CJC Open 1 (2019) 198–205

Quality Improvement

An Update on the Development and Feasibility Assessment of Canadian Quality Indicators for Atrial Fibrillation and Atrial Flutter

Roopinder K. Sandhu, MD, MPH,[a] Stephen B. Wilton, MD, MSc,[b] Jennifer Cruz, NP-Adult, MN,[c] Clare L. Aztema, MD, MSc,[d] Kendra MacFarlane, MSc,[e] Robert McKelvie, MD, PhD,[f] Laurie Lambert, PhD,[g] Kathy Rush, PhD, RN,[h] Rodney Zimmerman, MD,[i] Garth Oakes, PhD,[j] Mark Deyell, MD,[k] D. George Wyse, MD, PhD,[b] Jafna L. Cox, MD,[l] and Allan Skanes, MD[m]

[a] *Department of Medicine, Mazankowski Alberta Heart Institute, University of Alberta, Edmonton, Alberta, Canada;* [b] *Department of Cardiac Sciences, Libin Cardiovascular Institute of Alberta, University of Calgary, Calgary, Alberta, Canada;* [c] *Cardiac Arrhythmia Service, St Michael's Hospital, Toronto, Ontario, Canada;* [d] *Department of Emergency Medicine, Sunnybrook Health Sciences Centre, Toronto, Ontario, Canada;* [e] *Canadian Cardiovascular Society, Ottawa, Ontario, Canada;* [f] *Department of Medicine, Population Health Research Institute, McMaster University, London, Ontario, Canada;* [g] *Institut national d'excellence en santé et en services sociaux, Montreal, Quebec, Canada;* [h] *Faculty of Health and Social Development ART, School of Nursing, University of British Columbia, Kelowna, British Columbia, Canada;* [i] *Regina General Hospital, Regina, Saskatchewan, Canada;* [j] *CorHealth Ontario, Toronto, Ontario, Canada;* [k] *Department of Medicine, Division of Cardiology, University of British Columbia, British Columbia, Canada;* [l] *Departments of Medicine and of Community Health and Epidemiology, Dalhousie University, Halifax, Nova Scotia, Canada;* [m] *Department of Medicine, London Heart Institute, University of Western Ontario, London, Ontario, Canada*

ABSTRACT

Background: In 2010, the Canadian Cardiovascular Society Atrial Fibrillation/Atrial Flutter (AF/AFL) quality indicator (QI) working group was established to develop QIs and assess feasibility of measurement. After extensive review, 3 priority QIs were selected. However, none were measurable at a national level.

Methods: The working group reconvened in 2017 to review the relevance of previously proposed QIs, identify opportunities to develop new QIs, and propose an initial strategy for measuring and reporting.

Results: Two additional priority QIs were added to the previous 3: proportion of patients with nonvalvular (NV) AF/AFL sorted by stroke risk stratum and annual rate of hospitalization for a new heart failure diagnosis. An environmental scan was undertaken to determine the potential of existing databases to provide national and provincial estimates. On the basis of validated administrative codes, the Canadian

RÉSUMÉ

Contexte : En 2010, le groupe de travail des indicateurs de qualité (IQ) de la Société canadienne de cardiologie sur la fibrillation auriculaire (FA) et le flutter auriculaire (FLA) a été mis sur pied pour élaborer des IQ et évaluer la faisabilité d'utiliser ces IQ comme outils de mesure. Après un examen approfondi, trois IQ prioritaires ont été sélectionnés, mais aucun n'a pu être mesuré à l'échelle nationale.

Méthodologie : Le groupe de travail s'est réuni à nouveau en 2017 afin d'examiner la pertinence des IQ proposés au départ, de recenser des occasions d'élaborer de nouveau IQ et de proposer une stratégie initiale de mesure et de production de rapports à cet égard.

Résultats : Deux IQ prioritaires supplémentaires ont été ajoutés aux trois premiers : la proportion de patients atteints de FA non valvulaire (FANV) ou de FLA ayant fait l'objet d'un tri selon la strate de risque d'AVC et le taux annuel d'hospitalisations attribuables à un nouveau

Atrial fibrillation (AF), the most common sustained cardiac rhythm disorder,[1] is a critical public health issue. The prevalence of AF is rapidly rising[2,3] and is projected to double over the next 30 years because of an ageing population and increasing adverse lifestyle and cardiovascular risk factors that cause AF.[4] Clinically, the consequences associated with AF are significant with a 5-fold increase risk for ischemic stroke, a 3-fold increase risk in developing heart failure (HF), and a near doubling in mortality.[5-7] One of the most devastating sequelae of AF, stroke, is preventable with use of oral anticoagulation (OAC) therapy that is effective and safe, yet is underused.[8,9] The healthcare costs due to AF are high; an estimated $815 million Canadian dollars occur from hospitalizations alone annually.[10] Thus, the importance of understanding the quality of AF care in Canada is critically important to ensure

Received for publication April 15, 2019. Accepted May 21, 2019.

Ethics Statement: Research reported has adhered to the relevant ethical guidelines.

Corresponding author: Dr Roopinder K. Sandhu, 8440-112 St, 2C2 WMC, Edmonton, Alberta T6G 2B7, Canada. Tel.: +1-780-407-6827; fax: +1-780-407-6452.

E-mail: rsandhu2@ualberta.ca

See page 205 for disclosure information.

https://doi.org/10.1016/j.cjco.2019.05.007

Institute for Health Information discharge abstract database can be used for inpatients. In collaboration with the Canadian Primary Care Sentinel Surveillance Network, 2 of the 5 QIs can be assessed in outpatients (patients with NVAF/AFL sorted by stroke risk stratum and high risk for stroke NVAF/AFL receiving oral anticoagulation). Stroke prevention therapy can be further measured in selected provinces with linked databases including prescriptions.

Conclusions: This first step could provide a better initial understanding of the quality of AF/AFL care in Canada, but important gaps in the meaningful measurement of QIs remain. The AF/AFL QI working group has limited capacity to make progress without national level leadership and the resources to support data aggregation, data analysis, and pan-Canadian reporting.

diagnostic d'insuffisance cardiaque. Une analyse de l'environnement a été réalisée afin de déterminer si les bases de données existantes pouvaient fournir des estimations nationales et provinciales. Dans le cas de patients hospitalisés, on peut utiliser la Base de données sur les congés des patients de l'Institut canadien d'information sur la santé en se servant de codes administratifs validés. Dans le cas de patients non hospitalisés (patients atteints de FANV/FLA, triés par strate de risque, exposés à un risque élevé d'AVC en raison d'une FANV ou d'un FLA et recevant une anticoagulation orale), on peut mesurer deux des cinq IQ, en collaboration avec le Réseau canadien de surveillance sentinelle en soins primaires. Le traitement préventif de l'AVC peut continuer à faire l'objet de mesures dans certaines provinces grâce aux bases de données interreliées, comme les bases de données sur les ordonnances.

Conclusions : Cette première étape a permis d'obtenir une meilleure compréhension initiale de la qualité de la prise en charge de la FA et du FLA au Canada, mais d'importantes lacunes restent à combler pour rendre pertinente la mesure des IQ. Le groupe de travail des IQ sur de la FA et le FLA n'a pas toutes les capacités requises pour réaliser des progrès en l'absence de leadership national et de ressources permettant de soutenir le regroupement et l'analyse des données, ainsi que la production de rapports à l'échelle pancanadienne.

that all Canadians are receiving optimal care, that costs are contained, and that there is strong evidence to guide how resources are allocated.

To address this need, the Canadian Cardiovascular Society (CCS) established an AF/Atrial Flutter (AFL) quality indicator (QI) working group in 2010, tasked with developing and selecting QIs and performing a feasibility assessment. A detailed review of the process and findings has been published.[11] Briefly, a total of 27 QIs were initially proposed in 3 categorical areas: (1) access, (2) therapy, and (3) outcomes. After internal review, application of multiple rating strategies, and feedback from external experts, stakeholders, and CCS membership, 5 priority QIs were initially selected. The CCS directed a final list of no more than 3 priority QIs per Working Group. After further internal discussion focusing on the most clinically relevant, evidence-based, and generalizable indicators, the following 3 QIs were selected:

1. Proportion of patients with a diagnosis of NVAF/ AFL at high risk of stroke (age $\geq$ 75 years or CHADS2 $\geq$ 2 [Congestive heart failure, Hypertension, Age $\geq$ 75, Diabetes, prior Stroke or systemic embolism]) receiving an OAC.
2. Annual rate of stroke in patients with NVAF/AFL.
3. Annual rate of major hemorrhage in patients with NVAF/ AFL.

A feasibility assessment followed in which it was determined that none of the QIs as defined could be adequately measured using data sources available regionally, provincially, or at the national level across inpatient and outpatient healthcare settings.

Since this initial effort, a number of NVAF/AFL guideline documents have been updated,[12,13] and a report from the American College of Cardiology/American Heart Association on clinical performance and quality measures for patients with NVAF/AFL was published.[14] Accordingly, in June 2017, the CCS AF/AFL QI working group reconvened with a strategic plan focused on revisiting the relevance of previously proposed QIs, to identify opportunities for new indicator development and to propose an initial strategy for measuring and reporting on selected priority QIs.

Methods

The renewed AF/AFL QI working group retained its multidisciplinary and pan-Canadian composition and has membership consisting of academic and community clinician content-area experts (primary care, cardiology, emergency medicine), as well as representatives from the Canadian Institute for Health Information (CIHI), CorHealth Ontario, and Institut National d'Excellence en Santeá et en Services Sociaux. Three subgroups of the larger CCS AF/AFL QI working group were formed to address the QI categorical areas (access, therapy, outcomes).

The first task for the AF/AFL QI working group members was to participate in a survey to evaluate the relevance of 27 QIs and determine whether each QI should be kept as a priority indicator, kept as a nonpriority indicator, altered, or removed entirely. The threshold for an indicator to be placed in each of these categories was $>$ 50% of the votes. The results of the survey and any new proposed QIs were discussed among the members of the respective 3 categorical subgroups of the overall working group (access, therapy, outcomes) and then brought forth to the entire working group for review at the 2017 Canadian Cardiovascular Congress meeting. The priority indicators were also rated for relevance by attendees of the CCS AF and HF workshop in 2017. After the meeting, each subgroup was tasked with further narrowing down the list of priority QIs.

Finally, an environmental scan of existing registries, databases, and networks at the regional, provincial, and national levels capturing inpatient and outpatient populations to determine the feasibility of QI measurement was performed.

Results

Selection of QIs

The survey results for the 27 QIs according to the 3 categorical subgroups are shown in Table 1. Following the process outlined earlier, 5 QIs were selected as being most clinically important to determine standard quality of care for the broadest AF/AFL patient population briefly summarized are as follows:

Therapies Indicators

1. Proportion of patients with NVAF/AFL according to stroke risk strata.
2. Proportion of patients with a diagnosis of NVAF/AFL at high risk of stroke (age $\geq$ 75 years or CHADS2 $\geq$ 2) receiving an OAC.

Outcomes Indicators

1. Annual rate of stroke in NVAF/AFL.
2. Annual rate of major haemorrhage in NVAF/AFL.
3. Annual rate of hospitalization for a new diagnosis of HF.

The details (definitions of numerator, denominator, calculation method, and rationale) of each QI are summarized in Table 2.

Strategy for measuring and reporting QIs

Potential data sources

Inpatient setting. To provide national and provincial estimates on the proportion of patients with NVAF/AFL according to stroke risk stratum and determine rates of stroke, hemorrhage, and HF hospitalizations, the CIHI discharge abstract database can be used. The discharge abstract database contains information for all inpatient hospitalizations for all provinces and territories except Quebec. Data from Quebec are submitted to CIHI directly by the ministère de la Santé et des Services sociaux du Québec. Linked databases that include the Pharmacy Information Network for all available individuals in Alberta and British Columbia can provide inpatient estimates regarding the proportion of patients at high risk for stroke receiving OAC therapy.

Emergency department setting. The National Ambulatory Care Reporting System (NACRs) can be used to calculate stroke risk strata for patients with NVAF/AFL seen in the emergency department (ED) in 2 provinces with 100% mandatory reporting (Alberta and Ontario). The proportion of patients at high risk for stroke receiving OAC therapy can be estimated in provinces with linked databases that include prescription data.

Outpatient setting. The Canadian Primary Care Sentinel Surveillance Network (CPCSSN) is the first pan-Canadian primary care electronic medical record (EMR) surveillance system. There are currently 1180 participating primary care practices and 600 primary care practitioners with 1,800,000 patients in 8 provinces and territories. The EMR surveillance system captures comprehensive data regarding health conditions, encounter diagnoses, billing diagnoses, laboratory results, medications, physical signs, medical procedures, and referrals. With the use of the CPCSSN dataset, an EMR case definition for NVAF/AFL can be developed, and then the proportion of patients with NVAF/AFL according to stroke risk strata and the proportion of patients at high risk for stroke receiving OAC therapy can be measured.[15] NACRs can be used to calculate stroke risk strata for patients with NVAF/AFL seen at hospital-based physician offices in Alberta and Ontario, and provinces with linked databases with prescription data can calculate the proportion of patients at high risk for stroke receiving OAC therapy.

Cohort definition and reporting period

Patients $\geq$ 20 years can be identified using International Classification of Diseases, 9th Revision Clinical Modification (codes 427.3) or International Classification of Diseases, 10th Revision code I48 for AF/AFL from April 2, 2006, 2008, to March 31, 2016 (fiscal years), with follow-up to March 31, 2017. Incident AF/AFL can be defined by at least a 2-year washout period. The inclusion criteria should be (i) $\geq$ 1 hospital discharge diagnosis in any position in the discharge record, (ii) $\geq$ 1 ED visit or hospital-based physician office visit in the 6 coding conditions, and (iii) for the analysis on OAC use, patients who survived 90 days after initial diagnosis. The exclusion criteria include (i) valvular AF because these patients may carry a different prognosis, (ii) death during index hospitalization, (iii) incident AF the same day or after diagnosis of ischemic stroke only for the QI measure for incidence stroke rates, and (iv) history of HF only for the QI measure for rates of new HF hospitalization. The validated administrative codes corresponding to cohort, outcomes, bleeding risk, and comorbidity definitions are shown in Table 3.[16-21]

Discussion

The development and assessment of AF/AFL QIs are essential for monitoring and benchmarking care in Canada. This initial work was undertaken by the AF/AFL QI working group in 2010 and resulted in the selection of 3 priority QIs; however, none were measurable at a national level. Since that time, the working group reconvened and reviewed QIs in the areas of access, therapy, and outcomes. In addition to the previously selected 3 priority QIs, 2 other indicators were added with respect to therapies and outcomes. An environmental scan was undertaken, and it was determined that the 5 QIs could be measured in a limited capacity using national and selected provincial databases.

Among the 3 identified categorical areas for QI development, there was 1 QI related to "access"—confirmed diagnosis of AF/AFL and echocardiographic assessment. Although the consensus was to maintain this QI as a priority, challenges in measurement remain, particularly given that electrocardiograms and echocardiograms are mainly done in outpatient facilities. In certain provinces where echocardiograms are performed uniformly in hospitals because of strict government control, wait times are approaching several years, whereas in other provinces wait times are measured in days. For this reason, it was considered a lower priority compared with other QIs in the therapy and outcome areas. However, it is important to note that had we been able to measure this QI, it would have provided important information regarding the extent to which variations exist in access times across Canada for such a fundamental procedure as an echocardiogram.

Table 1. Survey results for the QIs in the access, therapies, and outcomes subgroups

	Access (n = 12)	Therapies (n = 8)	Outcomes (n = 7)
QI classification			
Keep as priority	Confirmed diagnosis of NVAF/AFL and echocardiographic assessment	Diagnosis of NVAF/AFL and at high risk of stroke receiving an OAC Risk stratification of patients with NVAF/AFL for stroke	Rate of stroke in patients with NVAF/AFL Rate of major hemorrhage in patients with NVAF/AFL
Keep as nonpriority	Percentage of patients with HF diagnosis with an EKG within 3 mo of diagnosis Percentage of patients with hypertension with an EKG within 3 mo of diagnosis Percentage of patients with valvular heart disease with an EKG within 3 mo of diagnosis Percentage of patients with a stroke with an EKG within 3 mo of diagnosis Percentage of patients with hyperthyroidism with an EKG within 3 mo of diagnosis Percentage of patients with palpitations with an EKG within 3 mo of diagnosis Percentage of patients with new diagnosis of AF with a transthoracic echocardiogram at 3 mo Percentage of patients with new diagnosis of AF with TSH at 3 mo Percentage of patients with new diagnosis of AF screened for hypertension (documented blood pressure) at 3 mo	Percentage of patients with CHADS2 score of $\geq$ 2 maintained on OAC post-catheter ablation for NVAF at 1 y post-ablation Anticoagulation for valvular AF Percentage of patients with diagnosis of AF prescribed an antiarrhythmic drug with follow-up EKG within 3 mo Percentage of patients with diagnosis of AF prescribed an antiarrhythmic with documentation of left ventricular function	Percentage of patients with major complications of catheter ablation for AF occurring within 30 d post-ablation Patients undergoing repeat catheter ablation(s) for AF within 2 y of the index procedure Population rate of diagnosis of AF Population rate of diagnosis of AFL Percentage of patients with diagnosis of AF prescribed an antiarrhythmic for $>$ 1 y with an EKG within 1 y demonstrating normal sinus rhythm
Remove	Percentage of patients with new diagnosis of AF with chest x-ray at 3 mo Percentage of patients with new diagnosis of AF screened for substance abuse		
Alter			
No clear majority		Quality of anticoagulation with warfarin in patients with AF/AFL Percentage of patients with new diagnosis of AF with documented resting heart rate $<$ 100 beats/min at 3 mo	

AF, atrial fibrillation; CHADS2, Congestive heart failure, Hypertension, Age $\geq$ 75, Diabetes, prior Stroke or systemic embolism; EKG, electrocardiogram; HF, heart failure; NVAF/AFL, nonvalvular atrial fibrillation/atrial flutter; QI, quality indicator.

The access subgroup then focused on whether physicians taking care of patients with AF/AFL could access subspecialty care (AF clinic) from the ED or outpatient settings. A prior nationwide report had found 14 AF clinics using various models of care.[22] Since that time, an environmental scan done estimates the presence of 19 AF clinics across Canada. There was no specific registry to access the number and location of AF clinics. The majority of clinics were within academic centers, and no standardized method for collection of data was occurring across the AF clinics. Given these observations, it was thought that a QI could not be developed at this time.

The assessment of stroke risk for patients with AF/AFL has been universally recommended among guidelines[12,13] and included as a performance measure among the various professional societies;[14] however, the specific stroke risk scheme and subsequent definition of eligibility for OAC use vary depending on the country. We maintained both priority quality outcome indicators as first proposed by the AF/AFL working group[11] to measure the rates of stroke and major hemorrhage because of their clinical relevance.

A new outcomes QI was developed to measure rates of hospitalization for new HF among patients with NVAF/AFL. HF and AF often coexist, and each condition worsens the prognosis of the other. After hypertension, HF is now the second most common comorbid condition. Furthermore, HF hospitalization (or rehospitalization) is recognized as a marker of quality of care, and if there is timely access to medical care and appropriate management of rate or rhythm, an HF episode may be circumvented.

Study limitations

Since the last feasibility assessment, the working group was able to determine that selected priority therapy and outcome QIs could be measured with modified definitions using national and select provincial databases. We recognize that there

Table 2. Summary of selected CCS AF/AFL QIs

Therapies indicators

A. Risk stratification of subjects with NVAF/AFL for stroke
Percentage of patients with a new diagnosis of NVAF/AFL who have a stroke risk prediction (CHADS2, CHA2DS2VASc, CHADS-65) score documented in their medical record or have the relevant elements of such scores recorded such that they can be readily and automatically calculated
Numerator: All patients with a diagnosis of NVAF/AFL who have a CHADS2 or CHA2DS2VASc score or CHADS-65 or the elements of these scores (stroke/TIA/SE, hypertension, heart failure, age $\geq$ 75 y, diabetes, atherosclerotic disease, age 65-74 y, female sex) documented in their medical record
Denominator: All patients with a diagnosis of NVAF/AFL
Period of assessment: Annually
Rationale: Will measure the proportion of patients with AF/AFL stratified for stroke risk using a recommended objective tool (CHADS2, CHA2DS2VASc, or CHADS-65)

B. Diagnosis of NVAF/AFL and at high risk of stroke (age $\geq$ 75 y or CHADS2 $\geq$ 2) receiving an OAC
Percentage of patients with a diagnosis NVAF/AFL $\geq$ 75 y of age OR $<$ 75 y of age with a CHADS2 score $\geq$ 2, and without a contraindication for anticoagulation, who are receiving a prescription for an OAC (warfarin [or other VKA], apixaban, dabigatran, rivaroxaban)
Numerator: Primary analysis: All patients with NVAF/AFL $\geq$ 75 y of age OR $<$ 75 y of age and a CHADS2 score $\geq$ 2, and without a contraindication for OAC, who are receiving a prescription for an OAC (warfarin [or other VKA] apixaban, dabigatran, rivaroxaban)
Secondary analysis: Include the possibility of reporting according to CHADS-65 and CHA2DS2VASc $\geq$ 2 in men and $\geq$ 3 in women
Denominator: All patients with NVAF/AFL $\geq$ 75 y of age OR $<$ 75 y of age and a CHADS2 score $\geq$ 2
Period of assessment: Annually
Rationale: Patients who are at high risk for stroke should be on an OAC for stroke prevention

Outcome indicators

C. Rate of stroke in patients with NVAF/AFL
Numerator: Primary analysis: The number of patients with NVAF/AFL who have a stroke (within 1 y)
Denominator: The number of patients with NVAF/AFL
Period of assessment: Annually
Rationale: Will measure the rate of stroke in patients with AF/AFL (according to risk score and antithrombotic use)

D. Rate of major haemorrhage in patients with NVAF
Annual rate of major haemorrhage in patients with diagnosis of NVAF/AFL receiving an OAC (warfarin [or VKA]), dabigatran, rivaroxaban, apixaban)
Numerator: Primary analysis: The number of patients with NVAF/AFL who are hospitalized for haemorrhage of any kind (an arbitrary definition of major bleeding) within a calendar year while taking an OAC
Secondary analysis: Possibility of reporting according to type of OAC (warfarin [or other VKA], apixaban, dabigatran, rivaroxaban)
Denominator: All patients with NVAF/AFL
Period of assessment: Annually
Rationale: Will measure the proportion of patients with NVAF/AFL who experience complication of anticoagulation (according to type of anticoagulant

E. Rate of hospitalization for new HF
Annual rate of new HF in patients with AF/AFL
Numerator: Primary analysis: The number of patients with NVAF/AFL who are hospitalized for new HF
Denominator: All patients with NVAF/AFL
Period of assessment: Annually
Rationale: Will measure the proportion of patients with NVAF/AFL who experience a new HF diagnosis

CCS, Canadian Cardiovascular Society; CHADS2, Congestive heart failure, Hypertension, Age $\geq$ 75, Diabetes, prior Stroke or systemic embolism; CHA2DS2VASc, Congestive heart failure, Hypertension, Age $\geq$75, Diabetes, prior Stroke or systemic embolism, Vascular disease, Age 65-74, Sex (female); HF, heart failure; NVAF/AFL, nonvalvular atrial fibrillation/atrial flutter; OAC, oral anticoagulant; QI, quality indicator; SE, systemic embolus; TIA, transient ischemic attack; VKA, vitamin K antagonist.

are several limitations and potential challenges to performing these analyses.

First, to develop a nationally representative dataset that allows fair interprovincial comparison, the cohort is mainly restricted to hospitalized patients. Confinement to inpatients may result in higher estimates of annual incidence of target outcomes, because hospitalized patients are older and have more comorbidities. A collaboration with CPCSSN would provide some data on the quality of AF/AFL care from the outpatient setting but will be cross-sectional in nature.

Second, fatal stroke or bleeding events that occur out of hospital would not be counted as outcomes. This would result in a reduced sensitivity and bias toward lower absolute event rates. However, most strokes and major bleeding events do result in hospitalization, and this limitation would not influence trends over time or inter-provincial comparisons. The components of bleeding risk stratification scores contain key components that cannot be calculated using administrative data.

Third, CIHI does not possess data on out-of-hospital mortality. Therefore, we anticipate this will result in analytic issues with censoring patients and potentially lead to an overestimate of the incidence of the outcomes of interest.[23]

Fourth, NACRs is only available with 100% completeness in Alberta and Ontario, and subsequently data regarding stroke risk stratification in the ED and hospital-based physician offices will be limited. Future initiatives to aid other provinces in complete reporting are needed.

Fifth, data on OAC therapy are currently limited to 2 provinces, which would provide a limited sense of geographical differences. The working group would like to work with CIHI

Table 3. Administrative codes

	ICD-9-CM	ICD-10-CM
Populations		
AF/AFL	427.3 427.31, 427.32	I48
Mitral or aortic valve disease	394, 395, 396, 424.0, 424.1	I05, I06, I08.0, I08.1, I085.2, I08.3, I34, I35
Tricuspid or pulmonary valvular disease	397, 424.2, 424.3	I07, I08.1, I08.2, I08.8, I08.9, I36, I37
Valve surgery and procedures	Procedure codes: 35.0, 35.1, 35.2, 35.96, 35.97, 35.99	CCI procedure codes: 1.HS.80,1.HS.90, 1.HT.80, 1.HT.89, 1.HT.90, 1.HU.80, 1.HU.90, 1.HV.80, 1.HV.90
Outcomes		
Stroke and embolic events		
Ischemic stroke	362.3, 33.x1, 434.x1,	H34.1, I63, I64
Systemic embolism	444	I74
Hemorrhagic stroke	430, 431, 432	I60, I61, I62
Transient ischemic attack	435	G45
Bleeding		
Major bleeding (includes intracranial hemorrhage and GI bleed)	362.81, 379.23, 430, 431, 432, 456.0, 456.20, 459.0, 530.21, 530.7, 530.82, 531.0, 531.2, 531.4, 431.6, 532.0, 532.2, 532.4, 532.6, 533.0, 533.2, 533.4, 533.6, 534.0, 534.2, 534.4, 534.6, 535.x1, 569.3, 569.85, 578, 596.7, 599.7, 719.1, 770.3, 784.7, 784.8, 786.3	H35.6, H43.1, I60, I61, I62, I85.x1, K22.11, K22.6, K25.0, K25.2, K25.4, K25.6, K26.0, K26.0, K26.2, K26.4, K26.6, K27.0, , K27.2, K27.4, K27.6, K28.0, K28.2, K28.4, K28.6, K29.x1, K31.80, K55.21, K62.5, K66.1, K92.0, K92.1, K92.2, M25.0, N02, R04, R31, R58 I31.2, J94.2
Embolic risk		
Heart failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4-425.9, 428	I25.5, I42.0, 142.6-I42.9, I43.x, I50.x
Hypertension	401-405	I10-I13, I15
Diabetes mellitus	250	E10-E14
Myocardial infarction	410, 412	I21, I22, I25.2
Coronary revascularization (CABG/PCI)	360, 361	1.IJ.50.~, 1.IJ.76.~
Chronic coronary artery disease	410, 411, 412, 413, 414, 429.2, V45.81, procedure codes 36.xx	I25.0-I25.2, I25.5, I25.8, I25.9
Peripheral vascular disease (including aortic plaque)	093.0, 437.3, 440.x, 441.x, 443.1-443.9, 447.1, 557.1, 557.9 V43.4 (procedure)	I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2 K55.1, K55.8, K55.9, Z95.8, Z95.9
Bleeding risk		
Alcohol misuse	265.2, 291.1-291.3, 291.5-291.9, 303.0, 303.9, 305.0, 357.5, 425.5, 535.3, 571.0-571.3, 980, V11.3	E52, F10, G62.1, I42.6, K29.2, K70.0, K70.3, K70.9, T51, Z50.2, Z71.4, Z72.1
Anemia	280-285	D50-D64
Excessive falls	E880-E886, E888	W00-W19
Hepatic disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 456.0-456.2, 570.x, 571.x, 572.2-572.8, 573.3, 573.4, 573.8, 573.9, V42.7	B18.x, I85.x, I86.4, I98.2, K70.x, K71.1, K71.3-K71.5, K71.7, K72.x-K74.x, K76.0, K76.2-K76.9, Z94.4
Cancer	140.x-172.x, 174.x-195.8, 200.x-208.x, 238.6 (malignancy) 196.x-199.x (metastatic solid tumor)	C00.x-C26.x, C30.x-C34.x, C37.x-C41.x, C43.x, C45.x-C58.x, C60.x-C76.x, C81.x-C85.x, C88.x, C90.x-C97.x (malignancy) C77.x-C80.x (metastatic solid tumor)
Coagulation platelet defect	287	D69

Continued

Table 3. Continued.

	ICD-9-CM	ICD-10-CM
Comorbidities		
Chronic kidney disease	583, 584, 585, 586, 592, 593.9	N00-N23
Hypothyroidism	243.x, 244.x	E01.x, E02.x, E03.x, E89.0
Hyperthyroidism	242.x	E05.x
Pulmonary embolism		I26
Pneumonia		J09, J10, J11, J12, J13, J14, J15, J16, J17, J18

CABG, coronary artery bypass grafting; GI, gastrointestinal; ICD-9-CM, International Classification of Diseases, 9th Revision Clinical Modification; ICD-10-CM, International Classification of Diseases, 10th Revision Clinical Modification; MI, myocardial infarction; PCI, percutaneous coronary intervention.

to use the National Prescription Drug Utilization Information System database, which contains claims and formulary data for public drug programs from 10 provinces/territories and formulary information from 1 federal drug program.

Sixth, other data sources do exist in the context of clinical trials or province-specific disease or procedure registries. However, the extent to which the clinical trial data in particular are truly reflective of their disease populations, as opposed to being convenience samples, may not always be apparent. Accessing clinical trial or registry data can be a challenge. Data quality, especially in regard to registries, may vary between different registries from different locations, even within a given province. Finally, the ability to link such information sources to other datasets, such as those pertaining to healthcare visits or drug prescriptions, will differ.

Last, administrative data can be subject to misclassification; however, many of the administrative codes have been previously validated.

The Future

The AF/AFL working group's environmental scan of available data illustrates incremental progress in our ability to assess the quality of AF/AFL care and drive evidence-based improvements. However, the obvious fragments in Canada's 13 health systems, lack of national leadership, and lack of resources for quality measurement and improvement limit progress.

In Canada, the Canadian Foundation for Healthcare Improvement (CFHI) is 1 of 10 pan-Canadian Health Organizations that operate at arm's length of the federal government. The CFHI is mandated to respond to disparate health policy issues and, more specifically, to support healthcare organizations to adapt, implement, and measure improvements in patient care, population health, and value for money. The obvious alignment between the efforts of the CCS AF/AFL quality working group and the CFHI's mandate suggests this fundamental health gap be filled by a national government entity, like the CFHI, or by a newly formed pan-Canadian Health Organization.

Of equal importance to national leadership, resources to support data aggregation, data analysis, and pan-Canadian reporting are urgently needed. Ideally, this fundamental component for ongoing improvement in quality of care should be embedded into the health system. Furthermore, there is an evident need to address the existing gaps cited in tracking QIs to make more meaningful strides in measurement and improvements in quality of care. For these reasons, investment in infrastructure at the provincial and federal level is imperative to facilitate measurement and reporting of QIs within the current health care context and to enable better and more streamlined reporting systems in the future.

Identifying gaps in care is essential for targeting improvement efforts. Arguably, to the extent that much of Canadian health care is publicly funded, the federal and provincial governments have a shared responsibility to provide the necessary resources and infrastructure for data acquisition in an effort to support evidence-based improvement efforts. Just as important, they have an obligation to report it. Canadian taxpayers are required to make significant financial contributions to the health care sector; as such, they deserve to know whether they

are getting the access, equity, and quality that they expect in return.

Acknowledgements

The authors thank all the members of the CCS AF/AFL QI working group for their contributions to quality improvement activities. We also thank the CIHI for their expertise regarding national inpatient data and the CCS staff who have organized meetings, compiled minutes, and maintained timelines in support of these activities.

Funding Sources

The resources required to review and refine the CCS AF/AFL QIs, in addition to the environmental scan completed and documented in this manuscript, were made possible through funding provided by Bristol-Myers Squibb, Pfizer, Novartis, and Edwards Lifesciences. The manuscript was written independently of any of the funding sources.

Disclosures

R.K.S.: research grants from Servier Alberta Innovation in Health Fund. S.B.W.: consulting fees/honoraria from Arca Biopharma; research grants from Medtronic, Boston Scientific, and Abbott Canada. M.D.: research grants from Abbott Canada, BMS Pfizer, and Johnson & Johnson; consulting fees/honoraria from Abbott Canada, BMS Pfizer, Boehringer Ingelheim, Johnson & Johnson, and Servier. D.G.W.: research grants from Population Health Research Institute, Montreal Heart Institute, Canadian Institute of Health Research Institutes, Boehringer Ingelheim, Portola, and Bayer HealthCare; consulting fees/honoraria from the National Institutes of Health (United States). J.L.C.: consulting fees/honoraria from Bayer, BMS Pfizer, and Servier. A.S.: research grant from Johnson & Johnson, Medtronic; consulting fees/honoraria from Bayer, BMS Pfizer, Boehringer Ingelheim, and Johnson & Johnson. The remaining authors have no conflicts of interest to disclose.

References

1. Chugh SS, Havmoeller R, Narayanan K, et al. Worldwide epidemiology of atrial fibrillation: a global burden of disease 2010 study. Circulation 2014;129:837-47.
2. Go AS, Hylek EM, Phillips KA, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the anticoagulation and risk factors in atrial fibrillation (ATRIA) study. JAMA 2001;285:2370-5.
3. Miyasaka Y, Barnes ME, Gersh BJ, et al. Secular trends in incidence of atrial fibrillation in olmsted county, minnesota, 1980 to 2000, and implications on the projections for future prevalence. Circulation 2006;114:119-25.
4. Ball J, Carrington MJ, McMurray JJ, Stewart S. Atrial fibrillation: profile and burden of an evolving epidemic in the 21st century. Int J Cardiol 2013;167:1807-24.
5. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. Stroke 1991;22:983-8.
6. Stewart S, Hart CL, Hole DJ, McMurray JJ. A population-based study of the long-term risks associated with atrial fibrillation: 20-year follow-up of the Renfrew/Paisley study. Am J Med 2002;113:359-64.
7. Lubitz SA, Moser C, Sullivan L, et al. Atrial fibrillation patterns and risks of subsequent stroke, heart failure, or death in the community. J Am Heart Assoc 2013;2:e000126.
8. Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. Ann Intern Med 2007;146:857-67.
9. Dentali F, Riva N, Crowther M, et al. Efficacy and safety of the novel oral anticoagulants in atrial fibrillation: a systematic review and meta-analysis of the literature. Circulation 2012;126:2381-91.
10. O'Reilly DJ, Hopkins RB, Healey JS, et al. The burden of atrial fibrillation on the hospital sector in canada. Can J Cardiol 2013;29:229-35.
11. Cox JL, Dai S, Gong Y, et al. The development and feasibility assessment of canadian quality indicators for atrial fibrillation. Can J Cardiol 2016;32:1566-9.
12. Macle L, Cairns J, Leblanc K, et al. 2016 Focused Update of the Canadian Cardiovascular Society Guidelines for the Management of Atrial Fibrillation. Can J Cardiol 2016;32:1170-85.
13. Kirchhof P, Benussi S, Kotecha D, et al. 2016 ESC guidelines for the management of atrial fibrillation developed in collaboration with ECATS. Europace 2016;18:1609-78.
14. Heidenreich PA, Solis P, Estes NAM 3rd, et al. 2016 ACC/AHA clinical performance and quality measures for adults with atrial fibrillation or atrial flutter. J Am Coll Cardiol 2016;68:525-68.
15. McAlister FA, Garrison S, Kosowan L, Ezekowitz JA, Singer A. Use of direct oral anticoagulants in Canadian primary care practice 2010-2015: a cohort study from the Canadian Primary Care Sentinel Surveillance Network. J Am Heart Assoc 2018;7:e007603.
16. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in icd-9-cm and icd-10 administrative data. Med Care 2005;43:1130-9.
17. Quan H, Khan N, Hemmelgarn BR, et al. Validation of a case definition to define hypertension using administrative data. Hypertension 2009;54:1423-8.
18. Kokotailo RA, Hill MD. Coding of stroke and stroke risk factors using international classification of diseases, revisions 9 and 10. Stroke 2005;36:1776-81.
19. Ronksley PE, Tonelli M, Quan H, et al. Validating a case definition for chronic kidney disease using administrative data. Nephrol Dial Transplant 2012;27:1826-31.
20. Jensen PN, Johnson K, Floyd J, et al. A systematic review of validated methods for identifying atrial fibrillation using administrative data. Pharmacoepidemiol Drug Saf 2012;21(Suppl 1):141-7.
21. Quan H, Li B, Saunders LD, et al; IMECCHI Investigators. Assessing validity of ICD-9-CM and ICD-10 administrative data in recording clinical conditions in a unique dually coded database. Health Serv Res 2008;43:1424-41.
22. Cruz J, Mariano Z, Dorian P. Atrial fibrillation clinics in Canada: a nationwide project report. Can J Cardiol 2018;34:1219-24.
23. Austin PC, Lee DS, Fine JP. Introduction to the analysis of survival data in the presence of competing risks. Circulation 2016;133:601-9.