Measuring Cardiovascular Quality in Primary Care Using Canadian Cardiovascular Harmonization of National Guidelines Endeavour and Electronic Medical Record Data in Ontario

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ABSTRACT

Background: This project uses electronic medical record (EMR) data to assess performance by family physicians (FPs) in the screening for, diagnosis, and management of cardiovascular disease (CVD) and risk factors against national harmonized guidelines by the Canadian Cardiovascular Harmonization of National Guidelines Endeavour (C-CHANGE).

Methods: A retrospective cohort study using the Electronic Medical Record Administrative Data Linked Database (EMRALD) was conducted. A set of quality indicators (QIs) were developed on the basis of the 2014 C-CHANGE guidelines. Twenty-three readily measurable QIs were used to measure performance in the screening for and management of CVD, and to identify gaps in performance.

Results: Our study population consisted of 324 Ontario FPs and 284,959 patients. We assessed 23 of the 74 recommendations. There was variance in rates of adherence to QIs related to screening rates for multiple chronic conditions and cardiovascular disease (CVD) cause a high burden on the Canadian health care system. Four in 5 Canadians have at least 1 risk factor for CVD, which is the leading cause of preventable death and disability nationwide. As the number of Canadians with risk factors for CVD increases, family physicians (FPs) have an increasingly important role and responsibility in its management. In 2014, the Canadian Cardiovascular Harmonized National Guidelines Endeavour (C-CHANGE) updated its guidelines for prevention and management of CVD, which assists health care practitioners by synthesizing the best available evidence.2,3 The C-CHANGE from 2014 is composed of 74 key recommendations selected from more than 400 recommendations sourced from 8 different guideline groups.4-11 Widespread adoption of C-CHANGE guidelines among FPs
CVD. Highest adherence to C-CHANGE guidelines was related to laboratory testing for patients with hypertension and prescription of antihypertensive therapies (≥ 91.4%). Lowest adherence to the guidelines was seen in administration of oral glucose tolerance tests for assessing prediabetic patients (4.4%).

Conclusions: FP EMR data can be used to measure adherence to one-third of the C-CHANGE recommendations. There are varying levels of adherence among the measurable C-CHANGE recommendations, and there is room for improvement in quality of primary care management of CVD in Ontario. There is potential to use EMR data to assess changes to CVD management in FP practice using guidelines if recommendations are quantifiable and measurable.

has the potential to improve quality of cardiovascular care. However, there is little information on how real-world practice reflects the recommendations from C-CHANGE.

In Ontario, more than 80% of FPs have adopted electronic medical records (EMRs) as of the most recent National Physician Survey.12 The increasing uptake of EMR in primary care practices provides opportunities to use routinely collected clinical data to evaluate quality of clinical care. The objectives of our study were to determine the feasibility and to develop methods to assess quality of care related to the screening and management of CVD in primary care in Ontario by using EMR data, and to obtain baseline measures on how closely FPs’ practices aligned with C-CHANGE guideline recommendations at the time of release.

Material and Methods

Data source

We conducted a retrospective cross-sectional study of patients enrolled in (“rostered” to FPs’ practices that contribute data to the Electronic Medical Record Administrative Data Linked Database (EMRALD) held at the Institute for Clinical Evaluative Sciences (ICES).13,14 Ontario has a publicly funded health care system, and individuals have a designated FP to whom they are “rostered.” EMRALD includes all patient chart data entered in the EMR dating back from the time the FP started using Telus Practice Solutions Suite EMR (TELUS Health, Montreal, QC). EMRALD contains longitudinal data as far back as 1986.

Cohort

The study cohort was derived from EMRALD and matched both the physician and patient inclusion and exclusion criteria. To be eligible, the physician had to be using the EMR for at least 18 months before data collection to meet optimal levels of data quality and completeness.13,14 Patients had to have a valid date of birth, to have a valid health insurance number, to be rostered to the FP, and to have made a visit to a participating EMRALD physician in the 36 months preceding data extraction. The data extraction took place between November 2013 and October 2014.

To evaluate the generalizability of our results, we compared the study physicians enrolled in EMRALD with all physicians in Ontario in terms of their sex, age, practice location, place of medical training, primary care model, and practice duration. We compared patients rostered to the study physicians with all patients in Ontario and all patients who were rostered to an FP in Ontario. We compared the groups and described population trends and differences. We analyzed coded data using SAS v9.2 (SAS Institute Inc, Cary, NC) and Microsoft Structured Query Language 2012 (Microsoft Corp, Redmond, WA).

These datasets were de-identified and linked using unique encoded identifiers and analyzed at ICES. Ethics approval was obtained from the institutional review board at Sunnybrook Health Sciences Centre, Toronto.

Quality indicator development

Recommendations from C-CHANGE clinical guidelines were developed into quality indicators (QIs) using Kotter et al.’s15 iterative development process to modify clinical guidelines into measurable QIs. All 74 recommendations from the C-CHANGE guideline were reviewed by the authors to assess measurability within the EMRALD database. A numerator, denominator, exclusion criteria, and time frame (look-back period in which the recommendation was met) were defined for each measurable recommendation. Measurability required availability of relevant clinical information in EMRALD, feasibility to capture the numerator and denominator in structured or semistructured fields, and consistency of data recording among FPs. QIs requiring search of unstructured free-text sources were excluded from the scope of this study.

Unless a specific timeline was specified in the wording of the recommendation, the timeframe and look-back period for searching the record was 18 months for all prescription indicators: 12 months for the most recent blood pressure (BP)
measurements; 18 months for the most recent hemoglobin A1c (HbA1c) results; 3 years for lipid profile tests and liver enzyme test results; and all-time for indicators involving other tests. When searching for body mass index (BMI) in adults, the last recorded BMI was used with no time restriction. For children, the most recent measurement of BMI from the previous 3 years were considered.

Age-based recommendations (ie, tests to be ordered when a patient is older than a certain age) included an additional 12-month buffer period to ensure subjects had adequate time to receive the care upon reaching the defined age. Preliminary data were reviewed by the investigators to ensure that the QIs measured captured the clinical relevance and intention of the recommendation as closely as possible.

Microsoft Structured Query Language was used to search the EMRALD database for inclusion and exclusion terminologies in the database (the patient’s medical history, demographic information, laboratory test results, medication list, problem list, and anthropometric measures). Previously developed EMR algorithms were used to identify the presence of hypertension, diabetes, ischemic heart disease or coronary artery disease (CAD), congestive heart failure, atrial fibrillation, stroke, and chronic kidney disease. Where macrovascular target organ damage was called for, we included CAD and stroke. Where target organ damage was called for, we were able to include CAD, stroke, and chronic kidney disease because we were unable to measure microvascular injuries or complications.

Measurable QIs were assessed for all eligible patients, with look-back periods counting back from the date of data collection. Descriptive statistics of the study population’s demographic and disease characteristics were calculated. The outcomes of interest were the unadjusted proportions of patients receiving guideline adherent care, calculated for each measurable QI.

**Results**

**Population characteristics**

There were 324 physicians who met the study inclusion criteria. Compared with the average Ontario FP, the study FPs were more likely to be female, younger, rurally represented, and medically trained in Canada (Table 1). Together, the study physicians had 284,959 patients rostered to their care. The age distribution, number of aggregated diagnosis groups (a comorbidity measure), and prevalence of chronic conditions were comparable between EMRALD patients and the average rostered patient in Ontario (Table 2). Patients’ medical history had been on the EMR for an average of 4.9 years with a standard deviation of ± 2.8 years. Participating FPs had been using their EMR for an average of 6.1 years (standard deviation ± 3.4 years).

**QI measurement**

Of 74 C-CHANGE QIs, 23 were deemed measurable. QIs were reported according to their order of appearance in the original guideline (see Fig. 1) and are described in the Supplemental Appendix S1. Four QIs were outcome based,
and 19 QIs were process based. Data in the EMR were not sufficient to accurately measure the remaining 51 recommendations because of data availability, high variability in recording among FPs, limited data standards, or subjectivity in interpretation of the recommendation.

High adherence was seen in QIs related to hypertensive patients. More than 90% of patients with hypertension undergo routine laboratory tests completed for blood chemistry potassium, sodium, creatinine, and lipid profile (QI 9a-c, e), but lower adherence rates were seen in other indicated laboratory tests of fasting plasma glucose (QI 9d, 56.9%) and 12-lead electrocardiography (QI 9f, 55.6%).

High adherence was seen for QIs related to receiving appropriate antihypertensive medication (QI 20, 73.2%), including for patients who also had CAD (QI 13, 81.5%; QI 23, 72.5%).

Lipid tests were performed in 79.8% of men aged more than 40 years and women aged more than 50 years with no look-back time limit, and when limited to the past 3 years the proportion of patients tested was 68.7% (QI 7). This proportion was higher at 91.9% in patients with hypertension (QI 9e).

Of all adults (n = 233,081), 67.6% had a height recorded; 77.4% had their weight recorded; 67.3% had both height and weight recorded separately in their medical history; and 67.1% had a BMI calculated in the EMR and recorded in their medical history. Only 2.2% of the population had a waist circumference recorded. Children between the ages of 2 and 17 years had their BMI recorded in the EMR in the past 3 years in 59.7% of the cases (QI 3). Smoking status was recorded for 61.0% of adults (QI 8), of whom 18.8% were current smokers, 26.2% were former smokers, and 54.9% never smoked.

The highest outcome-based indicator was the percentage of patients with diabetes whose last HbA1c reading was on target at less than 7.0% (QI 11, 59.7%). The 3 other outcome-based indicators were low. These consist of adults with a healthy BMI (QI 2, 34.1%); patients reaching HbA1c targets of less than 6.5% (QI 12, 39.4%); and patients with diabetes whose most recently recorded BP readings were on target at less than 130/80 (QI 14, 37.9%).

Patients who were overweight or obese (BMI > 25 kg/m²) represented 64.1% of the adult study population. Of these patients, 63.0% received a liver enzyme test in the last 3 years.

| Table 2. Descriptive characteristics of EMRALD patient population compared with all patients in Ontario |
|---------------------------------------------------------------------------------------------------------------|
| **All Ontario patients, March 31, 2014** | **Ontario rostered patients,* March 31, 2014** | **EMRALD rostered patients, March 31, 2014** |
| **N** | **%** | **N** | **%** | **N** | **%** |
| Total | 14,460,864 | 100 | 10,415,942 | 100 | 284,959 | 100 |
| Sex | | | | | | |
| Female | 7,355,447 | 50.9 | 5,463,075 | 52.5 | 158,049 | 55.5 |
| Male | 7,105,417 | 49.1 | 4,952,867 | 47.6 | 126,910 | 44.5 |
| Age group (y) | | | | | | |
| 0-17 | 2,921,606 | 20.2 | 1,814,188 | 17.4 | 49,412 | 17.0 |
| 18-29 | 2,376,105 | 16.4 | 1,577,711 | 15.2 | 37,250 | 13.1 |
| 30-44 | 2,991,737 | 20.7 | 2,082,918 | 20.0 | 62,168 | 21.8 |
| 45-64 | 4,004,426 | 27.7 | 3,166,848 | 30.2 | 58,435 | 20.6 |
| 65-84 | 1,879,226 | 13.0 | 1,560,857 | 15.0 | 44,278 | 15.5 |
| 85+ | 287,764 | 2.0 | 233,420 | 2.2 | 5606 | 2.3 |
| Income quintile | | | | | | |
| First (lowest) | 2,678,464 | 18.5 | 1,790,531 | 17.2 | 48,522 | 17.0 |
| Second | 2,744,264 | 19.0 | 1,982,573 | 19.0 | 48,969 | 17.2 |
| Third | 2,837,651 | 19.6 | 2,110,409 | 20.3 | 52,400 | 18.4 |
| Fourth | 3,051,515 | 21.1 | 2,309,165 | 22.2 | 60,514 | 21.2 |
| Fifth (highest) | 2,873,671 | 19.9 | 2,165,980 | 20.8 | 72,380 | 25.4 |
| Missing | 276,299 | 1.9 | 57,284 | 0.6 | 2174 | 0.8 |
| Rurality | | | | | | |
| Nonrural area | 12,820,125 | 88.7 | 9,221,469 | 88.5 | 226,856 | 79.6 |
| Rural area | 1,580,053 | 10.9 | 1,187,726 | 11.4 | 57,949 | 20.3 |
| Missing | 60,686 | 0.4 | 6747 | 0.1 | 154 | 0.1 |
| No. of ADGs | | | | | | |
| 0 ADGs | 1,313,256 | 9.1 | 725,231 | 7.9 | 14,456 | 5.1 |
| 1-4 ADGs | 6,441,104 | 44.5 | 4,879,393 | 46.9 | 145,403 | 51.0 |
| 5-9 ADGs | 4,765,921 | 33.0 | 3,908,790 | 37.5 | 102,827 | 36.1 |
| 10+ ADGs | 1,024,037 | 7.1 | 859,854 | 8.3 | 20,985 | 7.4 |
| Missing data | 916,546 | 6.3 | 42,674 | 0.4 | 1288 | 0.5 |
| Presence of condition | | | | | | |
| Previous AMI | 174,801 | 1.2 | 148,780 | 1.4 | 3933 | 1.4 |
| Asthma | 1,990,635 | 13.8 | 1,571,629 | 15.1 | 39,356 | 13.8 |
| CHF | 207,357 | 1.4 | 174,620 | 1.7 | 4963 | 1.7 |
| COPD | 835,575 | 5.8 | 704,907 | 6.8 | 19,173 | 6.7 |
| Diabetes | 1,305,025 | 9.0 | 1,099,386 | 10.7 | 26,481 | 9.3 |
| Hypertension | 2,887,490 | 20.0 | 2,468,841 | 23.7 | 61,488 | 21.6 |
| Mental health | 2,536,179 | 17.5 | 2,076,262 | 19.9 | 58,951 | 20.7 |
| Any chronic condition | 4,650,553 | 44.6 | 5,295,718 | 50.8 | 140,053 | 49.2 |

ADG, Aggregated Diagnosis Groups; AMI, acute myocardial infarction; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; EMRALD, Electronic Medical Record Administrative Data Linked Database.

* Rostered to an FP as the primary responsible physician.
When narrowed down to only patients who were classified as “overweight” (BMI 25-30 kg/m²), liver enzyme tests were completed for 59.9% of patients, compared with 66.5% of patients classified as “obese” with a BMI > 30 kg/m².

The lowest QI adherence rates were seen for 2 related recommendations, QIs 5 and 6: screening for impaired glucose tolerance or diabetes using 2-hour plasma glucose (2hPG) testing for patients who have plasma HbA1c results of 6.0% to 6.4% or 5.5% or 5.9%, respectively. We found that 2hPG tests were performed in these patients at 9.4% (QI 5) and 4.4% (QI 6) of the time, respectively.

**Interpretation**

Our retrospective cross-sectional study using primary care EMR data in Ontario provides baseline measures and practice-based perspective on how CVD is screened, tested, and managed among FPs in Ontario at the time of study. The EMRALD population is similar to that of the entire province, indicating generalizability. Our data show a wide variation in practice with some areas of high concordance to guidelines but also substantial gaps in management of CVD. This is consistent with previous research that highlights gaps in treatment and management of vascular risk factors, particularly for patients with comorbidities such as diabetes.25-28 While most studies focus on one area of vascular management or adherence to specific treatment type,29-31 our QIs provide insights on multiple aspects of CVD and can give guidance on what areas of vascular management have wider gaps than others.29

Only 23 of the 74 2014 C-CHANGE guidelines recommendations could be developed into QIs. Most wording of the recommendations had not been developed considering the feasibility of measuring it as a QI. The way in which data are recorded into EMRs by FPs (ie, free-text) limits the measurability. For example, the guideline recommended that patients with hypertension should have their left ventricular ejection fraction (LVEF) measured by echocardiogram or nuclear imaging. Upon searching for the text related to LVEF in the record, we found 14,394 of 48,956 patients with hypertension (29.4%) had “LVEF” or “echo” in their charts. Because of nonuniform use of terminology in the EMR, we were not confident in the measurability of this QI and omitted it.

Risk factors associated with patient ethnicity and race were omitted in our calculation. Waist circumference

![Figure 1. Adherence to Canadian Cardiovascular Harmonization of National Guidelines Endeavour (C-CHANGE) quality indicators (QIs) in the Electronic Medical Record Administrative Data Linked Database (EMRALD) population. 2hPG, 2-hour plasma glucose; A1c, haemoglobin A1c; ACE, angiotensin-converting enzyme; ARB, angiotensin-receptor blocker; ASA, acetylsalicylic acid; BMI, body mass index; BP, blood pressure; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CCB, calcium channel blocker; CKD, chronic kidney disease; ECG, electrocardiogram; EMR, electronic medical record; FPG, fasting plasma glucose; HIV, human immunodeficiency virus; IGT, impaired glucose tolerance; OGTT, oral glucose tolerance test; PCI, percutaneous coronary intervention; PO, per os (by mouth); SBP, systolic BP. *Denotes the QI is an outcome-based indicator (QI 2, 11, 12, 14). The remaining indicators are process-based indicators.](image-url)
1. % of adults with a BMI ≥ 25.0, with a liver test [Lookback: 3 years]
2. % of adults with BMI between 18.5 and 24.9 [Lookback: All time]
3. % of patients 2-17 years with BMI in the EMR [Lookback: 3 years]
4. % of patients ≥ 41 years and no diabetes, with an FPG or HbA1c test in the past 3 years [Lookback: 3 years]
5. % of patients ≥ 18 with FPG 6.1-6.9 and/or HbA1c 6.0%-6.4%, and a 2hPG test [Lookback: All time]
6. % of patients ≥ 18 with FPG 5.6-6.0 and/or HbA1c 5.5%-5.9%, and a 2hPG test [Lookback: All time]
7. % of patients with hypertension with a most recent BP above target (BP Target ≤ 140/90 if patient < 80 years, BP Target ≤ 150/90 if patient ≥ 80 years, BP Target ≤ 130/80 if patient = diabetes mellitus) and a prescription for at least two first line anti-hypertensive drugs [Lookback: 18 months]
8. % of patients ≥ 80 years with NO diabetes, CAD or stroke and an average systolic BP ≥ 160, and on antihypertensive therapies [Lookback: 18 months]
9. % of patients with diabetes mellitus, with an HbA1c ≤ 7.0% [Lookback: 18 months]
10. % of patients with diabetes mellitus, with an HbA1c ≤ 6.5% [Lookback: 18 months]
11. % of patients with diabetes mellitus, with a FBG ≤ 130/80 [Lookback: 18 months]
12. % of patients with diabetes mellitus, with an HbA1c ≤ 6.5% [Lookback: 18 months]
measured in the assessment of healthy weight (QI 1) were also omitted because of the low recording of waist circumference (5125 of 233,081 adult patients, 2.2%), and this QI focused instead on BMI.

Urinalysis was recommended as one of the routine tests to be completed for QI 9 but was excluded in the modified QI. Urinalysis is not well recorded in the EMR because of how urine dip test or urinalysis is performed in the clinic and recorded in the EMR. Only 324 of 48,965 (< 1%) adult patients with hypertension had a record of urinalysis in the structured laboratory test portion of the EMR.

Sixteen recommendations related to patient diet, lifestyle, and physical exercise were omitted because they were not routinely recorded in the EMR in a structured or semistructured fashion. This study demonstrates the potential to provide feedback to guideline developers on what is needed to allow guideline recommendations to become measurable as QIs. Furthermore, the limitations of measurability may be of interest to EMR providers and developers of EMR data standards. These limitations highlight opportunities to improve data standardization through data structure or user guidance. Standardized data and measurability of QIs are necessary for monitoring and continuously improving quality of care.

Several of the highest adherence indicators were related to the provision of appropriate antihypertensive medication for patients with comorbidities. These data are consistent with the awareness treatment and control of hypertension in Canada. An example of how the wording of a recommendation could be adapted easily to accommodate a QI is the lipid test (QI 7), which did not specify how frequently the test should be done. Although lipids had been done at some point, the rate in a more constrained time period was much less Reassuringly though, among patients with hypertension, the rates of lipid testing were much higher (QI 9e, 91.9%), suggesting that clinicians were responding to perceived higher risk in these patients.

The finding that statin use among patients with diabetes aged more than 40 years was 58.8% (QI 18) could indicate a significant treatment gap. However, this specific recommendation did not indicate if a statin should be used if their cholesterol is higher than a specific threshold. We found a low rate of antiplatelets for patients with CAD (QI 17, 43.4%). This may be reflective of the over-the-counter availability of acetylsalicylic acid and consequent inadequate documentation of acetylsalicylic acid use in the EMR. The majority of the outcome indicators were lower than 40%. Of concern, only 37.9% of patients with diabetes had a most recent BP measurement that was less than 130/80 mm Hg (QI 14). Furthermore, the majority of the adult population was overweight or obese. Only 34.1% of patients’ BMI was in the “normal” range of 18.5 to 24.9 (QI 2), consistent with the literature.

Limitations

Modifying practice guidelines to measurable QIs requires specific and quantified actions to be defined, and for whom they should be taken. As such, not every recommendation could be measured in the EMR. Because of each recommendation criterion, the denominator size is different in each QI and a composite score based on all the QIs could not be developed.

The interpretation of QI adherence rates should consider the context of the recommendation. The lowest QIs were related to 2hPG oral glucose tolerance test (QI 5 and 6), a time-consuming and costly, but more sensitive diagnostic test for diabetes for certain patient groups. For the A1c range of 5.5% to 6.0% (QI 6), the evidentiary base to conduct a 2hPG test is limited. We would suggest a review of this recommendation and its public health benefit because the tests are seldom being done in family practice. We found that with an ambiguous result suggesting prediabetes, physicians were reordering HbA1c or fasting plasma glucose tests instead of ordering the 2hPG.

Overall, pharmacologic therapy QIs showed higher adherence. For the recommendations that specify first-line and subsequent second-line or combination therapies, we presented the proportion of patients who had any of (QI 20) or 2 (QI 21) of the indicated drug therapies. It was not possible to precisely determine if 2 prescriptions provided in the same timeframe in the patient’s record meant that they were being taken simultaneously for combination therapy or if the physician prescribed a new drug without documenting the discontinuation of the previous drug. Additional work is required to fully assess the chronological sequencing of pharmacotherapy patterns.

This study was only performed on a convenience sample of FPs in Ontario. Findings may not be generalizable to the rest of Canada but can be used as a point of comparison for other studies. Likewise, the results reflect practice patterns as of the time of guideline release and may not be reflective of current practice. However, the results provide a baseline measure with which different time periods can be compared to identify changes in adherence and practice over time, as well as to identify the gaps in care and areas that are most in need of improvement.

Conclusions

This project is a preliminary demonstration showing feasibility to measure FP performance based on C-CHANGE and EMR data. On the basis of these study results, it will be possible to use EMR data to identify further patterns of care for the diagnosis and management of CVDs and identify factors that affect clinical practice. This project also demonstrates that QI data have the potential to be used to feedback to guidelines groups on the wording of recommendations and the level of adherence when assessing a recommendation’s significance or practicality. The value of the QI may suffer from variations in collection and recording of EMR data. This study should be able to help guidelines developers provide more implementable and measurable recommendations that better lend themselves to continuous improvement. This baseline assessment of FP practice performance can be compared prospectively for evaluation of different interventions and models of care on CVD management. The study demonstrates that databases such as EMRALD can be used to track changes in performance, patient adherence, and improvements to patient outcomes.

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**Data Statement**

The individual-level data underlying this study are based on records generated from the administration of Ontario’s publicly funded health system. ICES has a special designation under Ontario’s Personal Health Information Protection Act to use these data in studies that evaluate health care delivery and outcomes. This designation is granted by the Information and Privacy Commissioner of Ontario, and is contingent on a triennial review and ongoing oversight of the privacy practices at ICES. A variety of measures are deployed to protect the personal health information entrusted to ICES and, under the Personal Health Information Protection Act (Ontario Regulation 329/04), the underlying data are legally not allowed for public repository.

Although data-sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the Canadian Institute for Health Information. However, the analyses, conclusions, opinions, and statements expressed herein are those of the authors and not necessarily those of Canadian Institute for Health Information. Drs Ivers, Jaakkimainen, Butt, and Tu are supported by research scholar awards from the Department of Family and Community Medicine, University of Toronto.

**Disclosures**

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit CJC Open at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2018.11.003.