

## **Appendix 1 (as supplied by the authors): Data supplements**

Supplement 1: CANHEART data sources

Supplement 2: Indicator data sources

Supplement 3: Cardiovascular health and health services indicator definitions and data sources

Supplement 4: Age-standardized incidence of a major cardiovascular event among 40-79 year olds by health region (2008-12)

Supplement 5: Multivariable regression modeling

Supplement 6: Baseline characteristics and prevalence of cardiac risk factors, by Local Health Integration Network

Supplement 7: Use of physician services, risk factor screening and risk factor management, by Local Health Integration Network

Supplement 8: Risk ratios for likelihood of receiving selected preventative health services

Supplement 9: Incidence rates of major cardiovascular outcomes, by Local Health Integration Network (2008-12)

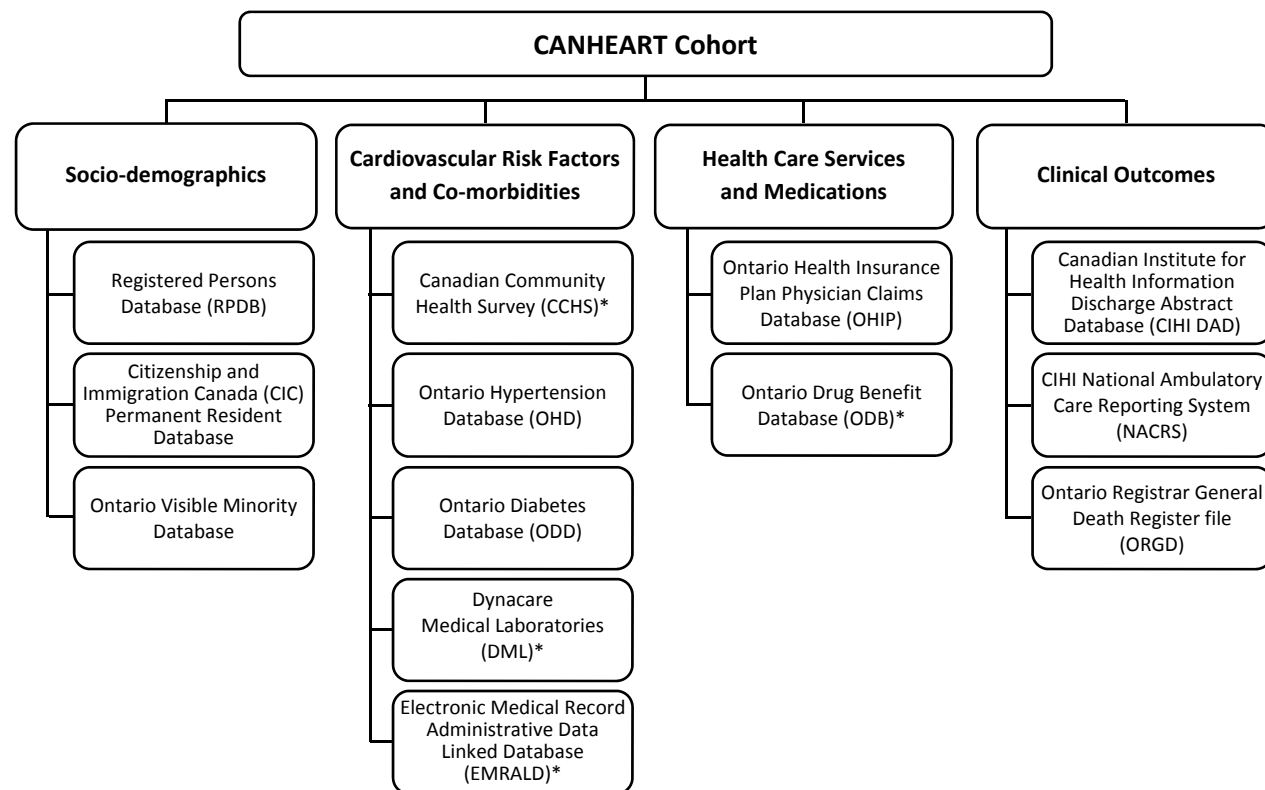
Supplement 10: LHIN-specific hazard ratios for the risk of a major cardiovascular event (2008-12)

Supplement 11: References

A PowerPoint slide collection summarizing key findings from the study, including regional maps of Ontario is available from the CANHEART website ([www.canheart.ca](http://www.canheart.ca)).

## Supplement 1: CANHEART data sources

Shown are the databases linked together using unique encoded personal identifiers. \*Indicates that data are only available for a representative sample of the CANHEART cohort.



### Description of data sources

**Canadian Community Health Survey (CCHS)** – An ongoing computer-assisted, population-based survey conducted by Statistics Canada since 2000 that uses a multi-stage cluster sampling design to collect information on self-reported health status, health determinants and health care utilization for the Canadian population age 12 and older.<sup>1</sup> The CCHS includes respondents from all ten provinces and three territories in Canada, including ~240,000 respondents (~40,000 biennially) from Ontario between 2000 and 2012. It is conducted in multiple languages to include non-English and non-French speaking residents, and uses sampling weights in data analyses to be representative of 98% of the Canadian population. For data referred to in this paper, only responses up to 2012 are linkable to other databases because encrypted health card numbers for later respondents were not available at the time of this cohort creation.

**Canadian Immigration and Citizenship Permanent Resident (CIC) Database** – Contains information from the application records for 3.1 million immigrants who arrived in Ontario

between 1985 and 2012. Data include permanent residents' demographic information such as country of birth, mother tongue, landing date, level of education, marital status and immigration category. Country of birth, mother tongue and surname (see the Ontario Visible Minority Database below) were used to derive the most likely ethnicity (Black, East Asian, Latin American, South Asian, Southeast Asian, West Asian/Arab, White-Eastern European or White-Western European) of immigrants in this database.<sup>1</sup> Information on immigrants arriving prior to 1985 is not available, but it is estimated that ~90% of these immigrants are White.<sup>2</sup>

**Canadian Institute for Health Information Discharge Abstract Database (CIHI DAD)** – Comprises individual-level data from the discharge abstracts of all Ontario hospitals for acute, chronic and rehabilitative care from 1988 onwards. Information includes admission and discharge dates, diagnoses and complications, procedures and comorbidities. Prior to April 2002, International Classification of Diseases (ICD)-9 coding was used with up to 16 diagnoses recorded in each abstract. Since April 2002, ICD-10 coding has been used with up to 25 diagnoses recorded.

**Canadian Institute for Health Information National Ambulatory Care Reporting System (NACRS)** – Provides individual-level data about all institution-based ambulatory care in Ontario, specifically care provided in emergency departments (ED) and out-patient clinics since 2000, and all day surgeries since 1988. Data include service dates, service provider, and diagnosis and procedure codes; and for ED visits, registration, triage and discharge times and triage level.

**Dynacare Medical Laboratories (DML) Database** – Provides outpatient results for select routine laboratory tests, including fasting lipid profiles and fasting glucose tests from 2002 onwards. DML is a major commercial laboratory provider in Ontario with geographic distribution across Ontario, but a higher concentration in urban areas. Our analyses indicate lipid and glucose tests are available for >2.4 million individuals in the overall CANHEART cohort, and that the demographic characteristics of people tested at DML clinics are similar to those tested elsewhere.<sup>2</sup> Key variables include test performed, service date, specimen collection time and test result.

**Electronic Medical Record Administrative data Linked Database (EMRALD)** – Compilation of clinical information from the electronic medical records (EMR) of over 350,000 patients from ~400 family physicians across Ontario. Previous analyses have demonstrated that EMRALD patients are fairly representative of the overall Ontario population who accesses primary care.<sup>3</sup> Participation is voluntary, but physicians are required to have been using their EMR system for a minimum of two years to ensure that their records contain near complete information about each patient. Records provide documentation about visits including diagnoses, assessments performed and their results, treatment and prescriptions provided and reports received from other health care providers.

**Office of the Registrar General of Ontario Vital Statistics Database (ORGD)** – Contains information about all deaths registered in Ontario since 1990 including cause of death. Since

health card numbers are not provided in this dataset, records are linked to the RPDB and other health administrative databases by deterministic (79%) and probabilistic (17%) data linkage.

**Ontario Diabetes Database (ODD)** – Validated registry of all Ontarians identified as having diabetes since 1991 with demonstrated sensitivity of 86% and specificity of 90% compared with physician-assigned diagnoses identified in chart audits.<sup>4</sup> An individual is said to have diabetes if he/she has had two OHIP claims with a diabetes diagnosis, one OHIP service claim for diabetes management or intensive insulin therapy counselling, or one hospitalization with a diabetes diagnosis within two years. The date and source of diagnosis is defined using the first record of a diabetes diagnosis meeting the above the criteria.

**Ontario Drug Benefit Database (ODB)** – Contains information on prescription drug claims covered by and made to the Ontario Drug Benefit programme. This programme primarily covers drug expenses for Ontarians with a valid OHIP card who are 65 years and older or residents of long-term care facilities, but also provides coverage to others such as those receiving social assistance. Key data elements include dispensing date, drug identifier, quantity supplied and whether the recipient is a resident of a long-term care facility.

**Ontario Health Insurance Plan (OHIP) Claims Database** – This database captures all reimbursement claims made since 1991 by registered health care providers who are eligible to claim under OHIP. This includes fee-for-service physicians (covering 94% of Ontario’s physicians), other health care providers and community-based labs. Excluded are services received in psychiatric hospitals, services provided by alternate funding plans (e.g. private insurance and federal programmes), diagnostic procedures performed on an inpatient basis (e.g. radiology, ECGs) and laboratory services performed in hospitals (inpatient or same day). Information includes encrypted service provider and specialty if a physician, diagnosis, service provided, date of service and fee paid.

**Ontario Hypertension Database (OHD)** – Validated registry of all Ontarians identified with hypertension since 1988 with demonstrated sensitivity of 73% and specificity of 95% compared with physician-assigned diagnoses identified in chart audits.<sup>5</sup> An individual is said to have hypertension if he/she has had one hospital admission with a hypertension diagnosis, or an OHIP claim with a hypertension diagnosis followed within two years by either an OHIP claim or a hospital admission with a hypertension diagnosis. The date of the first record of a hypertension diagnosis meeting the above criteria is defined as the date of diagnosis.

**Ontario Visible Minority Database** – Dataset which uses validated lists of South Asian and Chinese surnames to assign an ethnicity of Chinese or South Asian (Canada’s two largest visible minority groups), or “general” to individuals in the RPDB.<sup>6</sup> Surnames not unique to the South Asian or Chinese populations are purposely excluded from the lists. Specificity is over 99.5% and positive predictive value is 89 to 92%; sensitivity is 50% for South Asians, 80% for Chinese.

**Registered Persons Database (RPDB)** – Provides basic demographic information about anyone who has ever received an Ontario health card number. Key data variables include date of birth, date of death, sex, geographical information and time periods for which an individual was eligible for coverage under the Ontario Health Insurance Plan (OHIP). All health card numbers are encoded before being linked to other databases at the Institute for Clinical Evaluative Sciences (ICES).

## Supplement 2: Indicator data sources

Indicator	Data Source(s)*	Availability
Physician services and clinical events	Ontario Health Insurance Plan Physician Claims Database Canadian Institute for Health Information Discharge Abstract Database Ontario Registrar General Death Register file	All
Drug prescriptions	Ontario Drug Benefits database	n=1,328,153 and includes claims funded by and made to the ODB programme, primarily by residents aged 65 and over
Health behaviours	Canadian Community Health Survey	n=68,067 (2005-2012)
Lipid and HbA1c test results	Dynacare Medical Laboratory database	n=1,389,072
Systolic blood pressure and components of the Framingham Global CVD risk score	Electronic Medical Record Linked Administrative Database	n=35,790 for baseline systolic blood pressure prior to 2008, n=64,381 for Framingham score (2006-2012); Estimates for the Erie St. Clair and North West LHINs were not calculated due to insufficient samples sizes.

Note: CVD = cardiovascular disease, LHIN = Local Health Integration Network, ODB=Ontario Drug Benefits.

\* See Appendix 1 for a description of individual data sources.

### Supplement 3: Cardiovascular health and health services indicator definitions and data sources

Indicator	CANHEART Definition	Exclusions	Data source
Major cardiovascular event	Hospitalization for acute myocardial infarction (ICD-10 codes I21, I22) or stroke (I60, I61, I63 excluding I63.6, I64, H34.1), or death due to ischemic heart disease (I20-25) or stroke (I60-69)	None	CIHI DAD, ORGD
Prevalence of smoking	Daily or occasional smoker	None	CCHS
Prevalence of obesity	Body mass index $\geq 30$ kg/m <sup>2</sup>	Individual was pregnant on survey date	CCHS
Prevalence of physical inactivity	Average daily energy expended during leisure time activities < 1.5kcal/kg/day	None	CCHS
Prevalence of inadequate fruit and vegetable consumption	< 5 servings of fruits and vegetables per day	None	CCHS
Prevalence of hypertension	Physician diagnosed hypertension prior to January 1, 2008	None	OHD
Prevalence of diabetes	Physician diagnosed diabetes prior to January 1, 2008	None	ODD
Total cholesterol	Most recent total cholesterol test result between January 1, 2002 and January 1, 2008	None	DML
High density lipoprotein (HDL)	Most recent HDL cholesterol test result between January 1, 2002 and January 1, 2008	None	DML
Low density lipoprotein (LDL)	Most recent LDL cholesterol test result between January 1, 2002 and January 1, 2008	None	DML
Visited a family physician	Percentage of population who visited a family physician within the past 24 months (2006-07)	None	OHIP
Annual number of visits to a family physician	Mean number of visits to a family physician per person per year during 2006-07	None	OHIP
Periodic health exam	Percentage of population who received a periodic health exam within the past 36 months (2005-07)	None	OHIP

<b>Indicator</b>	<b>CANHEART Definition</b>	<b>Exclusions</b>	<b>Data source</b>
Visited a specialty physician	Percentage of population who visited a specialty physician within the past 24 months (2006-07)	None	OHIP
Annual number of visits to a specialty physician	Mean number of visits to a specialty physician per person per year during 2006-07	None	OHIP
Dyslipidemia screening	Percentage of men $\geq 40$ years and women $\geq 50$ years with a full fasting lipid profile within the past 36 months (2005-07)	Females $< 50$ years old with neither baseline diabetes or hypertension	OHIP
Diabetes screening	Percentage of patients $\geq 40$ years with a fasting blood glucose or HbA1c screening test within the past 36 months (2005-07)	Diabetes at baseline	OHIP
Percentage of patients on statins	Percentage of 65+ year olds who had a prescription for a statin filled in the 100 days prior to January 1, 2008	$< 65$ years old on Jan 1, 2007	ODB
Lipid control	Percentage of 65+ year olds with a statin prescription filled in the 100 days prior to Jan 1, 2008 whose latest LDL test result between 2008 and 2012 met the Canadian Dyslipidemia Guidelines target of 2 mmol/L. <sup>10</sup>	LDL test result between 2008 and 2012 unavailable	ODB, DML
Percentage of patients with hypertension and on $\geq 1$ anti-hypertensive medication taking $\geq 2$ anti-hypertension medications	Percentage of 65+ year olds with hypertension and $\geq 1$ prescription for an anti-hypertensive drug filled in the 100 days prior to January 1, 2008 who had $\geq 2$ anti-hypertension medications filled during the same period	$< 65$ years old on Jan 1, 2007	ODB
Measured blood pressure (BP) control among hypertensive patients	Percentage of patients with hypertension with controlled BP ( $< 140/90$ mmHg) based on the average of the 3 most recent measurements during 2008-2012. Hypertensive individuals were identified from either (a) terminology in the cumulative patient profile, (b) an anti-HTN prescription and elevated blood pressure ( $\geq 140$ mmHg diastolic or $\geq 90$ mmHg diastolic) on the same day, or (c) blood pressures meeting Canadian Hypertension Education Program criteria.	Individuals with no blood pressure measurement during the 5 year follow-up period	EMRALD

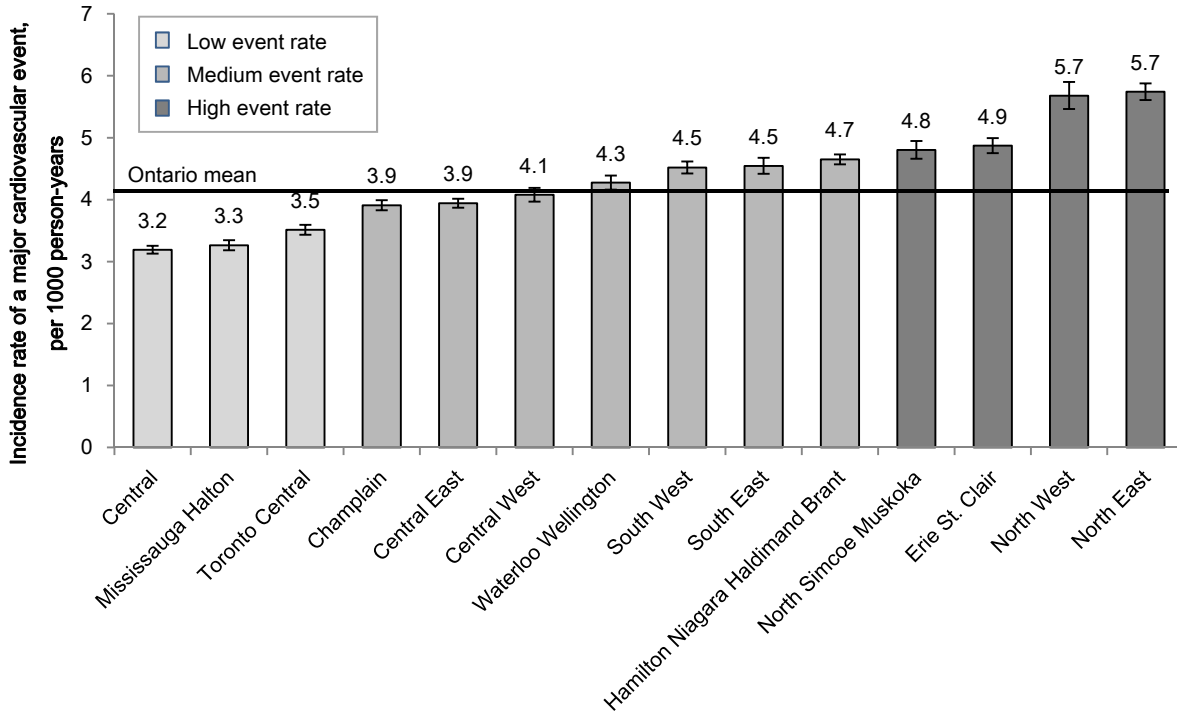


<b>Indicator</b>	<b>CANHEART Definition</b>	<b>Exclusions</b>	<b>Data source</b>
Annual visits to a family physician for hypertension	Mean number of visits to a family physician for hypertension per person per year during 2008-12 (among individuals with hypertension)	Individuals without physician-diagnosed hypertension and those with < 1 year of follow-up	OHIP
Percentage of diabetics on selected medications a. Anti-glycemic medication (oral agents or insulin) b. ACE inhibitor or ARB c. Statins	Percentage of 65+ year olds with lab confirmed diabetes or a history of anti-glycemic medications prior to January 1, 2008 who had a prescription for selected medications filled in the 100 days prior to January 1, 2008	< 65 years old on Jan 1, 2007	ODB
Percentage of diabetics under glyceemic control	Percentage of diabetics who have achieved glyceemic control (HbA1c ≤7%) based on the latest HbAc1 test result available during the study period (2008-12). Diabetics were defined as having lab confirmed diabetes or a history of prescriptions for anti-glycemic medications prior to January 1, 2008.	< 65 years old on Jan 1, 2007	ODB, DML

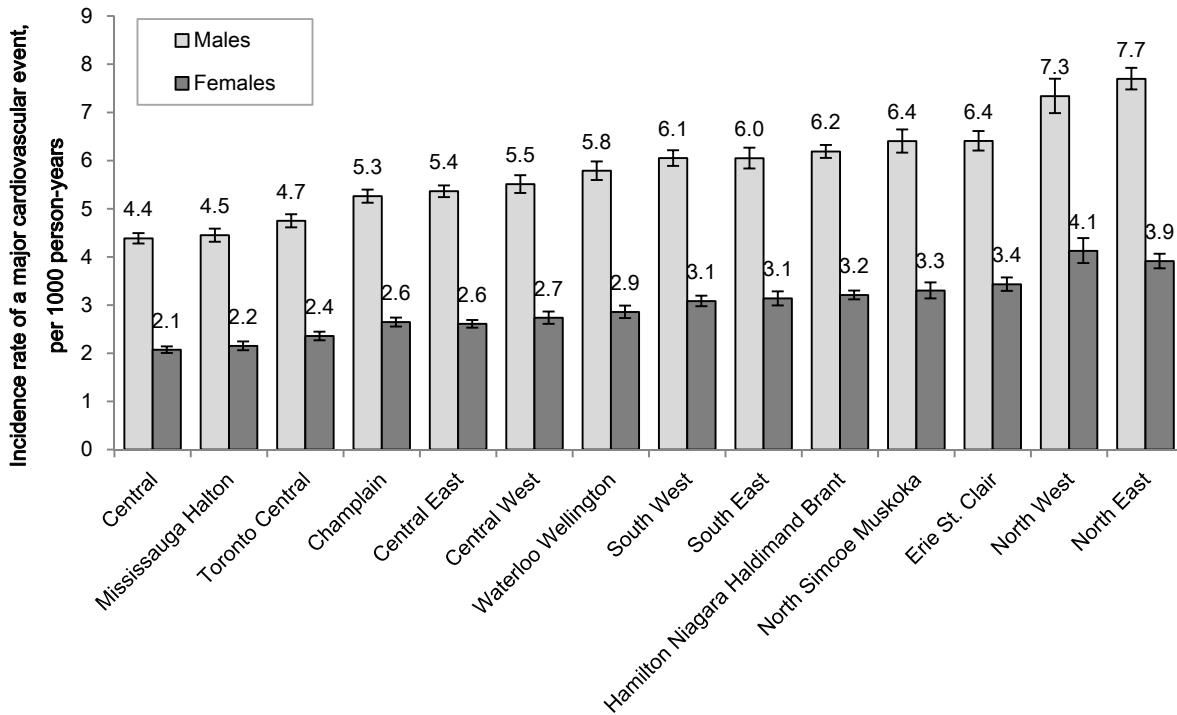
Note: ACE = angiotension converting enzyme, ARB = angiotensin receptor blocker, CCHS = Canadian Community Health Survey, CIHI DAD = Canadian Institute for Health Information Discharge Abstract Database, DML = Dynacare Medical Laboratories database, EMERALD = Electronic Medical Record Administrative Data Linked Database, HTN = hypertension, ODD = Ontario Diabetes Database, ODB = Ontario Drug Benefit Claims database, OHD = Ontario Hypertension Database, and OHIP = Ontario Health Insurance Plan Physician Claims database.

**Supplement 4: Age-standardized incidence of a major cardiovascular event among 40-79 year olds by health region (2008-12)**

**A. Overall**



**B. By sex**



## Supplement 5: Multivariable regression modeling

To determine the contribution of patient and health system factors to variation in cardiovascular disease (CVD) event rates between health regions (or Local Health Integration Networks, LHINs), we performed sequential multivariable multilevel Cox proportional hazards analyses adjusting for a) age and sex, b) other patient-level factors such as the traditional cardiac risk factors (smoking, diabetes, hypertension, total (TC) and high density lipoprotein (HDL) cholesterol levels), neighbourhood income and ethnicity, and c) health system factors. Each model adjusted for the listed variables in addition to the variables in the preceding models with the effect of individual LHINs assumed to follow a normal distribution and modeled as random effects (or frailty terms), and patient-level covariates modeled as fixed effects.<sup>7</sup> Variation in CVD event rates between regions was examined by calculating the median hazard ratio (MHR) as:  $MHR = \exp[\sqrt{2 \times \sigma^2} \times \Phi^{-1}(0.75)]$ , where  $\sigma^2$  is the variance of the LHIN-specific random effects and  $\Phi^{-1}(0.75)$  is the 75<sup>th</sup> percentile of the normal distribution with mean=0 and variance=1, and is equal to 0.674.<sup>8</sup> The MHR quantifies the median relative difference in the hazard of CVD events for an identical patient in all 14 LHINs when all possible comparisons of higher versus lower-risk LHINs are made.<sup>9</sup>

The degree of variation explained by each model in the sequence of adjustment was determined by computing the percent change in the variance of the LHIN-specific random effects from an unadjusted model. Age, sex, traditional cardiac risk factors and ethnicity were chosen as explanatory variables because of their known association with the risk of CVD.<sup>10, 11</sup> The ethnicity of individuals was determined using an algorithm identical to that used in the CANHEART Immigrant study, and is based on an individual's country of birth, mother tongue and surname (for Chinese and South Asians).<sup>11</sup> Since we did not have information about ethnicity on immigrants arriving in Ontario prior to 1985, these immigrants were grouped with individuals born in Ontario as long-term residents. Previous analyses have shown that > 90% of long-term residents are White.<sup>11</sup>

To identify candidate health system factors as explanatory variables, we conducted age and sex-adjusted Cox proportional hazards analyses for the individual health services indicators studied (Appendix 3) on the risk of a CVD event. Indicators significantly associated with CVD risk at a P-value of 0.20 or less were considered for inclusion as explanatory health system factors. We did not include medication prescriptions because this information was only available for the population  $\geq 65$  years of age. Similarly, blood pressure control was not considered because this information was only available for a sub-population of our cohort. We then used backwards variable elimination, sequentially excluding indicators that were not statistically significant ( $P > 0.05$ ). Since our earlier analyses demonstrated high correlation between dyslipidemia and diabetes, among these, we only included dyslipidemia screening in the final model because it influences the clinical decision to prescribe statins, is a prerequisite to formal quantitation of 10-year CVD risk, and the use of statins has been associated with lower CVD risk. Sensitivity

analyses were performed that included models with the other health system variables and the results were generally similar to that with dyslipidemia screening only (unpublished data).

Where neighbourhood income, smoking status, TC or HDL test results were missing, we performed multiple imputation, creating 5 imputation datasets. Variables used in the imputation models were age on January 1, 2008, sex, ethnic group, baseline hypertension, baseline diabetes, incidence of a major cardiovascular event and time to a first major cardiovascular event or end of study period if a major cardiovascular event was not experienced. For smoking status only, baseline chronic obstructive lung disease and smoking cessation counselling by a family physician were also used. These variables were chosen because they have been shown to be either predictive of TC, HDL or smoking status, or were potentially related to the risk of having a CVD event.<sup>12</sup> Since age and HDL were not normally distributed, they were log transformed in the imputations. We assumed values were missing at random since Dynacare Medical Laboratories has laboratories all over Ontario and the CCHS is sampled to be representative of the Canadian population. A comparison of observed and imputed mean TC and HDL levels and smoking status by LHIN demonstrated reasonably similar values.

Using similar multivariable, multilevel models with the effects of LHINs modeled as random effects and patient-level covariates modeled as fixed effects, the likelihood of receiving selected preventative health services (i.e., annual visits to a family physician, dyslipidemia screening, periodic health exam) was compared among LHINs after adjusting for individual demographics and cardiovascular risk using a modified Framingham risk score. The modified Framingham risk score is a points-based score developed using the methods described by Sullivan et al in creating the original Framingham risk score.<sup>13</sup> A score was calculated for each individual by assigning points based on the presence or absence of each traditional risk factor (age, sex, smoking, hypertension, diabetes, TC and HDL) with higher scores indicating a higher risk. Further details are provided elsewhere.<sup>11</sup>

Poisson regression was used for the annual number of visits to a family physician while logistic regression was used for dyslipidemia screening and periodic health exam. Pearson correlation coefficients between the incidence of CVD events and the likelihood of receiving health services for each LHIN, and their associated P-values were then computed.

## Supplement 6: Baseline characteristics and prevalence of cardiac risk factors, by Local Health Integration Network\*

Characteristic	Central	Mississauga Halton	Toronto Central	Champlain	Central East	Central West	Waterloo Wellington	South West	South East	Hamilton Niagara Haldimand Brant	North Simcoe Muskoka	Erie St. Clair	North West	North East	Overall
Population size, n	717,628	469,267	496,209	529,473	661,624	314,418	291,756	403,034	222,717	596,935	193,299	277,027	104,912	265,848	<b>5,544,147</b>
<b>Baseline characteristics</b>															
Age on Jan 1, 2008, mean yrs ± SD	54.3 ± 10.4	53.7 ± 10.2	54.1 ± 10.4	54.5 ± 10.2	54.7 ± 10.4	53.6 ± 10.2	54.3 ± 10.3	55.3 ± 10.4	55.9 ± 10.5	55.2 ± 10.6	55.1 ± 10.5	55.1 ± 10.4	54.8 ± 10.2	55.5 ± 10.4	<b>54.6 ± 10.4</b>
Female sex, %	52.6	51.8	50.9	52.2	52.5	50.9	51.6	52.2	52.9	52.4	52.0	51.8	50.6	51.8	<b>52.0</b>
< Secondary school graduation, %†	14.6	11.6	12.3	13.5	15.4	19.1	18.4	17.4	16.0	16.7	17.4	16.7	20.3	22.0	<b>15.7</b>
Ethnicity, %†															
White	65.3	70.5	76.3	89.3	70.2	59.1	90.7	95.3	94.7	93.2	94.7	90.9	92.0	93.9	<b>81.3</b>
South Asian	5.5	9.2	4.0	1.1	9.1	20.4	2.1	0.7	0.6	1.2	0.5	1.8	0.1	0.1	<b>4.6</b>
Chinese	14.1	4.6	6.3	1.9	7.4	1.8	1.9	0.7	0.5	1.3	0.8	1.4	0.5	0.2	<b>4.3</b>
Black	3.6	3.2	3.4	1.9	5.0	9.5	0.8	0.6	0.2	0.7	0.5	0.9	0.1	0.3	<b>2.6</b>
Other	11.5	12.5	10.1	5.7	8.3	9.2	4.5	2.8	4.0	3.6	3.5	5.0	7.2	5.6	<b>7.2</b>
Immigrant ≤20 years in Ontario, %	28.2	24.7	20.7	7.6	18.6	27.6	8.8	4.7	1.9	6.2	2.6	6.8	1.3	0.9	<b>14.1</b>
Low-income neighborhood, %‡	32.9	23.5	45.9	34.0	46.3	41.9	36.3	38.2	44.4	37.5	33.8	37.7	34.0	46.4	<b>37.9</b>
Rural or small-town residence, %§	0.8	0.2	0.0	18.1	8.0	3.2	12.3	34.6	42.5	4.7	39.3	10.2	39.8	35.1	<b>12.7</b>
<b>Cardiac risk factors</b>															
Cigarette smoker, %†	13.9	16.4	14.8	17.7	16.8	14.9	16.9	19.2	22.4	20.1	21.9	20.2	23.2	24.1	<b>17.7</b>
Hypertension, %	32.1	32.7	29.1	29.5	34.3	35.4	28.0	32.9	32.6	31.6	32.1	34.7	31.2	34.1	<b>32.1</b>
Systolic blood pressure, mean mmHg¶	125.5	125.5	123.8	127.5	124.5	126.9	125.6	127.5	126.0	126.1	130.8	.	.	131.2	<b>126.6</b>
Diabetes, %	13.2	12.5	11.5	10.9	13.8	15.9	10.6	10.7	10.8	11.1	10.4	12.4	12.4	12.6	<b>12.1</b>
Obesity (BMI ≥ 30 kg/m <sup>2</sup> ), %†	14.2	15.2	14.1	18.3	17.0	17.4	20.2	20.6	22.5	20.7	21.3	21.4	24.5	23.6	<b>18.2</b>

Appendix to: Tu JV, Chu A, Maclagan L, et al.; Cardiovascular Health in Ambulatory Care Research Team (CANHEART). Regional variations in ambulatory care and incidence of cardiovascular events. *CMAJ* 2017. doi: 10.1503/cmaj.160823. Copyright © 2017 Joule Inc. or its licensors

Characteristic	Central	Mississauga Halton	Toronto Central	Champlain	Central East	Central West	Waterloo Wellington	South West	South East	Hamilton Niagara Haldimand Brant	North Simcoe Muskoka	Erie St. Clair	North West	North East	Overall
Physically inactive, %†	50.7	49.2	43.8	39.7	50.5	54.8	46.1	46.6	43.6	46.6	42.2	51.8	42.4	45.7	<b>47.3</b>
Inadequate fruit and vegetable consumption (< 5/day), %†	57.5	57.7	58.6	56.4	60.1	58.0	60.2	60.8	59.9	58.8	59.5	64.4	66.0	61.0	<b>59.2</b>
Total cholesterol, mean mmol/L	4.81	4.81	4.84	4.88	4.79	4.78	4.86	4.82	4.91	4.81	4.91	4.87	4.70	4.90	<b>4.83</b>
High density lipoprotein, mean mmol/L	1.35	1.34	1.40	1.36	1.35	1.31	1.32	1.32	1.36	1.33	1.35	1.33	1.23	1.31	<b>1.35</b>
Low density lipoprotein, mean mmol/L	2.83	2.85	2.84	2.89	2.80	2.83	2.86	2.84	2.87	2.82	2.89	2.80	2.74	2.87	<b>2.84</b>
Framingham 10-year CVD risk, mean %¶	11.2	11.5	10.8	12.2	12.4	12.5	12.1	12.8	12.5	12.5	13.1	.	.	15.3	<b>12.1</b>

Note: BMI = body mass index, CVD = cardiovascular disease.

\* Values for cardiac risk factors are age-/sex-standardized to the 2006 Ontario census population.

† Estimates are from a study sub-population of individuals linked to the 2005-2012 and 2001-2012 (for ethnicity) Canadian Community Health Surveys, and exclude on-reserve Indigenous populations. Estimates are weighted using Statistics Canada survey weights.

‡ Defined as neighbourhood income quintile=1 or 2, where quintile 1 has the lowest income.

§ Based on Statistics Canada's 2006 census population and defined as community size of <10 000.

¶ Estimates are from a study sub-population of individuals linked to the Electronic Medical Record Administrative data Linked Database (EMRALD). . = suppressed due to small sample sizes.

|| Estimates are from a study sub-population linked to the Dynacare Medical Laboratories database.

## Supplement 7: Use of physician services, risk factor screening and risk factor management, by Local Health Integration Network

Indicator	Central	Mississauga Halton	Toronto Central	Champlain	Central East	Central West	Waterloo Wellington	South West	South East	Hamilton Niagara Haldimand Brant	North Simcoe Muskoka	Erie St. Clair	North West	North East	Overall
	<i>% unless otherwise indicated*</i>														
Visited a family physician	87.6	88.0	83.1	85.8	88.6	89.6	86.7	86.9	84.7	88.1	89.0	87.6	82.1	84.9	<b>87.0</b>
Mean annual visits to a family physician, per person	4.3	4.2	4.0	3.3	4.1	4.7	3.0	3.3	3.1	3.4	3.4	4.0	2.8	3.2	<b>3.8</b>
Periodic health exam	66.0	63.8	60.7	61.4	60.8	58.9	52.0	54.0	46.9	52.2	55.6	51.3	41.9	43.0	<b>57.4</b>
Visited a specialty physician	59.7	59.3	60.9	60.1	59.0	57.1	54.5	54.4	55.0	59.6	55.0	58.2	52.7	55.2	<b>58.1</b>
Mean annual visits to a specialty physician, per person	1.8	1.6	2.1	1.7	1.6	1.5	1.4	1.3	1.3	1.7	1.3	1.6	1.3	1.3	<b>1.6</b>
Dyslipidemia screening	75.1	73.0	66.0	67.8	72.9	73.9	65.9	58.9	63.0	64.6	62.3	61.5	54.6	52.7	<b>67.3</b>
Diabetes screening	76.8	74.4	68.4	69.8	75.3	76.3	69.7	61.9	66.3	67.1	66.5	63.5	54.1	55.2	<b>69.6</b>
Prescribed statins	31.9	31.6	30.5	30.2	35.3	32.0	28.8	30.5	29.0	32.9	29.7	33.0	28.8	31.7	<b>31.7</b>
LDL $\leq$ 2 mmol/L among statin users†	52.2	51.7	50.9	53.4	57.2	50.9	51.9	51.3	56.5	51.0	49.8	50.0	41.7	49.0	<b>52.6</b>
<b>Among individuals with hypertension</b>															
Prescribed $\geq$ 2 anti-hypertensive medications	53.7	56.1	55.4	56.2	56.6	56.4	56.4	56.1	56.2	55.2	56.4	53.4	57.1	58.9	<b>55.8</b>
Controlled blood pressure‡	65.9	66.3	68.3	70.1	66.0	64.3	58.1	63.6	55.9	75.0	53.4	.	.	52.0	<b>64.4</b>
Mean annual visits to a family physician for hypertension, per person (2008-12)	1.2	1.1	1.1	0.8	1.1	1.3	0.7	0.8	0.8	0.8	0.7	1.0	0.6	0.8	<b>1.0</b>
<b>Among individuals with diabetes §</b>															
Prescribed anti-glycemic medication	69.9	72.8	71.0	66.7	72.2	70.4	71.1	70.8	71.2	71.8	70.8	76.7	85.2	72.8	<b>70.8</b>
Prescribed ACE inhibitor/ARB	66.9	67.2	67.6	64.2	71.9	66.5	66.1	66.3	73.9	69.2	69.5	70.6	74.5	66.7	<b>67.7</b>
Prescribed statins	60.4	60.9	61.2	58.9	63.5	58.8	58.8	58.8	62.4	61.3	58.1	57.8	54.3	55.1	<b>60.2</b>
HbA1c $\leq$ 7%	58.5	58.1	58.0	60.8	59.8	52.5	65.7	64.2	58.5	58.2	55.2	65.5	49.6	60.9	<b>59.3</b>

Note: ARB = angiotensin II receptor blocker, ACE = angiotensin converting enzyme, CI = confidence interval, LDL = low density lipoprotein.

\* Values are age- and sex-standardized to the 2006 Ontario census population. Study period for family and specialty physician visits is 2006-07. Study period for periodic health exams, and cholesterol and diabetes screening is 2005-07. Prescribed medications are in the 100 days prior to January 1, 2008 among  $\geq$ 65 year olds on January 1, 2007. Anti-hypertensive medications are among individuals prescribed at least one anti-hypertensive medication.

† LDL  $\leq$ 2 mmol/L is based on the latest result available between 2008 and 2012, and is the target in Canadian Dyslipidemia Guidelines.<sup>10</sup>

‡ Defined as <140/90 mmHg based on the average of the three most recent measurements during 2008-2012 among hypertensive patients in the Electronic Medical Record Administrative data Linked Database (EMRALD). . = suppressed due to small sample sizes.

§ Among  $\geq 65$  year olds on January 1, 2007 with lab confirmed diabetes or a history of prescriptions for anti-glycemic medications prior to January 1, 2008. HbA1c  $\leq 7\%$  is based on the latest result available between 2008 and 2012.



### Supplement 8: Risk ratios for likelihood of receiving selected preventative health services\*

Local Health Integration Network	Annual visits to a family physician <i>Relative risk</i> (95% confidence interval)	Dyslipidemia screening <i>Odds ratio</i> (95% confidence interval)	Periodic health exam <i>Odds ratio</i> (95% confidence interval)
Central	1.21 (1.11, 1.31)	1.57 (1.34, 1.84)	1.57 (1.34, 1.86)
Mississauga Halton	1.18 (1.09, 1.27)	1.36 (1.16, 1.59)	1.41 (1.20, 1.67)
Toronto Central	1.13 (1.04, 1.22)	1.04 (0.89, 1.22)	1.29 (1.10, 1.52)
Champlain	0.94 (0.87, 1.02)	1.13 (0.97, 1.33)	1.28 (1.08, 1.50)
Central East	1.12 (1.04, 1.22)	1.42 (1.21, 1.66)	1.30 (1.11, 1.54)
Central West	1.26 (1.16, 1.36)	1.44 (1.23, 1.69)	1.26 (1.07, 1.49)
Waterloo Wellington	0.84 (0.78, 0.91)	1.02 (0.87, 1.19)	0.87 (0.74, 1.03)
South West	0.92 (0.85, 0.99)	0.76 (0.65, 0.89)	0.96 (0.81, 1.13)
South East	0.87 (0.80, 0.94)	0.93 (0.79, 1.09)	0.74 (0.62, 0.87)
Hamilton Niagara Haldimand Brant	0.96 (0.88, 1.03)	0.97 (0.82, 1.13)	0.88 (0.75, 1.04)
North Simcoe Muskoka	0.96 (0.89, 1.04)	0.88 (0.75, 1.03)	1.00 (0.85, 1.18)
Erie St. Clair	1.11 (1.03, 1.20)	0.85 (0.73, 1.00)	0.85 (0.72, 1.01)
North West	0.78 (0.72, 0.85)	0.62 (0.53, 0.73)	0.57 (0.48, 0.67)
North East	0.87 (0.81, 0.95)	0.60 (0.51, 0.70)	0.62 (0.53, 0.74)
<b><i>p-value for trend</i></b>	<b>0.005</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>

\* Risk ratios are from multivariable multilevel regression models (Poisson for annual visits to a family physician, logistic for dyslipidemia screening and periodic health exam) adjusting for individual cardiovascular risk, in which the effects of individual LHINs were modeled as random effects and all other covariates (age, sex, income, ethnicity, modified Framingham cardiovascular risk score) were modeled as fixed effects. Income is defined as census-derived area-based income quintile.

## Supplement 9: Incidence rates of major cardiovascular outcomes, by Local Health Integration Network (2008-12)

Outcome	Central	Mississauga Halton	Toronto Central	Champlain	Central East	Central West	Waterloo Wellington	South West	South East	Hamilton Niagara Haldimand Brant	North Simcoe Muskoka	Erie St. Clair	North West	North East	Overall
	<i>Per 1000 person-years*</i>														
AMI	1.6	1.7	1.6	2.1	2.1	2.2	2.2	2.4	2.4	2.5	2.7	2.5	3.1	3.3	2.2
Stroke	1.1	1.2	1.3	1.1	1.2	1.3	1.4	1.4	1.4	1.4	1.4	1.6	1.8	1.6	1.3
Cardiovascular death†	0.8	0.8	1.1	1.0	1.0	1.0	1.2	1.2	1.3	1.3	1.2	1.3	1.3	1.5	1.1
AMI, stroke, or cardiovascular death†	3.2	3.3	3.5	3.9	3.9	4.1	4.3	4.5	4.5	4.7	4.8	4.9	5.7	5.7	4.1

Note: AMI = acute myocardial infarction.

\* All estimates are age- and sex-standardized to the 2006 Ontario census population.

† Cardiovascular death is classified as ischemic heart disease death or cerebrovascular death. Cause of death is known for 99% of all deaths. Unknown causes of death were considered non-cardiovascular deaths.

**Supplement 10: LHIN-specific hazard ratios for the risk of a major cardiovascular event (2008-12)\***

LHIN	Model					
	Unadjusted	Age, sex	+ Traditional risk factors†	+ Neighbourhood income	+ Ethnicity	+Health system factors‡
	<i>Hazard ratio (95% confidence interval)</i>					
Central	0.72 (0.65, 0.81)	0.74 (0.67, 0.82)	0.75 (0.68, 0.82)	0.75 (0.69, 0.83)	0.83 (0.77, 0.89)	0.86 (0.81, 0.92)
Mississauga Halton	0.71 (0.64, 0.80)	0.76 (0.69, 0.84)	0.78 (0.71, 0.85)	0.80 (0.73, 0.87)	0.83 (0.77, 0.89)	0.86 (0.81, 0.91)
Toronto Central	0.78 (0.70, 0.88)	0.81 (0.74, 0.89)	0.83 (0.76, 0.91)	0.82 (0.75, 0.90)	0.86 (0.80, 0.92)	0.88 (0.83, 0.94)
Champlain	0.90 (0.80, 1.00)	0.91 (0.83, 1.01)	0.93 (0.85, 1.02)	0.94 (0.86, 1.03)	0.93 (0.87, 1.00)	0.96 (0.90, 1.02)
Central East	0.92 (0.82, 1.03)	0.92 (0.84, 1.02)	0.91 (0.83, 0.99)	0.89 (0.82, 0.98)	0.93 (0.86, 1.00)	0.96 (0.90, 1.01)
Central West	0.90 (0.80, 1.01)	0.96 (0.87, 1.06)	0.93 (0.85, 1.02)	0.92 (0.84, 1.01)	0.94 (0.87, 1.01)	0.96 (0.90, 1.02)
Waterloo Wellington	0.97 (0.87, 1.09)	1.00 (0.91, 1.10)	1.03 (0.94, 1.13)	1.03 (0.94, 1.13)	1.02 (0.94, 1.10)	1.01 (0.95, 1.08)
South West	1.09 (0.97, 1.22)	1.05 (0.96, 1.16)	1.05 (0.96, 1.15)	1.05 (0.96, 1.15)	1.02 (0.95, 1.10)	1.00 (0.95, 1.07)
South East	1.13 (1.01, 1.27)	1.06 (0.96, 1.17)	1.05 (0.96, 1.16)	1.04 (0.95, 1.14)	1.01 (0.93, 1.09)	0.99 (0.93, 1.05)
Hamilton Niagara Haldimand Brant	1.12 (1.00, 1.25)	1.09 (0.99, 1.20)	1.09 (0.99, 1.20)	1.09 (1.00, 1.19)	1.07 (0.99, 1.15)	1.05 (0.99, 1.12)
North Simcoe Muskoka	1.15 (1.03, 1.29)	1.12 (1.01, 1.24)	1.12 (1.02, 1.24)	1.13 (1.03, 1.24)	1.10 (1.02, 1.18)	1.09 (1.03, 1.16)
Erie St. Clair	1.16 (1.04, 1.30)	1.14 (1.03, 1.25)	1.11 (1.01, 1.22)	1.11 (1.01, 1.22)	1.09 (1.01, 1.17)	1.07 (1.00, 1.13)
North West	1.33 (1.18, 1.49)	1.32 (1.19, 1.46)	1.33 (1.21, 1.46)	1.34 (1.21, 1.47)	1.29 (1.19, 1.40)	1.23 (1.15, 1.31)
North East	1.40 (1.25, 1.57)	1.34 (1.21, 1.47)	1.29 (1.18, 1.42)	1.27 (1.16, 1.39)	1.23 (1.14, 1.32)	1.16 (1.09, 1.23)
<i>Median hazard ratio (95% CI)</i>	<i>1.22 (1.10, 1.31)</i>	<i>1.19 (1.09, 1.26)</i>	<i>1.18 (1.08, 1.25)</i>	<i>1.18 (1.08, 1.24)</i>	<i>1.14 (1.06, 1.19)</i>	<i>1.11 (1.05, 1.15)</i>
<b><i>Explained LHIN level variation (%)</i></b>	<b>--</b>	<b>26.3</b>	<b>33.2</b>	<b>35.8</b>	<b>59.0</b>	<b>74.5</b>

\* From a multivariable multilevel Cox proportional hazards models, in which the effects of LHINs were modeled as random effects (frailty terms) and patient-level covariates modeled as fixed effects. A major cardiovascular event is defined as hospitalization for acute myocardial infarction or stroke, or death due to ischemic or cerebrovascular disease.

† Traditional risk factors include smoking, diabetes, hypertension, total cholesterol and high density lipoprotein cholesterol. Income is defined as census-derived area-based income quintile.

‡ Health system factors include dyslipidemia screening, family physician visits, and periodic health exams.

## Supplement 11: References

1. Rezai MR, Maclagan LC, Donovan LR, Tu JV. Classification of Canadian immigrants into visible minority groups using country of birth and mother tongue. *Open Med* 2013; 7(4): e85-93.
2. Tu JV, Chu A, Donovan LR et al. The Cardiovascular Health in Ambulatory Care Research Team (CANHEART): Using big data to measure and improve cardiovascular health and health care services. *Circ Cardiovasc Qual Outcomes* 2015; 8: 204-212.
3. Tu K, Mitiku TF, Ivers NM et al. Evaluation of electronic medical record administrative data linked database (EMRALD). *Am J Manag Care* 2014; 20(1): e15-e21.
4. Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario: Determination of prevalence and incidence using a validated administrative data algorithm. *Diabetes Care* 2002; 25(3): 512-516.
5. Tu K, Campbell NR, Chen ZL, Cauch-Dudek KJ, McAlister FA. Accuracy of administrative databases in identifying patients with hypertension. *Open Med* 2007; 1(1): e18-e26.
6. Shah B, Chiu M, Amin S, Ramani M, Sadry S, Tu JV. Surname lists to identify South Asian and Chinese ethnicity from secondary data in Ontario, Canada: a validation study. *BMC Med Res Methodol* 2010; 10(1): 42.
7. Therneau TM, Grambsch PM. *Modeling Survival Data: Extending the Cox Model*. New York: Springer Science+Business Media New York; 2000.
8. Bengtsson T, Dribe M. Quantifying the family frailty effect in infant and child mortality by using median hazard ratio (MHR). *Historical Methods* 2010; 43(1): 15-27.
9. Austin PC, Wagner P, Merlo J. The median hazard ratio: a useful measure of variance and general contextual effects in multilevel survival analysis. *Stat Med* 2016; In press. DOI:10.1002/sim.7188.
10. Mahmood SS, Levy D, Vasan RS, Wang TJ. The Framingham Heart Study and the epidemiology of cardiovascular disease: a historical perspective. *The Lancet* 2015; 383(9921): 999-1008.
11. Tu JV, Chu A, Rezai MR et al. The Incidence of major cardiovascular events in immigrants to Ontario, Canada: The CANHEART Immigrant Study. *Circulation* 2015; 132: 1549-1559.
12. Sterne JAC, White IR, Carlin JB et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. *BMJ* 2009; 339: 157-160.
13. Sullivan LM, Massaro JM, D'Agostino RB. Presentation of multivariate data for clinical use: The Framingham Study risk score functions. *Statist Med* 2004; 23(10): 1631-1660.