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Original Article

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 **C**anadian **C**ardiovascular **H**armonization of **N**ational **G**uidelines **E**ndeavour (C-CHANGE).

Methods: A retrospective cohort study using the **E**lectronic **M**edical **R**ecord **A**dministrative **D**ata **L**inked **D**atabase (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

RÉSUMÉ

Introduction : Ce projet consiste à utiliser les données de dossiers médicaux électroniques (DME) pour faire l'évaluation de la performance des médecins de famille (MF) dans le dépistage, le diagnostic et la prise en charge des maladies cardiovasculaires (MCV) et des facteurs de risque par rapport aux lignes directrices nationales harmonisées de l'Initiative canadienne d'harmonisation des lignes directrices nationales (C-CHANGE pour *Canadian Cardiovascular Harmonization of National Guidelines Endeavour*).

Méthodes : Nous avons mené une étude de cohorte rétrospective à l'aide de la banque de données EMRALD (*Electronic Medical Record Administrative data Linked Database*). Nous avons élaboré un ensemble d'indicateurs de qualité (IQ) à partir des lignes directrices de la C-CHANGE de 2014. Nous avons utilisé 23 IQ facilement mesurables pour évaluer la performance dans le dépistage et la prise en charge des MCV, et pour déterminer les lacunes de la performance.

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.[1] 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 **C**anadian **C**ardiovascular **H**armonized **N**ational **G**uidelines **E**ndeavour (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[3] 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

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Ethics Statement: Ethics approval was obtained from the institutional review board at Sunnybrook Health Sciences Centre, Toronto.

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CVD. Highest adherence to C-CHANGE guidelines was related to laboratory testing for patients with hypertension and prescription of antihypertensive therapies ($\geq$ 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.

Résultats : La population de notre étude consistait en 324 MF de l'Ontario et 284 959 patients. Nous avons évalué 23 des 74 recommandations. Il y avait un écart dans les taux d'observation des IQ liés aux taux de dépistage des MCV. La plus grande observation des lignes directrices de la C-CHANGE était liée aux épreuves de laboratoire des patients atteints d'hypertension et ayant des ordonnances d'antihypertenseurs ($\geq$ 91.4%). La plus faible observation des lignes directrices était notée dans l'administration des épreuves d'hyperglycémie provoquée par voie orale lors de l'évaluation des patients prédiabétiques (4,4 %).

Conclusion : Les données des DME des MF peuvent être utilisées pour mesurer l'observation du tiers des recommandations de la C-CHANGE. Il existe des niveaux variés d'observation des recommandations mesurables de la C-CHANGE, et il y a une marge d'amélioration de la qualité de la prise en charge en soins primaires des MCV en Ontario. Il est possible d'utiliser les données des DME pour faire l'évaluation des changements dans la prise en charge des MCV dans la pratique des MF à l'aide des lignes directrices si les recommandations sont quantifiables et mesurables.

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 **E**lectronic **M**edical **R**ecord **A**dministrative Data **L**inked **D**atabase (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.'s[15] 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)

Table 1. Generalizability of study physicians from the EMRALD

	All Ontario physicians, March 31, 2014		EMRALD cohort physicians, March 31, 2014	
	n	%	n	%
Total	8219	100	324	100
Sex				
Female	3621	44.1	180	55.6
Male	4598	56.0	144	44.4
Age group (y)				
1: < 35	843	10.3	55	17.0
2: 35-44	1667	20.3	106	32.7
3: 45-54	2342	28.5	81	25.0
4: 55-79	3367	41.0	82	25.3
Rurality				
Rural	388	4.7	34	10.5
Suburban	1192	14.5	47	14.5
Urban	6639	80.8	243	75.0
Medical training location				
Canada	5722	69.6	294	90.7
International (including US)	2497	30.4	30	9.3
≥ 25% bills from ED				
No	7998	97.3	302	93.2
Yes	221	2.7	22	6.8
Primary care reform model				
FHG or FHN	2605	31.7	27	8.3
FHO	3773	45.9	286	88.3
No model	1343	16.3	0	0
Other	498	6.1	11	3.4
	Mean	SD	Mean	SD
Age as of March 31, 2014	51.2	11.8	46.1	10.8
Years in practice	17.7	10.4	15.7	9.6
Years since graduation	25.2	12.3	19.8	11.3

ED, emergency department; EMRALD, **E**lectronic **M**edical **R**ecord **A**dministrative Data **L**inked **D**atabase; FHG, Family Health Group; FHN, Family Health Network; FHO, Family Health Organization; SD, standard deviation.

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,[16] diabetes,[17,18] ischemic heart disease or coronary artery disease (CAD),[19] congestive heart failure, atrial fibrillation,[20] stroke,[21] and chronic kidney disease.[22] 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[23,24] (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,

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	17.3
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	3,146,848	30.2	85,345	30.0
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	6506	2.3
Income quintile						
First (lowest)	2,678,464	18.5	1,790,531	17.2	48,522	17.0
Second	2,743,264	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	1,109,386	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	6,450,553	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, **E**lectronic **M**edical **R**ecord **A**dministrative Data **L**inked **D**atabase.

*Rostered to an FP as the primary responsible physician.

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/m^2) represented 64.1% of the adult study population. Of these patients, 63.0% received a liver enzyme test in the last 3 years

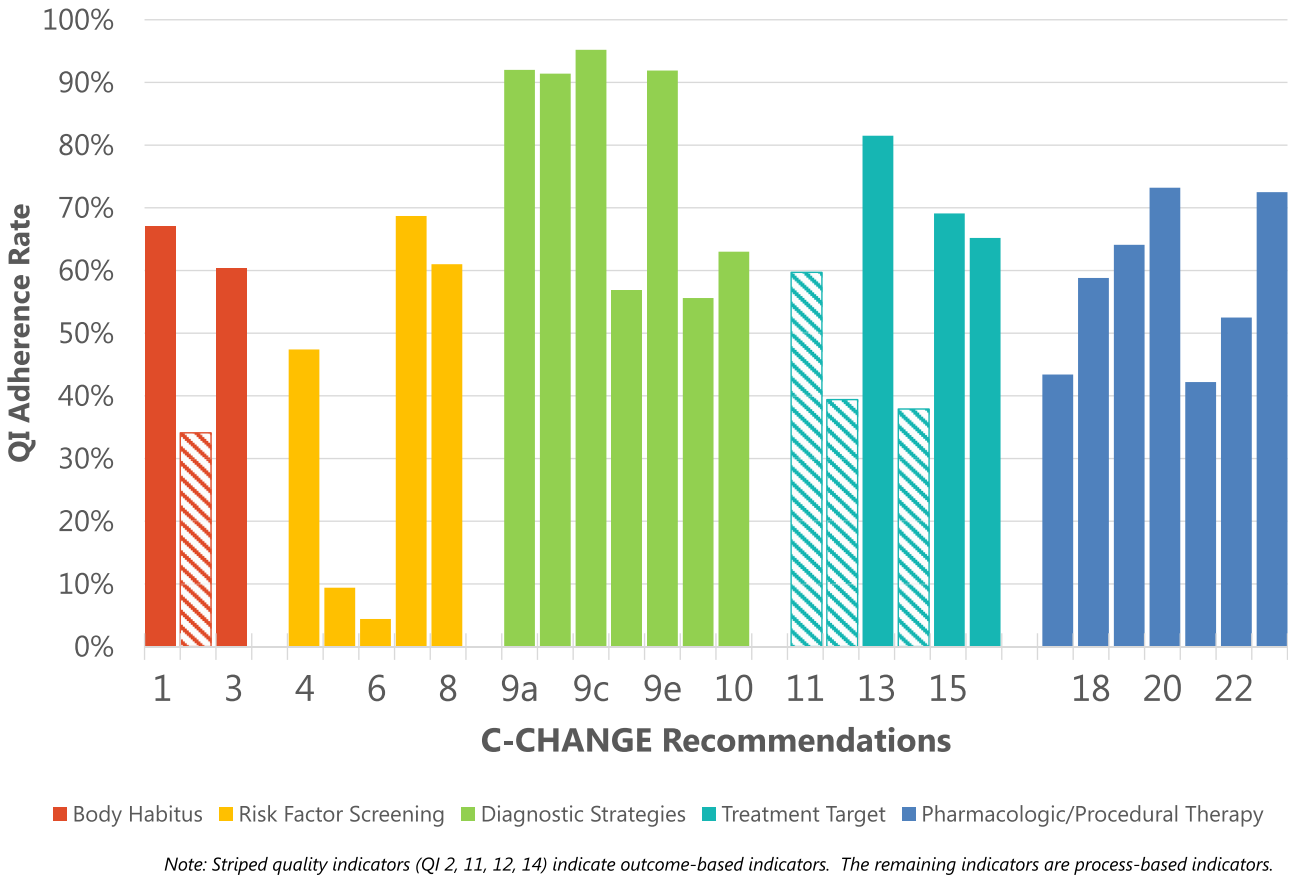

Figure 1. Adherence to Canadian Cardiovascular Harmonization of National Guidelines Endeavour (C-CHANGE) quality indicators (QIs) in the Electronic Medical Record Administrative Data Linked Database (EMRALD) population. 2hPG, 2-hour plasma glucose; A1c, haemoglobin A1c; ACE, angiotensin-converting enzyme; 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.

(QI 10). When narrowed down to only patients who were classified as "overweight" (BMI 25-30 kg/m^2), liver enzyme tests were completed for 59.9% of patients, compared with 66.5% of patients classified as "obese" with a BMI $>$ 30 kg/m^2.

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

Body Habitus

1. **% of adults with a body mass index (BMI) recorded [Lookback: All time]** Height, weight and waist circumference should be measured and BMI calculated for all adults.
2. *** % of adults with BMI between 18.5 and 24.9 [Lookback: All time]** Maintenance of a healthy body weight (BMI 18.5 to 24.9 kg/m^2, and waist circumference less than 102 cm for men and less than 88 cm for women) is recommended for non-hypertensive individuals to prevent hypertension and for hypertensive patients to reduce blood pressure. All overweight hypertensive individuals should be advised to lose weight.
3. **% of patients 2-17 years with BMI in the EMR [Lookback: 3 years]** Measuring body mass index (BMI = weight[kg]/height[m]^2) in children aged two to seventeen years.

Risk Factor Screening

4. **% of patients ≥ 41 years and no diabetes, with an FPG or HbA1c test in the past 3 years [Lookback: 3 years]** Screening for diabetes using FPG and/or A1c should be performed every 3 years in individuals ≥ 40 years of age or at high risk using a risk calculator. More frequent and/or earlier testing with either FPG and/or A1c or 2hPG in a 75 g OGTT should be considered in those at very high risk using a risk calculator or in people with additional risk factors for diabetes.
5. **% of patients ≥ 18 with FPG 6.1-6.9 and/or HbA1c 6.0%-6.4%, and a 2hPG test [Lookback: All time]** Testing with 2hPG in a 75 g OGTT should be undertaken in individuals with FPG 6.1-6.9 mmol/L and/or A1c 6.0%-6.4% in order to identify individuals with IGT or diabetes.
6. **% of patients ≥ 18 with FPG 5.6-6.0 and/or HbA1c 5.5%-5.9%, and a 2hPG test [Lookback: All time]** Testing with 2hPG in a 75 g OGTT may be undertaken in individuals with FPG 5.6-6.0 mmol/L and/or A1c 5.5%-5.9% and ≥ 1 risk factor(s) in order to identify individuals with IGT or diabetes.
7. **% of male and ≥ 41 years or female ≥ 51 years or have diabetes mellitus, hypertension, CKD, currently smoke or are overweight, who have a lipid test [Lookback: 3 years]** Screening of plasma lipids is recommended in adult men > 40 and women > 50 years of age or postmenopausal. Screen lipids at any age for: smoking, diabetes, hypertension, overweight, rheumatoid arthritis, systemic lupus erythematosis, psoriatic arthritis, ankylosing spondylitis, inflammatory bowel disease, chronic obstructive pulmonary disease, chronic HIV infection, CKD, abdominal aneurysm and erectile dysfunction. Consider screening individuals of First Nations or South Asian ancestry at an earlier age.
8. **% of adult patients with smoking status recorded in the EMR [Lookback: All time]** All patients/clients should be asked if they use tobacco and should have their tobacco use status documented on a regular basis. All physicians, nurses and other health care workers should strongly advise all patients who smoke to quit and provide brief advice.

Diagnostic Strategies

9. **a. % of patients with hypertension, with a test for potassium; b. % of patients with hypertension with a test for sodium; c. % of patients with hypertension with a test for creatinine; d. % of patients with hypertension, with a test for FBG; e. % of patients with hypertension with lipid profile test; f. % of patients with hypertension with a test for ECG [Lookback: all time]** Hypertension-Routine laboratory tests that should be performed for the investigation of all patients with hypertension include: urinalysis; blood chemistry ([9a] potassium, [9b] sodium and [9c] creatinine); (9d) fasting blood glucose; (9e) fasting serum total cholesterol and high density lipoprotein cholesterol, low density lipoprotein cholesterol and triglycerides; and standard (9f) 12-lead electrocardiography
10. **% of patients with a BMI ≥ 25.0, with a liver test [Lookback: 3 years]** Additional investigations, such as liver enzyme tests, urinalysis and sleep studies (when appropriate), to screen for and exclude other common overweight/obesity-related health problems.

Treatment Targets

11. *** % of patients with diabetes mellitus, with an HbA1c ≤ 7.0% [Lookback: 18 months]** Therapy in most individuals with type 1 or type 2 diabetes should be targeted to achieve an A1c ≤ 7.0% in order to reduce the risk of microvascular and, if implemented early in the course of disease, macrovascular complications.
12. *** % of patients with diabetes mellitus, with an HbA1c ≤ 6.5% [Lookback: 18 months]** An A1c ≤ 6.5% may be targeted in some patients with type 2 diabetes to further lower the risk of nephropathy and retinopathy, but this must be balanced against the risk of hypoglycemia.
13. **% of patients with CAD or stroke and an average systolic BP ≥ 140 in the last year with antihypertensive therapy [Lookback: 18 months]** Antihypertensive therapy should be strongly considered if systolic blood pressure readings average 140 mmHg or higher in the presence of macrovascular target organ damage.
14. *** % of patients with diabetes with most recent BP < 130/80 [Lookback: 1 year]** Persons with diabetes mellitus should be treated to attain systolic blood pressures of less than 130 mmHg and diastolic blood pressures of less than 80 mmHg. (These target blood pressure levels are the same as the blood pressure treatment thresholds.)
15. **% of hypertensive patients with CAD or stroke with an average diastolic BP > 90 over the past 12 months, and on antihypertensive therapy [Lookback: 18 months]** Antihypertensive therapy should be strongly considered if diastolic blood pressure readings average 90 mmHg or higher in the presence of macrovascular target organ damage or other independent cardiovascular risk factors.
16. **% of patients ≥ 80 years with NO diabetes, CAD or stroke and an average systolic BP ≥ 160, and on antihypertensive therapies [Lookback: 18 months]** In the very elderly (age 80 years and older), who do not have diabetes or target organ damage, the SBP threshold for initiating drug therapy is ≥ 160 mmHg and the SBP target is <150 mmHg.

Pharmacologic/Procedural Therapy

17. **% of patients with CAD and a prescription for anti-platelet agents [Lookback: 18 months]** Patients with documented coronary artery disease, in the absence of specific contraindications or documented intolerance, should be treated with anti-platelet agents; for patients with a history of chronic stable angina, remote PCI, or CABG, ASA (75 mg PO to 162 mg) PO daily indefinitely
18. **% of patients ≥ 40 years with diabetes and a prescription for statin therapy [Lookback: 18 months]** Statin therapy should be used to reduce cardiovascular risk in adults with type 1 or type 2 diabetes with any of the following features: Age ≥40 years
19. **% of patients ≥ 55 years with diabetes and a prescription for ACE inhibitors or ARBs [Lookback: 18 months]** ACE inhibitor or ARB, at doses that have demonstrated vascular protection, should be used to reduce cardiovascular risk in adults with type 1 or type 2 diabetes with any of the following: Age ≥ 55 years
20. **% of patients with hypertension and a prescription for at least one of these kinds of drugs for thiazide diuretics; β-blockers; ACE inhibitors; CCBs or ARBs [Lookback: 18 months]** Initial therapy should consist of monotherapy with a thiazide diuretic; a β-blocker (in patients younger than 60 years); an ACE inhibitor (in nonblack patients); a long-acting CCB; or an ARB. If there are adverse effects, another drug from this group should be substituted. Hypokalemia should be avoided in patients treated with thiazide diuretic monotherapy.
21. **% 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 agents [Lookback: 18 months]** Combination therapy using two first-line agents may also be considered as initial treatment of hypertension if systolic blood pressure is 20 mmHg above target or if diastolic blood pressure is 10 mmHg above target.
22. **% of patients with CAD, diabetes mellitus, hypertension or CKD and a prescription for ACE or ARBs [Lookback: 18 months]** For persons with cardiovascular or kidney disease, including microalbuminuria or with cardiovascular risk factors in addition to diabetes and hypertension, an ACE inhibitor or an ARB is recommended as initial therapy.
23. **% of patients with hypertension and CAD and a prescription for ACE or ARBs [Lookback: 18 months]** An ACE inhibitor or ARB is recommended for most patients with hypertension and coronary artery disease

Figure 1. Continued

measurements 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.[32] 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.[33,34]

Limitations

Modifying practice guidelines to measurable QIs requires specific and quantified actions to be defined, and for whom they should be taken.[35] 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.[34-41] For the A1c range of 5.5% to 6.0% (QI 6), the evidentiary base to conduct a 2hPG test is limited.[42,43] 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 work 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 authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

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.