization, or cardiovascular death	2.4 (2.2–2.5)	4.7 (4.3–5.2)	4.8 (4.5–5.1)	5.4 (5.0–5.9)	5.6 (5.2–6.1)	6.7 (6.3–7.1)	7.2 (6.8–7.5)	8.9 (8.7–9.2)	5.6 (5.5–5.7)	8.1 (8.1–8.1)
Females, n	90 632	43 007	41 564	41 080	26 997	30 363	60 816	77 328	411 787	2 715 704
AMI	0.2 (0.2–0.3)	0.8 (0.7–0.9)	0.7 (0.6–0.8)	0.5 (0.4–0.6)	1.0 (0.9–1.2)	0.9 (0.8–1.1)	0.8 (0.7–0.9)	1.4 (1.3–1.5)	0.8 (0.7–0.8)	1.2 (1.2–1.2)
Stroke	0.6 (0.5–0.7)	1.1 (1.0–1.3)	0.7 (0.6–0.8)	1.0 (0.8–1.1)	1.1 (0.9–1.2)	0.7 (0.6–0.9)	0.8 (0.7–0.9)	0.8 (0.7–0.9)	0.8 (0.8–0.8)	1.0 (0.9–1.0)
AMI/stroke ratio	0.4 (0.3–0.5)	0.7 (0.6–0.9)	1.1 (0.8–1.4)	0.5 (0.4–0.6)	1.0 (0.8–1.2)	1.3 (1.0–1.6)	0.9 (0.8–1.1)	1.7 (1.5–2.0)	1.0 (0.9–1.0)	1.3 (1.2–1.3)
Revascularization	0.3 (0.3–0.4)	1.0 (0.9–1.1)	0.8 (0.7–0.9)	0.8 (0.6–0.9)	1.2 (1.0–1.4)	1.5 (1.3–1.7)	1.2 (1.1–1.3)	2.0 (1.9–2.1)	1.1 (1.0–1.1)	1.5 (1.5–1.5)
Revascularization/ AMI ratio	1.4 (1.1–1.8)	1.2 (1.0–1.5)	1.1 (0.9–1.4)	1.6 (1.3–2.1)	1.2 (0.9–1.5)	1.6 (1.3–2.0)	1.6 (1.3–1.9)	1.4 (1.3–1.6)	1.4 (1.3–1.5)	1.2 (1.2–1.2)
Cardiovascular death	0.3 (0.2–0.3)	0.5 (0.4–0.6)	0.5 (0.4–0.6)	0.3 (0.3–0.4)	0.5 (0.4–0.7)	0.4 (0.3–0.6)	0.4 (0.3–0.4)	0.6 (0.5–0.7)	0.4 (0.4–0.5)	0.7 (0.7–0.7)
Either AMI, stroke, revascularization or cardiovascular death	1.1 (1.1–1.2)	2.7 (2.5–3.0)	2.1 (1.9–2.3)	2.1 (1.9–2.3)	2.9 (2.6–3.2)	2.9 (2.6–3.1)	2.5 (2.3–2.7)	3.6 (3.4–3.8)	2.4 (2.3–2.5)	3.4 (3.4–3.4)

Data are per 1000 person-years (95% confidence interval) unless otherwise stated. Revascularization procedures include percutaneous coronary intervention or coronary artery bypass graft surgery. Cause of death is known for 96% of immigrants and 99% of long-term residents with cardiovascular death defined as death attributable to ischemic heart disease or stroke and unknown causes considered noncardiovascular. AMI indicates acute myocardial infarction.

Afghanistan) in comparison with other immigrants from the Middle East and West Asia (19%). Relatively high incidences of cardiovascular events among immigrants born in Guyana and Trinidad and Tobago were also observed, explained in part by the heavy presence of South Asian diaspora among migrants to Canada from these regions of the world.

Association Between CANHEART Cardiac Risk Factor Score and Cardiovascular Event Rates

Figure 3 shows the association between the risk factor burden measured by using our cardiac risk factor score and the 10-year age-standardized incidence of major cardiovascular events in both ethnic group and country of birth analyses. By ethnicity, the correlation coefficients between the mean cardiac risk factor score and cardiovascular event rate were

0.76 for males and 0.92 for females. By country of birth, the corresponding correlation coefficients were 0.81 for males and 0.75 for females, demonstrating that variation in risk factor burden contributes to the event rate differences found in this study.

Role of Sociodemographics and Risk Factors to Event Rate Variation

A series of sequential sex-specific Cox regression models exploring the contribution of ethnicity, age, socioeconomic status, traditional cardiovascular risk factors, and BMI to individual-level differences in major cardiovascular event rates by ethnic group is shown in Figure 4. A adjustment for age and socioeconomic status reduced the variation among different ethnic groups and the long-term residents, with a further reduction seen after adjustment for traditional risk

Table 4. Age-Standardized Incidence of a Major Cardiovascular Event by Ethnicity and Length of Stay in Ontario, Canada, Before Study Inception

Length of Stay in Ontario, Canada Before Study Inception	Incidence of a Major Cardiovascular Event								
	East Asian	Black	White-Western European	Southeast Asian	Latin American	West Asian/Arab	White-Eastern European	South Asian	All immigrants
Males, n	83 535	41 907	41 434	27 159	28 176	41 407	61 096	88 161	412 875
<10 y	2.1 (1.9–2.3)	4.7 (4.2–5.3)	4.5 (4.0–5.0)	5.0 (4.5–5.5)	5.7 (5.1–6.4)	6.7 (6.2–7.2)	6.7 (6.3–7.2)	8.5 (8.2–8.8)	5.4 (5.3–5.5)
10+ y	2.9 (2.7–3.2)	4.4 (3.8–5.0)	4.8 (4.4–5.2)	6.3 (5.6–7.1)	5.2 (4.7–5.9)	6.5 (5.9–7.1)	7.2 (6.6–7.8)	9.6 (9.1–10.2)	5.7 (5.6–5.9)
10+y/<10 y ratio	1.4 (1.2–1.6)	0.9 (0.8–1.1)	1.1 (0.9–1.2)	1.3 (1.1–1.5)	0.9 (0.8–1.1)	1.0 (0.9–1.1)	1.1 (1.0–1.2)	1.1 (1.1–1.2)	1.1 (1–1.1)
Females, n	90 632	43 007	41 564	41 080	26 997	30 363	60 816	77 328	411 787
<10 y	1.0 (0.9–1.1)	2.5 (2.2–2.8)	2.0 (1.7–2.4)	1.9 (1.7–2.1)	2.7 (2.3–3.1)	2.9 (2.6–3.3)	2.4 (2.2–2.6)	3.4 (3.3–3.6)	2.3 (2.2–2.3)
10+ y	1.5 (1.4–1.7)	3.0 (2.6–3.4)	2.1 (1.8–2.3)	2.3 (2.0–2.7)	3.0 (2.6–3.4)	2.6 (2.2–3.1)	2.5 (2.2–2.8)	3.6 (3.3–3.9)	2.5 (2.4–2.6)
10+y/<10 y ratio	1.6 (1.4–1.8)	1.2 (1.0–1.4)	1.0 (0.8–1.2)	1.2 (1.0–1.5)	1.1 (0.9–1.4)	0.9 (0.7–1.1)	1.0 (0.9–1.2)	1.0 (0.9–1.2)	1.1 (1.1–1.2)

Data are per 1000 person-years (95% confidence interval) unless otherwise stated.

factors. However, all ethnic groups (with the exception of South Asian males) had persistently lower event rates than long-term residents after adjustment for all sociodemographic and risk factor variables. Significant differences in the hazard ratios between certain ethnic groups also remained, demonstrating that ethnic origin is an independent predictor of cardiovascular events.

Discussion

The CANHEART Immigrant Study demonstrates that most immigrant groups to Canada have lower rates of major cardiovascular events than long-term residents of similar age, and that striking variations in the event rates exist between immigrants from different ethnic backgrounds. East Asian immigrants, composed predominantly of ethnic Chinese,

had the lowest burden of cardiac risk factors and events overall, although the event rate increased with greater duration in Canada. We also found certain high-risk groups such as South Asian immigrants, including those born in Guyana, and immigrants born in Afghanistan and Iraq had a high burden of traditional risk factors and frequent cardiovascular events. Our findings demonstrate that the 4 traditional modifiable cardiac risk factors (smoking, dyslipidemia, hypertension, diabetes mellitus) originally identified from a white cohort in the Framingham Heart Study and subsequently confirmed in major multiethnic epidemiological studies (eg, Seven Countries Study, INTERHEART, INTERSTROKE) are important contributors to variations in cardiovascular event rates in migrant populations from very diverse ethnic backgrounds and countries of the world.^{15–18}

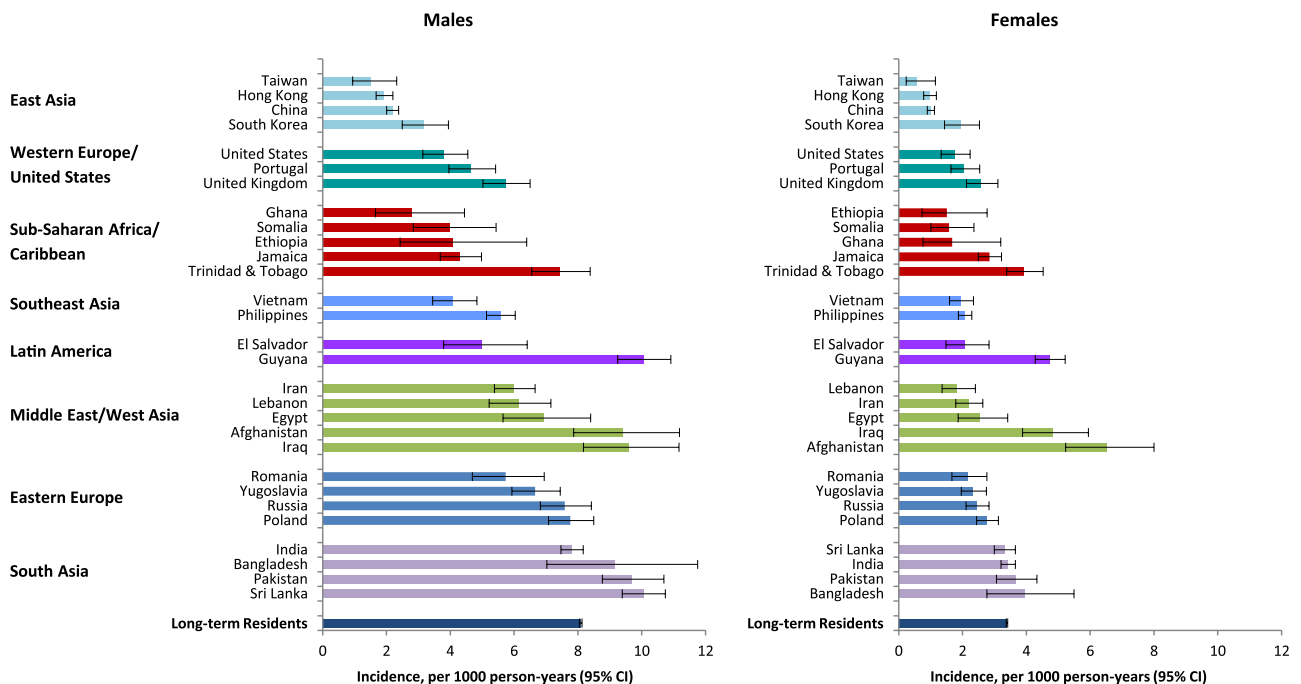


Figure 2. Age-standardized incidence of a major cardiovascular event by country and region of birth among 29 countries of birth with at least 5000 immigrants, 2002 to 2011. CI indicates confidence interval.

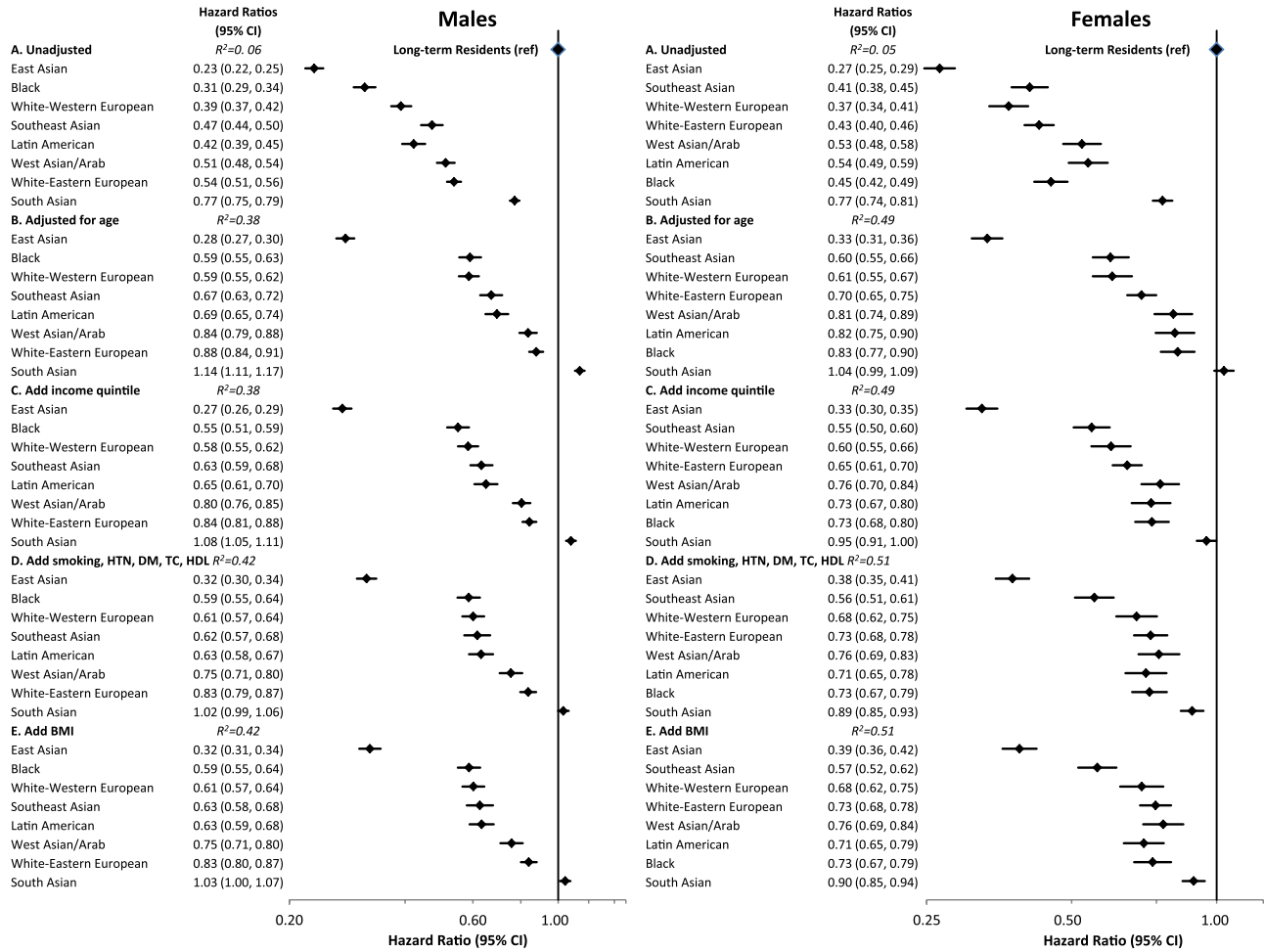


Figure 4. Relative risk of a major cardiovascular event using Cox proportional hazard modeling, 2002 to 2011. Independent variables were added sequentially from models A to E. The R^2 for each model indicates the proportion of variation in outcomes explained by each model. BMI indicates body mass index; CI, confidence interval; DM, diabetes mellitus; HDL, high-density lipoprotein; HTN, hypertension; and TC, total cholesterol.

whereas studies from the United States and the United Kingdom show that racial/ethnic disparities in access to cardiac procedures may exist.^{26,27}

Our findings within ethnic groups are generally consistent with previous studies conducted in other high-income countries. In Europe, black immigrants have also been found to have high stroke rates relative to AMI rates, which have been attributed in part to high rates of hypertension and the protective effects of relatively high high-density lipoprotein levels, low smoking rates, and low fibrinogen levels.²² South Asian immigrants in this and other studies have been found to have a high burden of metabolic syndrome and insulin resistance, as evidenced by high rates of central obesity, diabetes mellitus, hypertension, and low high-density lipoprotein levels.²⁸ The higher incidence of events observed among the East Asian immigrants with greater duration of stay in Canada is consistent with the Ni-Hon-San study, which showed that Japanese immigrants to California and Hawaii had higher cardiovascular event rates with greater exposure to a Western lifestyle than those who remained in Japan.²⁹ Previous studies have also shown that rates of diabetes mellitus and cholesterol levels are

rapidly rising in the Chinese population in both Canada and East Asia from historically low levels which may contribute to the increasing event rates observed in our study with greater duration of stay and acculturation to Western diets and lifestyles.^{30,31}

Our study is unique in that it includes a very large sample of immigrants, representing 201 countries from all parts of the world, followed for a decade using linked electronic databases. However, a limitation is that significant residual variation between ethnic groups remains that cannot be completely accounted for by traditional risk factors or neighborhood socioeconomic differences. Possible contributing factors that warrant additional research include (1) variations in dietary practices, alcohol intake, and physical activity levels; (2) premigration environmental exposures (urbanization, air pollution, second hand smoke, health care access); (3) precision in measuring certain risk factors (eg, measured blood pressure, incomplete smoking and lipid data); (4) cultural differences in health-seeking behavior; (5) variations in the proportion and types of immigrants who decide to emigrate back to their home country; and (6) genetic factors not yet identified.

In summary, we found striking variations in the burden of cardiac risk factors and the incidence of major cardiovascular events among a population of >800 000 immigrants to Ontario, Canada. Our study provides new information that may assist clinicians and policy makers in developing strategies to prevent cardiovascular diseases in immigrant populations. A focus on the prevention, early identification, and management of the classical cardiac risk factors coupled with provision of equitable access to health care services could potentially prevent many cardiovascular events. Additional studies to identify other modifiable risk factors contributing to outcome differences between immigrant populations are also warranted.

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Disclosures

None.

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CLINICAL PERSPECTIVE

Immigrants from ethnic minority groups represent an increasing proportion of the population in many high-income countries. In the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) Immigrant Study, we determined the prevalence of traditional cardiac risk factors (smoking, diabetes mellitus, high cholesterol, and hypertension) and the 10-year incidence rates of major cardiovascular events (myocardial infarction, stroke, revascularization, cardiovascular death) in a large cohort of 824 662 immigrants aged 30 to 74 as of January 2002, from 8 major ethnic groups and 201 countries of birth, who immigrated to Ontario, Canada, between 1985 and 2000. The age-standardized 10-year incidence rates were 30% lower among immigrants overall in comparison with a reference cohort of 5.2 million long-term residents (predominantly white individuals born in Canada). In general, higher incidence rates were observed in the immigrant groups with the highest burden of traditional risk factors. East Asian immigrants (predominantly ethnic Chinese) were at the lowest risk, but their risk increased with greater duration of stay in Canada. South Asian immigrants, including those born in Guyana, and immigrants born in Iraq and Afghanistan were found to be at highest risk overall. Adjustment for age, socioeconomic status, and differences in risk factor prevalence could explain a part but not all of the differences in clinical event rates between immigrants from different ethnic backgrounds. Clinicians should be aware that the 10-year incidence rate of major cardiovascular events varies dramatically among immigrants from different ethnic backgrounds, and that an immigrant's ethnic background may influence the development of clinical events in addition to the traditional cardiac risk factors.