A NOVEL METHOD USING PRESCRIPTION TREATMENT PATTERNS TO ESTIMATE HEART FAILURE PREVALENCE IN CANADA

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BACKGROUND

Heart failure (HF) is a condition in which the heart cannot pump enough blood to fully meet the oxygen demand of the body[1]. This is due to one of two reasons: the heart cannot fill with enough blood, or the heart cannot pump blood to the rest of the body with enough force[2]. HF has been shown to negatively impact a patient's quality of life by affecting their physical, psychological, social, and economic status[3]. Despite currently available therapies for HF, both mortality and hospitalization remain high[4,5]. Approximately 22,000 deaths per year occur due to HF, comparable to the annual number of deaths from breast, colorectal, prostate and pancreatic cancer combined[6,7]. HF presents a challenge to the healthcare system as it is the most common cause of an inpatient hospitalization in patients aged 65 or older, and prior cost studies demonstrated a substantial cost per HF hospitalization[8,9].

Approximately 600,000 Canadians are diagnosed with HF, however existing Canadian HF prevalence estimates use hospital and, where available, primary care diagnosis from databases which are limited in coverage and availability[10]. As HF has a large impact on the Canadian healthcare system, it is important to have up-to-date prevalence estimates.

OBJECTIVES

The objective of this study is to identify treated Canadian HF patients through the development of a model using retail prescription patterns from a national database to validate and build upon Canadian literature prevalence estimates.

DATA SOURCE

IMS Brogan's (IMS) E360 Canadian Electronic Medical Record (EMR) database:

- A primary care medical record database housing approximately 1,000,000 patient medical records from Ontario – Canada's largest province – including diagnosis, laboratory values, and prescriptions.

IMS Brogan's Longitudinal (LRx) database:

- A national retail pharmacy based dispensed prescription database projected to 100% coverage.

METHODS

Phase 1: Develop and test predictive model

- A Classification and Regression Tree (CART) model predicting HF prescription patterns was constructed using the IMS E360 EMR database.
- As it has been shown that class imbalance between the two cohorts, HF and non-HF, may result in poorer model accuracy, the dataset was balanced by randomly selecting non-HF patients for study inclusion resulting in an approximate 1:1.25 ratio of HF to non-HF patients[11].
- Age, gender, prescriptions, referrals, and physician specialty variables were used in developing the CART model.
- To aid in preventing overfitting, a minimum of 25 patients per final node was required.
- After training, the CART model's HF predictive accuracy was validated using a naïve test dataset of approximately 15% of the HF patients to establish the model's accuracy, positive and negative predictive values (PPV and NPV).
- Clinical opinion was engaged to confirm the rules generated by the statistical model.

Inclusion criteria – Phase 1

- Aged ≥18.
- ≥1 Anatomical Therapeutic Classification (ATC)-1 cardiovascular prescription.
- ≥2 doctor visits between January 2006 - January 2015.
- ≥1 HF diagnosis (International Classification of Diseases – Ninth Revision 428) used to positively identify a heart failure patient.

Phase 2: Application of predictive model to national LRx dataset

- To identify national HF patients, the CART model was applied to the national LRx dataset.
- All patients with >6 months follow-up in the LRx dataset were used to identify the prevalence of treated HF patients by age group.
- The CART model's estimated prevalence of HF was then validated against current Canadian HF literature sources.

Inclusion criteria – Phase 2

- Aged ≥18.
- >6 months follow-up.

RESULTS

Patients and Variables

- 675 HF patients and 840 randomly sampled non-HF patients were included to develop the CART model (Figure 1).
- Age and standardized duration treated with a beta-blocker, ACE/ARB, high-ceiling diuretic, and vasodilator were strong predictors of HF, while physician referral and gender were not.
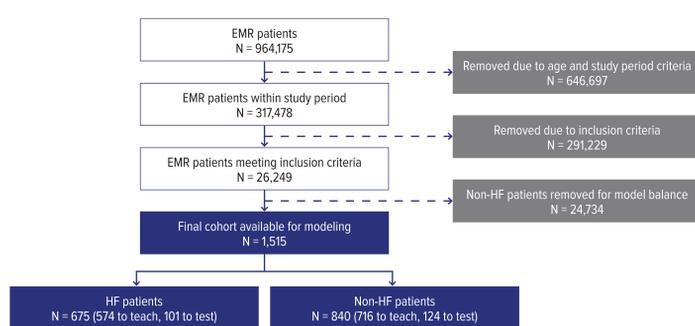
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EMR patients
N = 964,175
    │
    ├──────────────► Removed due to age and study period criteria
    │                N = 646,697
EMR patients within study period
N = 317,478
    │
    ├──────────────► Removed due to inclusion criteria
    │                N = 291,229
EMR patients meeting inclusion criteria
N = 26,249
    │
    ├──────────────► Non-HF patients removed for model balance
    │                N = 24,734
Final cohort available for modeling
N = 1,515
    │
    ├──────────────────────────────┐
HF patients                    Non-HF patients
N = 675 (574 to teach, 101 to test)   N = 840 (716 to teach, 124 to test)
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Figure 1. 1,515 patients were included in the study with approximately 15% reserved as a test set

Model Accuracy

- The model had 80.0% accuracy, 81.1% PPV, and 79.5% NPV when applied against the test dataset.
- Comparatively, a separate study found that a case definition of two HF diagnoses within all primary or secondary records or one HF diagnosis within all hospital records in a year had a positive predictive value of 55.6%[10].
- Of the patients incorrectly predicted as HF when the model was applied to all patients treated with a cardiovascular ATC-1 treatment in the entire EMR dataset, 25.3% had a pre-HF diagnosis (e.g. hypertensive heart disease; old myocardial infarction; mitral insufficiency or stenosis; or pulmonary embolism with infarction).

Prevalence

- The study estimated a 2014 national aged ≥18 HF prevalence of 2.31%, or 657,902 treated patients.

- When applied to patients aged ≥40, the study estimated 648,493 HF treated patients, which aligned well with national literature estimates of 590,416 and 626,199 patients, which are based on diagnosis codes[10,12]. It should be noted that the literature sources did not indicate that the identified patients were treated for their HF or identify the number of patients with HF without a recorded diagnosis.
- We expected a higher prevalence estimate, as compared to literature sources, as the model would identify HF patients in and out of the hospital, while the literature relied mostly on hospital discharge records.
- When the model's prevalence estimates were stratified by patient age group, the majority differed by <0.5% from literature prevalence estimates (Table 1).

Table 1. Total and age group stratified HF prevalence from two literature sources and the HF predictive model

Categories		Blais et. al.[‡ 7]	Statistics Canada[† 7]	HF Predictive Model
HF Population Aged ≥18 in Canada (2014)		N/A	N/A	657,902
HF Prevalence Aged ≥18 in Canada (2014)[10]		N/A	N/A	2.31%
HF Population Aged ≥40 in Canada (2014)		590,416	626,199	648,493
HF Prevalence Aged ≥40 in Canada (2014)[10]		3.3%	3.5%	3.6%
AGE GROUP PREVALENCE	40-44	0.1%	0.1%	0.4%
	45-49	0.4%	0.4%	0.8%
	50-54	0.8%	0.7%	0.9%
	55-59	1.4%	1.4%	1.5%
	60-64	2.5%	2.4%	2.5%
	65-69	4.1%	4.0%	3.9%
	70-74	6.5%	6.2%	4.6%
	75-79	10.2%	9.6%	6.9%
	80-84	15.1%	14.5%	17.5%
	85+	23.4%	22.6%	23.8%

HF Definition:
‡ 1 hospital discharge abstract with an HF diagnosis code in any field or at least 2 physician claims within a 1-year period
† 1 or more hospitalizations with a HF diagnosis code

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CONCLUSION

The model's Canadian HF prevalence estimates closely match values found in literature both in overall and age stratified prevalence. As of 2014, approximately 2.31% of Canadians aged ≥18 are treated for HF. Overall, this study provides a mechanism to calculate detailed prevalence estimates in Canada when applied to retail prescription data.