Incidence of Heart Failure Among Immigrants to Ontario, Canada: A CANHEART Immigrant Study

GIANCARLO DI GIUSEPPE, MPH,[1,2] ANNA CHU, MHSc,[1,2] JACK V. TU, MD, PhD,[1,2,3] SHAMILA SHANMUGASEGARAM, PhD,[4] PETER LIU, MD,[2,4] AND DOUGLAS S. LEE, MD, PhD[1,2,5]

Toronto, Ontario, Canada and Ottawa, Ontario, Canada

ABSTRACT

Background: Several known traditional cardiovascular risk factors contribute to the development of heart failure (HF); however, whether ethnicity is also an important predictor is not well established. We determined the incidence of hospitalization for HF among ethnic groups in Ontario, Canada, and examined differences in risk factor prevalence that may contribute to disparities in HF hospitalization incidence between groups.

Methods and Results: We conducted a retrospective observational study from 2008 to 2012 with the use of a linked cohort derived from population-based health administrative, clinical, and survey datasets. We followed 895,823 recent immigrants from 8 ethnic groups and 5.3 million long-term residents aged 40−105 years for incident HF hospitalization. Sex-stratified age-standardized HF incidence was lower among all immigrant groups than long-term residents. Among immigrants, Black men and West Asian women had the highest incidence of hospitalizations for HF (1.19 and 1.60 per 1000 person-years, respectively), and East Asians of both sexes had the lowest incidence. After adjusting for sociodemographic characteristics, comorbidities, and other risk factors, the association between ethnicity and HF hospitalization risk remained significant.

Conclusions: HF hospitalization incidence varies widely among ethnic immigrant groups, highlighting the importance of ethnicity as a potential independent risk factor for HF development. (*J Cardiac Fail 2019;25:425−435*)

Key Words: Heart failure, ethnicity, immigrants, epidemiology, cohort study.

Heart failure (HF) has become increasingly prevalent worldwide and is associated with significant morbidity and mortality, especially in the elderly.[1] In the United States, HF accounts for 6.5 million days of hospitalization, and is the primary diagnosis in ∼1 million hospital admissions annually.[2,3] Although the incidence of HF has declined in recent years in North America,[4,5] with improved survival and an aging population it is projected that by 2030 the annual costs associated with hospitalizations due to HF as the main diagnosis will rise from $482 million to $722 million in Canada.[6] Although hypertension, coronary artery disease, and valvular conditions contribute significantly to HF development,[7] ethnicity as a potential risk factor has not been explored in most previous studies.[8−10] Literature

has shown that African-American individuals have a higher incidence than those of primarily European ancestry,[10] which may partly be explained by ethnic differences in cardiovascular risk factors, such as diabetes or hypertension.[11] However, much less is known about HF incidence in other ethnic groups.

Among high-income countries, Canada is one of the most ethnically and culturally diverse.[12] Canada continues to see high rates of immigration annually, with the majority of immigrants settling in the province of Ontario. However, little is known about the incidence of HF in these immigrant populations. Although studies in Europe have shown that immigrant populations have higher HF incidence rates and generally poorer cardiac health,[13] whether these findings are generalizable to other immigrant populations and whether they vary by ethnic group are unknown. The objectives of the present study were to (1) determine the incidence of HF hospitalization among different ethnic groups in Ontario's immigrant population and (2) examine underlying differences in the prevalence of HF risk factors between these ethnic groups. This information will provide insights into ethnic differences for incident HF in a multicultural Canadian setting and internationally.

Methods

Study Population and Design

In brief, the Cardiovascular Health in Ambulatory Care Research Team (CANHEART) big data initiative is a retrospective observational cohort study linking multiple population-based datasets, including population-based administrative, clinical, and survey datasets, on more than 9.8 million Ontario adult residents aged 20−105 years with the use of unique encoded personal identifiers.[14] Individuals were identified from the Ontario Registered Persons Database (RPDB) and followed for 5 years from January 1, 2008, to December 31, 2012, for incident cardiovascular events. The RPDB is a population database managed by the Ministry of Health and Long-Term Care and contains basic demographic information about anyone who has ever been eligible for Ontario's Health Insurance Plan (OHIP), a government-funded universal health care service available to almost all residents of Ontario, which enables free access to medically necessary health care services. Further details on data linkage methods used to create the CANHEART cohort have been described previously.[14]

For this study, among 6,282,855 individuals aged 40−105 years on January 1, 2008, we identified a subpopulation of 895,823 recent immigrants born in 201 different countries and a reference cohort of 5,272,065 long-term residents without a known hospitalization for HF in the preceding 20 years (Supplemental Fig. 1). Recent immigrants were identified through linkage to the Immigration, Refugees, and Citizenship Canada (IRCC) Permanent Resident Database, and defined as those immigrating to Ontario in 1985 or later. Individuals not linkable to IRCC were considered to be long-term residents and composed predominantly

of white individuals (>95%) born in Canada (~83%) or who immigrated to Ontario before 1985 (~17%).[15] Immigrants were further categorized into 8 ethnic groups with the use of previously validated algorithms based on country of birth, mother tongue, and surname.[16,17] The eight ethnic groups were (1) East Asian, (2) Southeast Asian, (3) Black (from Sub-Saharan Africa and the Caribbean), (4) West Asian/Arab, (5) Latin American, (6) South Asian, (7) Eastern European, and (8) Western European (the latter 2 comprising "white" immigrants). Individually, these algorithms have demonstrated generally high positive predictive values (PPVs) and negative predictive values (NPVs) for the ethnic groups being studied.[16,17] Individuals were excluded if they were not eligible for OHIP in 2006 and 2007 or were a resident of a long-term care facility in the 5 years before January 1, 2008.[14] This study was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre.

Data Sources

Data sources used in creating the CANHEART cohort have been described previously.[14] Briefly, information on age, sex, and residence postal code was obtained from the RPDB. Postal codes were linked to Statistics Canada's 2006 census data to obtain additional sociodemographic information such as neighborhood median income (derived by Statistics Canada from household incomes and number of residents as a proxy for socioeconomic status) and rural residence. Low-income neighborhoods were defined as being in the lowest 2 neighborhood income quintiles, where quintiles are specifically ranked within each census metropolitan area, census agglomeration, or residual area in Ontario. At the time of immigration, IRCC captures key demographic information for every landing immigrant, including country of birth (also used to determine income group of country of birth),[18] immigration class (eg, economic, family, refugee),[19] and landing date, which were obtained from the IRCC Permanent Resident Database.

Baseline cardiovascular risk factor information was obtained through linkage to chronic disease databases that use validated algorithms based on health administrative databases (for hypertension, diabetes, and atrial fibrillation)[20−22] and the nationally representative Canadian Community Health Survey (for smoking and body mass index; available for 116,692 respondents).[23] Hospitalization data was obtained from the Canadian Institute for Health Information Discharge Abstract Database, which contains information from the discharge abstracts of all Ontario hospital admissions from 1988 on. Diagnoses for acute myocardial infarction (AMI), coronary revascularization with either percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) surgery, atrial fibrillation, valvular heart disease (VHD), valvular surgery, as well as our primary outcome, HF, were identified using validated codes from the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and Tenth Revision, Canada (ICD-10-CA).[14,24,25] Comorbidity disease status was quantified with

the use of scores based on the Johns Hopkins Adjusted Clinical Group (ACG) Case-Mix Adjustment System.[26]

Primary Outcome and Classification of Heart Failure

Our primary outcome of interest was the incidence of hospitalization for HF as the primary diagnosis from 2008 to 2012, identified with the use of ICD-10 code I50 which has been validated in hospitalized Canadian patients.[27] We chose not to include HF diagnosed outside of hospital because this may not be consistently coded in the community setting.

To examine potential causes of HF, we grouped each index HF hospitalization into 1 of 5 mutually exclusive categories with the use of a modified hierarchic algorithm originally developed in the Framingham Heart Study based on a person's cardiovascular disease history.[28,29] In descending order, our classification system assigned each incident HF case to (1) ischemic heart disease, (2) VHD, (3) atrial fibrillation, (4) hypertension or diabetes, or (5) unknown or other. Ischemic heart disease was defined as previous AMI or revascularization with PCI or CABG surgery, and VHD was the composite of hospitalization for VHD and previous cardiac valve surgery.

Statistical Analyses

Descriptive statistics were performed on continuous and categoric variables and reported as mean $\pm$ SD and proportions with 95% confidence intervals (CIs), respectively. One-way analysis of variance, Student's t test, and χ^2 test were used to compare differences in the distributions of baseline characteristics among ethnic groups. Sex-stratified cardiovascular risk factor prevalence and incidence rates were age-standardized to the 2006 Ontario census population.

Incidence rates for HF hospitalizations were calculated as events per 1000 person-years of observation with 95% CIs. In addition, cumulative incidence functions by ethnicity were compared with the use of Gray's test for equality over time. Because HF is a disease primarily affecting older populations, cumulative incidence functions accounted for all-cause mortality as a competing risk.[30]

Sex-stratified Cox proportional hazards regression models were used to determine the unadjusted, age-adjusted, and multivariable-adjusted association between immigrant ethnicity and risk of HF hospitalization compared with long-term residents. With long-term residents as the reference group, risk factors adjusted for in the multivariable model were decided a priori and included age, low neighborhood income quintile, rural or small-town residence, history of AMI, PCI or CABG surgery, VHD, atrial fibrillation, hypertension, or diabetes mellitus, current smoker, and obesity. Obesity was defined as a body mass index (BMI) ≥ 30 kg/m^2, and age was log-transformed to account for the near-exponential association with HF risk in regression analyses. Time in Ontario, income group of country of birth, and immigrant status were excluded from the model owing to their multicollinearity with ethnicity. Collinearity was present in the multivariable regression model where the immigrant ethnicity was predicting the immigrant status and country of birth income group (eg, East Asian ethnic groups and high income and economic status). Where missing, data on obesity and smoking status were imputed by means of multiple imputation.[15] All 2-sided P values <0.05 were considered to be significant. Statistical analyses were performed in R version 3.1.2 and SAS version 9.4 (SAS Institute, Cary, North Carolina) at ICES.

Sensitivity Analysis

Because HF is commonly diagnosed in the outpatient setting, we performed a post hoc sensitivity analysis excluding individuals from our cohort with outpatient-diagnosed HF but no known history of hospitalization for HF (in addition to those with a HF hospitalization already excluded). These individuals were identified from physician billings by means of a validated algorithm of ≥ 2 outpatient claims for HF within 1 year, which has been shown to have 85% sensitivity and 97% specificity.[31]

Results

Baseline Cohort Characteristics

Our study population had a mean follow-up time of 4.9 years, representing 29,815,775 person-years of total observation. Baseline sociodemographic data for the immigrant cohort by ethnic group and long-term residents are presented in Table 1. Recent immigrants composed 14.5% (n = 895,823) of our study population, with the largest ethnic group being South Asian (22.5%) and the smallest Latin American (6.6%). Overall, recent immigrants were younger than long-term residents (mean age 52.9 $\pm$ 11.6 vs 57.6 $\pm$ 12.3; P < 0.001), were more likely to live in low-income neighborhoods (50.3% vs 36.4%; P < 0.001), and had lower age- and sex-adjusted Johns Hopkins ACG comorbidity scores (7.3 $\pm$ 4.6 vs 8.5 $\pm$ 4.5; P < 0.001). At study inception, the mean duration of time in Canada for the immigrant cohort was 11.8 $\pm$ 6 years, with 58.0% of immigrants born in medium-income countries and 45.2% of immigrants admitted under the Economic Class program. Immigrants of West Asian/Arab (30.1%) and Eastern European (33.0%) descent had the highest proportion of refugees.

Prevalence of HF Risk Factors

Prevalence of HF risk factors for each ethnic group and long-term residents are presented in Table 2. With the exception of diabetes, male and female immigrants had lower rates of all risk factors compared with long-term residents. For diabetes, East Asian and European immigrants had lower rates and all other ethnic groups higher rates than long-term residents. Black and South Asian immigrants had the highest diabetes rates. In addition, by ethnic group, hypertension rates were higher among Blacks (men 37.4%,

Table 1. Baseline Characteristics of Study Population

Characteristic	East Asian (n = 186,971)	Southeast Asian (n = 77,840)	Latin American (n = 58,849)	Eastern European (n = 126,560)	Western European (n = 77,621)	Black (n = 83,107)	South Asian (n = 201,166)	West Asian/Arab (n = 83,709)	All Immigrants[†] (n = 895,823)	Long-Term Residents (n = 5,272,065)
Age on Jan 1, 2008 (y)	54.5 ± 12.8	52.9 ± 11.8	52.1 ± 10.9	52.3 ± 10.5	52.8 ± 12.0	51.0 ± 10.7	53.5 ± 11.6	51.9 ± 10.8	52.9 ± 11.6	57.6 ± 12.3
Male (%)	48.1	38.7	49.2	48.5	50.5	48.9	53.1	56.1	49.6	48.1
Income quintile (%)										
1 (lowest)	21.9	30.8	32.8	24.8	15.8	40.0	30.4	27.9	27.4	17.1
2	24.7	25.5	24.9	18.5	19.0	23.3	25.5	18.4	22.9	19.3
3	19.5	21.1	19.2	19.5	18.4	18.3	22.1	18.9	19.9	19.7
4	19.0	14.6	13.9	21.9	20.6	12.0	14.5	19.7	17.2	21.1
5 (highest)	14.9	8.0	9.1	15.3	26.3	6.4	7.5	15.1	12.5	22.9
Rural or small-town residence (%)	0.4	0.5	0.8	1.0	10.1	0.5	0.3	0.3	1.3	14.7
Income of country of birth (%)*										
Low	5.9	16.3	0	0	0.2	39.2	72.9	11.9	23.8	N/A
Medium	58.3	83.4	99.9	99.3	7.1	44.2	24.6	83.1	58.0	
High	35.9	0.3	0.1	0.7	92.7	16.7	2.5	4.9	18.2	
Years in Ontario up to Jan 1, 2008	11.4 ± 5.6	12.0 ± 6.0	12.9 ± 6.5	12.4 ± 5.6	13.9 ± 6.4	13.2 ± 5.9	10.4 ± 5.8	10.7 ± 6.0	11.8 ± 6.0	N/A
Immigration class (%)										
Economic	53.9	51.5	30.5	41.3	54.4	29.3	44.2	46.1	45.2	N/A
Family	37.2	40.3	41.6	24.5	43.5	47.3	42.5	22.5	37.3	
Refugee	5.1	7.6	26.0	33.0	0.5	21.2	12.2	30.1	15.7	
Other/unknown	3.8	0.6	1.8	1.1	1.6	2.3	1.1	1.3	1.8	
Johns Hopkins ACG score	6.4 ± 4.6	7.7 ± 4.3	8.0 ± 4.5	7.2 ± 4.4	6.8 ± 4.6	7.9 ± 4.5	7.6 ± 4.6	7.5 ± 4.9	7.3 ± 4.6	8.5 ± 4.5
Years of follow-up	4.9 ± 0.6	4.9 ± 0.5	4.9 ± 0.5	4.9 ± 0.5	4.9 ± 0.6	4.9 ± 0.5	4.9 ± 0.6	4.9 ± 0.6	4.9 ± 0.6	4.8 ± 0.7

ACG, Adjusted Clinical Groups.

*Country of birth income group is based on the World Bank's 2006 country classification.[18]

[†]P values for comparisons between all immigrants and long-term residents are <.001 on all characteristics.

Table 2. Age-Standardized Baseline Prevalence of Risk Factors for Heart Failure

HF Risk Factor	East Asian	Southeast Asian	Latin American	Eastern European	Western European	Black	South Asian	West Asian/Arab	All Immigrants	Long-Term Residents
Men, n	89,893	30,161	28,974	61,361	39,225	40,623	106,880	46,938	444,055	2,533,806
AMI	0.6	1.5	2.3	2.6	2.0	1.4	2.9	2.5	1.9	3.8
	(0.5−0.6)	(1.3−1.7)	(2.1−2.6)	(2.4−2.7)	(1.8−2.2)	(1.3−1.6)	(2.8−3.1)	(2.3−2.7)	(1.9−2.0)	(3.8−3.9)
PCI or CABG surgery	0.8	2.0	2.7	3.4	2.3	1.7	4.4	3.9	2.7	4.6
	(0.8−0.9)	(1.8−2.2)	(2.4−3.0)	(3.2−3.6)	(2.1−2.5)	(1.5−1.9)	(4.2−4.5)	(3.7−4.2)	(2.7−2.8)	(4.6−4.6)
Valvular heart disease	0.2	0.3	0.3	0.5	0.5	0.3	0.3	0.4	0.3	0.7
	(0.1−0.2)	(0.3−0.4)	(0.2−0.4)	(0.4−0.6)	(0.4−0.6)	(0.2−0.4)	(0.3−0.4)	(0.3−0.5)	(0.3−0.3)	(0.7−0.8)
Atrial fibrillation	0.9	1.4	0.9	2.3	2.0	0.8	0.7	1.4	1.2	2.6
	(0.9−1.0)	(1.2−1.6)	(0.8−1.1)	(2.1−2.5)	(1.8−2.2)	(0.6−0.9)	(0.7−0.8)	(1.3−1.6)	(1.1−1.2)	(2.6−2.7)
Hypertension	25.2	42.1	30.7	30.5	27.5	37.4	35.5	26.6	31.4	35.6
	(24.8−25.5)	(41.2−42.9)	(29.8−31.5)	(30.0−31.1)	(26.9−28.2)	(36.6−38.3)	(35.1−35.9)	(26.0−27.2)	(31.2−31.5)	(35.6−35.7)
Diabetes mellitus	11.9	18.4	17.3	10.6	10.4	20.9	25.6	15.7	16.8	14.4
	(11.7−12.2)	(17.9−19.0)	(16.7−18.0)	(10.2−10.9)	(10.0−10.8)	(20.3−21.6)	(25.3−25.9)	(15.2−16.1)	(16.7−16.9)	(14.3−14.4)
Obesity (BMI ≥30 kg/m^2)*	2.4	6.2	13.1	16.9	13.3	9.3	9.1	18.9	10.9	21.7
	(0.4−5.4)	(0.7−15.9)	(4.7−24.4)	(9.9−23.3)	(8.2−19.3)	(3.8−16.7)	(4.8−13.4)	(9.3−29.2)	(8.9−13.2)	(21.0−22.5)
Current smoker*	21.0	14.9	9.5	19.9	24.8	21.6	11.8	21.9	17.3	23.2
	(13.2−28.2)	(7.3−24.3)	(4.4−18.5)	(13.1−29.1)	(17.1−32.6)	(8.4−28.0)	(7.7−16.5)	(12.2−30.9)	(14.5−19.8)	(22.5−24.1)
Women, n	97,078	47,679	29,875	65,199	38,396	42,484	94,286	36,771	451,68	2,738,259
AMI	0.2	0.5	1.0	0.7	0.7	0.7	1.0	0.7	0.7	1.4
	(0.2−0.3)	(0.4−0.6)	(0.8−1.1)	(0.7−0.8)	(0.6−0.8)	(0.6−0.8)	(1.0−1.1)	(0.6−0.9)	(0.6−0.7)	(1.4−1.5)
PCI or CABG surgery	0.2	0.5	0.9	0.9	0.7	0.6	1.2	1.0	0.7	1.3
	(0.2−0.3)	(0.4−0.6)	(0.8−1.0)	(0.8−1.0)	(0.6−0.8)	(0.5−0.7)	(1.1−1.3)	(0.9−1.2)	(0.7−0.8)	(1.3−1.3)
Valvular heart disease	0.2	0.3	0.4	0.5	0.5	0.4	0.3	0.5	0.4	0.8
	(0.2−0.3)	(0.3−0.4)	(0.3−0.5)	(0.4−0.5)	(0.4−0.6)	(0.3−0.5)	(0.3−0.4)	(0.4−0.6)	(0.3−0.4)	(0.8−0.8)
Atrial fibrillation	0.9	0.9	0.9	2.0	1.6	0.9	0.7	1.3	1.1	2.1
	(0.9−1.0)	(0.8−1.0)	(0.8−1.1)	(1.9−2.2)	(1.5−1.8)	(0.8−1.0)	(0.6−0.7)	(1.2−1.5)	(1.1−1.2)	(2.1−2.1)
Hypertension	28.9	42.8	35.7	32.8	30.4	46.9	36.8	30.4	34.9	37.8
	(28.5−29.3)	(42.1−43.5)	(34.8−36.5)	(32.3−33.4)	(29.7−31.1)	(46.1−47.7)	(36.4−37.3)	(29.7−31.1)	(34.7−35.1)	(37.7−37.8)
Diabetes mellitus	11.1	16.3	17.0	8.9	9.1	22.3	22.8	14.8	15.4	12.0
	(10.8−11.3)	(15.9−16.7)	(16.5−17.6)	(8.6−9.2)	(8.8−9.5)	(21.7−22.8)	(22.5−23.1)	(14.3−15.2)	(15.2−15.5)	(11.9−12.0)
Obesity (BMI ≥30 kg/m^2)*	1.4	6.8	30.6	16.7	20.9	25.6	9.8	11.1	13.5	19.2
	(0.3−3.3)	(0.6−13.4)	(16.8−39.5)	(10.7−25.9)	(14.8−28.3)	(16.4−34.3)	(5.6−15.3)	(5.2−22.0)	(10.9−16.4)	(18.6−20.0)
Current smoker*	1.1	3.9	2.2	16.2	11.1	2.0	1.1	11.8	5.7	18.7
	(0.1−3.2)	(0.4−9.1)	(0.4−4.2)	(11.5−21.5)	(7.4−15.5)	(0.3−4.9)	(0.1−2.6)	(3.9−21.3)	(4.4−7.1)	(18.1−19.4)

Results are presented as % (95% confidence interval) unless otherwise specified.

AMI, acute myocardial infarction; BMI, body mass index (kg/m^2); CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention.

*From a subpopulation of respondents to the 2005−2010 Canadian Community Health Surveys (men, n = 34,659; women, n = 43,715).

women 46.9%) and Southeast Asians (men 42.1%, women 42.8%) compared with long-term residents (men 35.6%, women 37.8%).

Incidence of HF

We identified 2,751 cases (0.003%) of incident HF hospitalizations among our immigrant cohort (men 44.3%, women 55.7%) compared with 42,539 (0.008%) among long-term residents (men 51.1%, women 48.9%) during the observation period. Incidence rates for each ethnic group and long-term residents are presented in Table 3. Among both men and women, long-term residents had a higher incidence of HF than all of the ethnic groups. Among immigrants, Black men and West Asian/Arab women had the highest incidence rates (1.19 and 1.60 per 1000 person-years, respectively) and East Asians of both sexes had the lowest (0.38 and 0.51 per 1000 person-years for men and women, respectively). By 10-year age group (Fig. 1), incidence rates were similar between each ethnic group and long-term residents for all age groups except ≥80-year-olds, where male immigrants had a 2−6 times lower incidence rate than male long-term residents. Men also tended to develop HF at a younger age than women.

Figure 2 illustrates the cumulative incidence function for HF hospitalization of each ethnic group and long-term residents during the 5-year study period accounting for all-cause mortality as a competing risk. A significant difference in the cumulative incidence was observed among the 8 ethnic groups and long-term residents (Gray's test: $P < 0.001$). Among both male and female immigrants, South Asians had the highest cumulative incidence and East Asians the lowest.

Sex-stratified causal classifications for HF hospitalizations are presented in Table 3. For male immigrants and long-term residents overall, HF was most associated with ischemic heart disease (38.3% and 46.1%, respectively) followed by hypertension or diabetes. However, hypertension or diabetes represented the largest attributable proportion to HF classification in Black, East Asian, and Southeast Asian men, ranging from 41.8% to 51.7%. Among all female ethnic groups and long-term residents, the reverse was observed, with HF being most attributable to hypertension or diabetes (43.1% in immigrants, 33.6% in long-term residents) followed by ischemic heart disease. An exception was among East Asian and Eastern European women, where atrial fibrillation was the second highest contributor. Overall, a significant difference between ethnic groups and long-term residents for both men and women in HF causal classification was observed ($P < 0.001$).

Role of Traditional Cardiovascular Risk Factors in HF

In unadjusted regression analyses, all male and female ethnic groups were at a significantly lower risk of HF than long-term residents (Fig. 3). After adjusting for age, all male ethnic groups remained at lower risk. However, the lower risks among South Asian (hazard ratio [HR] 0.98,

Table 3. Age-Standardized Incidence and Classification of Heart Failure

Variable	East Asian	Southeast Asian	Latin American	Eastern European	Western European	Black	South Asian	West Asian/Arab	All Immigrants	Long-Term Residents
Men, n	141	96	76	155	105	120	392	135	1220	21,739
Age-standardized incidence of HF, per 1000 person-years (95% CI)	0.38 (0.32−0.45)	1.0 (0.80−1.23)	0.94 (0.71−1.21)	1.06 (0.88−1.27)	0.98 (0.79−1.21)	1.19 (0.94−1.47)	1.16 (1.05−1.29)	1.14 (0.95−1.37)	0.90 (0.85−0.96)	1.93 (1.90−1.95)
HF classification, n (%)										
Ischemic heart disease	35 (24.8)	24 (25.0)	31 (40.8)	61 (39.4)	31 (29.5)	29 (24.2)	190 (48.5)	66 (48.9)	467 (38.3)	10,018 (46.1)
Valvular heart disease	14 (9.9)	—	—	12 (7.7)	12 (11.4)	8 (6.7)	24 (6.1)	13 (9.6)	92 (7.5)	1,657 (7.6)
Atrial fibrillation	25 (17.7)	13 (13.5)	12 (15.8)	19 (12.3)	26 (24.8)	14 (11.7)	27 (6.9)	12 (8.9)	148 (12.1)	3110 (14.3)
Hypertension or diabetes	59 (41.8)	46 (47.9)	26 (34.2)	50 (32.3)	25 (23.8)	62 (51.7)	136 (34.7)	36 (26.7)	440 (36.1)	5638 (25.9)
Unknown/other	8 (5.7)	—	—	13 (8.4)	11 (10.5)	7 (5.8)	15 (3.8)	8 (5.9)	73 (6.0)	1316 (6.1)
Women, n	176	134	97	216	166	143	455	144	1531	20,800
Age-standardized incidence of HF, per 1000 person-years (95% CI)	0.51 (0.44−0.60)	0.97 (0.81−1.15)	1.16 (0.93−1.43)	1.34 (1.16−1.54)	1.41 (1.20−1.65)	1.26 (1.06−1.50)	1.48 (1.33−1.63)	1.60 (1.33−1.90)	1.13 (1.08−1.19)	1.78 (1.75−1.80)
HF classification, n (%)										
Ischemic heart disease	34 (19.3)	30 (22.4)	32 (33.0)	54 (25.0)	46 (27.7)	36 (25.2)	134 (29.5)	46 (31.9)	412 (26.9)	6828 (32.8)
Valvular heart disease	24 (13.6)	21 (15.7)	11 (11.3)	35 (16.2)	23 (13.9)	15 (10.5)	49 (10.8)	19 (13.2)	197 (12.9)	2323 (11.2)
Atrial fibrillation	38 (21.6)	18 (13.4)	—	55 (25.5)	28 (16.9)	—	29 (6.4)	—	204 (13.3)	3675 (17.7)
Hypertension or diabetes	70 (39.8)	56 (41.8)	44 (45.4)	64 (29.6)	62 (37.3)	77 (53.8)	230 (50.5)	57 (39.6)	660 (43.1)	6997 (33.6)
Unknown/other	10 (5.7)	9 (6.7)	—	8 (3.7)	7 (4.2)	—	13 (2.9)	—	58 (3.8)	977 (4.7)

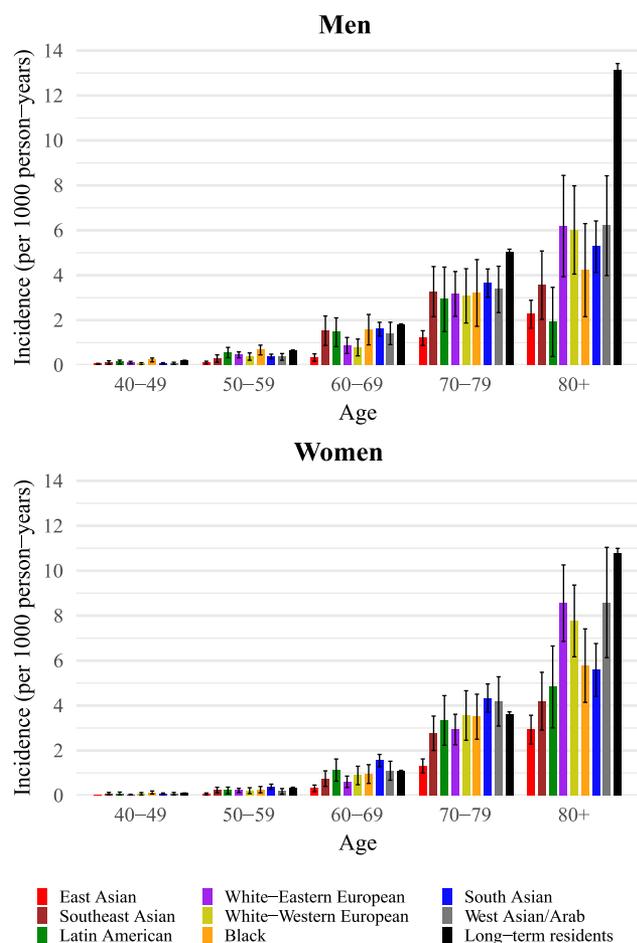−, suppressed due to small sample size; CI, confidence interval; HF, heart failure.

Fig. 1. Incidence of heart failure hospitalization stratified by age group.

95% CI 0.89−1.08) and West Asian/Arab (HR 0.94, 95% CI 0.80−1.10) women were no longer statistically significant. Being a recent immigrant was independently associated with a lower HF risk, and length of time spent in Canada since landing (<10 y vs ≥10 y) did not appear to change this risk (Supplemental Table 1). In addition, after age-adjustment, the risk among refugees was not statistically different from long-term residents (Supplemental Table 1).

After adjusting for age, sociodemographics, and HF risk factors, all male ethnic groups remained at a lower risk of HF compared with long-term residents, with East Asian men remaining at lowest risk among the immigrant groups (HR 0.27, 95% CI 0.22−0.31; Fig. 3). However, among women, Western Europeans, South Asians, and West Asians were not at significantly different risk compared with long-term residents. Low-income neighborhood and rural or small-town residence, hypertension, obesity, smoking, diabetes, and a history of AMI, coronary revascularization, VHD, or atrial fibrillation were all independently associated with an increased risk of HF in multivariable analysis (Supplemental Table 1).

In sensitivity analyses, 2,740 (0.6%) immigrants and 41,643 (1.6%) long-term residents with HF diagnosed in an outpatient setting and no HF hospitalization before study enrollment were excluded from analyses of outcomes. Sex-stratified incidence among all immigrant ethnic groups remained lower than long-term residents (Supplemental Table 2). Similar trends in HF risk among the various ethnic groups were also observed in unadjusted, age-adjusted, and multivariable regression (Supplemental Table 2).
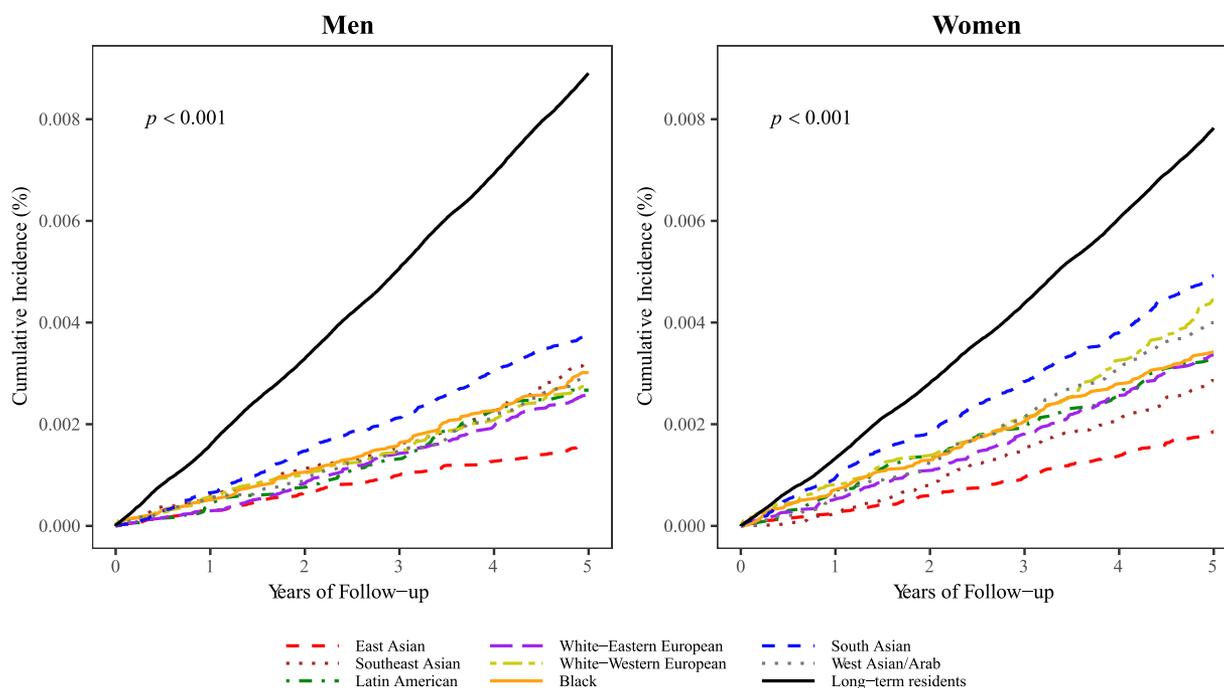

Fig. 2. Five-year cumulative incidence for heart failure hospitalization.
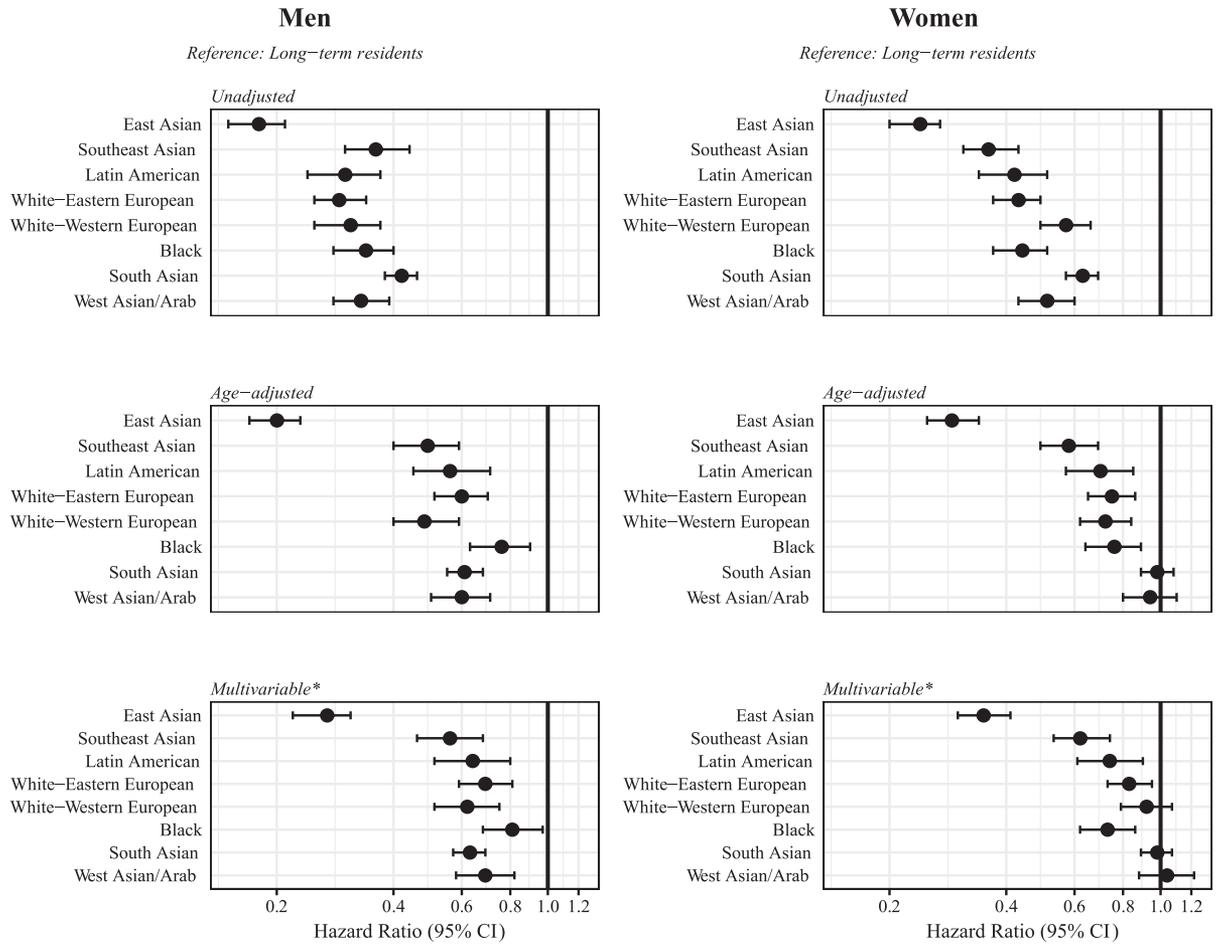
Fig. 3. Association of immigrant ethnicity and risk of heart failure hospitalization, with ethnic groups ordered by overall increasing incidence of heart failure. *Adjusted for age, low income quintile, rural residence, history of acute myocardial infarction, percutaneous coronary intervention or coronary artery bypass graft surgery, valvular heart disease, atrial fibrillation, hypertension, or diabetes mellitus, current smoker and obesity ($\geq$30 kg/m^2).

Discussion

In this study, we report novel findings from, to our knowledge, the largest population-based cohort assessing differences in the association between ethnicity and HF incidence. We found that immigrants to Ontario, Canada, of diverse ethnic backgrounds have a lower incidence of HF hospitalization than Canadian-born residents and long-term immigrants, even after adjusting for sociodemographic and cardiovascular risk factors. Among immigrants, those of West Asian, South Asian, and Black ethnicity had a higher incidence compared with other immigrant ethnic groups of similar age and sex. We also found that the prevalence of traditional cardiac risk factors varied among ethnicities, with East Asians having the lowest frequency of traditional cardiovascular risk factors, which likely contributes to their lower incidence of HF. Overall, ethnicity appeared to be an important independent risk factor for the development of HF.

The ethnic differences in incidence of HF hospitalization seen in this study have several possible explanations. Particularly, the healthy immigrant effect, and observation that immigrants tend to be relatively healthier than the host population, has been previously described.[32] HF incidence rates were similar between immigrants and long-term residents when stratified by 10-year age groupings except among men aged $\geq$80 years, where immigrants had lower incidence than long-term residents (Fig. 1). This finding suggests variation in the relative incidence of HF between immigrants and long-term residents across age groups. After adjustment for baseline cardiovascular risk factors, male immigrants in particular were still at lower risk of HF than their long-term resident counterparts compared with women. Immigration Canada uses a points-based system for potential immigrants who must undergo mandatory medical assessment, which results in an immigrant population of higher education, economic status, and overall better general health than the Canadian-born population.[33] In this study, immigrants overall were healthier than long-term residents, with long-term residents' age-standardized prevalence of AMI, revascularization interventions, VHD, and atrial fibrillation double that of immigrants. With an average time in Ontario of 12 years, our immigrant cohort may

not yet show signs of the impact of Western lifestyles and the associated risk factors for cardiovascular health, such as sodium-rich diets,[34] which have been shown to negatively affect the cardiovascular health of immigrants.[35−37] Refugees are the only immigrant population exempt from the medical assessment requirement, and thus they may not be subject to the healthy immigrant effect. Indeed, after age-adjustment they were not at significantly different risk of HF than long-term residents.

Although our finding of lower HF incidence among East Asian immigrants compared with long-term residents is consistent with previous results elsewhere, the lower incidence observed among other ethnic groups in our study contrasts with reports of increased incidence compared with native white residents.[38,39] To our surprise, the lower incidence of HF observed among Blacks in our study conflicts with the higher incidence found in African-Americans from several studies in the United States.[40−42] This difference may be related to differences in the characteristics of these populations, particularly that we define Black as an ethnicity rather than a race. Black study populations in the United States largely represent those born in the country and who tend to have a higher prevalence of cardiac risk factors compared with non-Blacks.[41−43] However, those in our study comprise immigrants from the Caribbean and Africa and tend to have lower cardiovascular disease rates compared with those of Western countries.[44,45]

The variation in cardiovascular risk factors seen in this study is consistent with the literature from higher-income countries and may aid in explaining the differences in immigrant HF incidence. A recent study by Fang et al discovered that the prevalence of coronary heart disease and stroke was significantly lower in immigrants to the United States than native citizens, with heterogeneity of these cardiovascular diseases by country of birth.[46] Our findings are similar, with our immigrant cohort having lower age-standardized prevalence of cardiovascular disease risk factors than native-born Canadian long-term residents, and with a significant disparity in the distribution of risk factors among the ethnic immigrant groups. South Asian participants had the largest burden of ischemic heart disease among all immigrants. This finding has been reproduced consistently in Europe, Canada, and the United States[47−49] and is a possible explanation for the elevated HF incidence seen among this ethnic group.

A strength of the present study is that it consisted of a very large sample size representative of the entire population of Ontario, Canada. Detailed immigration data were available on immigrants from 201 countries, creating the opportunity to assign every individual in our study population an ethnicity with reasonable accuracy. We used validated methods to accurately link health care data across several decades and databases to create a cohort with comprehensive data on cardiovascular health. Sensitivity analysis produced no change in results after excluding individuals with an HF diagnosis made in an outpatient setting (which may have confounded our original results),

further strengthening our observations. Despite these strengths, we recognize several limitations. Multiple comparisons were performed with no adjustment and should be considered when interpreting tests of significance. Though we lacked more clinical data that could support the healthy immigrant effect, the selective system used by Immigration Canada for approving prospective immigrants, as described above, can lead to an overall healthier immigrant population compared with long-term Canadian residents, thereby contributing to their lower risk of HF hospitalization. Our method of assigning ethnicity may have also resulted in some misclassification. Identifying Southeast Asians from country of birth and mother tongue alone has a particularly low PPV (0.47).[16] Therefore, we additionally used a surname algorithm to assign ethnicity (PPV for South Asians = 89.3 and for Chinese = 91.9) which we think improved the accuracy of our classification.[16] The NPV for assignment based on country of birth and mother tongue is also unanimously above 0.93, suggesting a suitable classification system.[16] In addition, we lacked some clinical information that may further assist in identifying the factors contributing to differences in HF between ethnic groups, such as information on left ventricular ejection fraction. Also, information on smoking status and body mass index were available for only a subpopulation of our entire cohort and was imputed for the remainder of our population. These factors are well established predictors of HF.[50] However, we think that we have been able to capture the major risk factors, specifically hypertension, diabetes, and cardiac history.

In summary, we found prominent variations in both the incidence of hospitalization for HF and prevalence of cardiovascular risk factors among immigrants of different ethnicities with HF incidence significantly lower in immigrants than in long-term residents of Ontario. Among immigrants, Blacks and South Asians had the highest incidence of HF hospitalization, which may be due to the higher prevalence of hypertension and diabetes in these populations. This study provides insight into how physicians may better approach the cardiovascular health of patients from diverse ethnic backgrounds. By being aware of the importance of ethnicity as a possible marker of HF risk, physicians may be able to effectively target their health promotion efforts at HF prevention to reduce related complications. Future research into the genetic, cultural, and environmental causes of variations between ethnic groups would further enhance our understanding of HF in these populations.

Dedication

This manuscript is dedicated to the memory of Jack V. Tu, MD, PhD (March 1, 1965−May 30, 2018).

Disclosures

None.

Acknowledgements

Supplementary Materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cardfail.2019.03.006.

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