The IMPROVE-AF Study:
IMproving InPatient Rates of Oral Anticoagulation for Stroke PreVEntion in Atrial Fibrillation

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Abstract (max 250 words):
Atrial fibrillation (AF) and flutter (AFL) remain among the most common arrhythmias that occur in hospital. In a recent cohort study of 3,556 patients admitted to St. Michael's Hospital, guideline-indicated oral anticoagulation (OAC) was prescribed at discharge to less than 60% of eligible patients. A major barrier to guideline adherence was efficiently identifying appropriate patients who are identified to have atrial fibrillation, and warrant anticoagulation prior to discharge. Failure to prescribe OAC is multifactorial, and results from lack of awareness of the AF, and failure to assess risks and benefits and indicated by guidelines. Partnered with a multidisciplinary healthcare analytics research team, we have devised a quality improvement initiative with the aim of increasing the prescribing rates of OAC on discharge in newly identified AF/AFL. An iterative computer algorithm auto-identifies patients with AF/AFL on hospital electrocardiogram, estimates bleeding and stroke risks based on co-morbidities extracted from the hospital electronic medical record, and delivers a daily list of candidate patients for OAC. This "Atrial Fibrillation Alert" system notifies the electrophysiology consult service in real-time, triggering automatic assessment requests to consultant cardiology and internal medicine physicians while the patient is still in hospital, and triggers an education/information program directed at the treating team. The analytics team monitors discharge medications on these patients to determine trends in OAC prescription rates.
We anticipate that, in addition to a sustained increase in guideline-concordant OAC use, patients will be appropriately investigated for acute precipitants of AF/AFL that are potentially reversible and would otherwise go unnoticed.

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Proposal

Overall Goals and Objectives

The primary goal for this quality improvement initiative is to increase the rate of guideline-indicated oral anticoagulant (OAC) usage at hospital discharge among St. Michael's Hospital (Toronto, Ontario, Canada) inpatients identified as having atrial fibrillation (AF) or atrial flutter (AFL) on electrocardiography (ECG) by 50% within 6 months.

The secondary goal is to identify and validate a semi-automated means of improving care for these patients, and increase the community engagement around guideline-concordant care for patients with AF/AFL.

The Bristol-Myers Squibb-Pfizer Alliance Request for Proposals aims to support quality improvement work focused on improving screening, case finding, and diagnosis of AF/AFL and guideline-indicated stroke treatment optimization. This is completely aligned with our ongoing project and we are confident that the support of the RFP would substantially promote the sustainability of this initiative.

Our specific objectives and their alignment with the RFP focus are as follows:

- *Case-finding/diagnosis of atrial fibrillation:*
  –to ensure that our project identifies, for potential inclusion and within 24 hours, every emergency room or admitted patient with an ECG demonstrating AF or AFL performed at St. Michael's Hospital (current or prior documentation of AF/AFL).

- *Guideline-indicated stroke treatment optimization:*
  – to perform an automated assessment of stroke and bleeding risks among identified patients (using the validated CHADS-65 and HAS-BLED scoring systems), communicated to front-line clinicians, along with current recommendations for stroke prevention from the Canadian Cardiovascular Society (CCS).
  – to establish an ongoing feedback-and-audit system within the hospital whereby rates of appropriate OAC are monitored regularly and consultant specialist physicians from cardiology and internal medicine are automatically assessing patients at preventable risk of stroke due to AF/AFL.

Our project is designed to have **immediate and significant impact** on patient care and system processes, and has the support of hospital administration. We are optimistic that with demonstrable success, our initiative is scalable and broadly applicable to other hospitals willing to adopt data-driven system changes.

Current Assessment of Needs in Target Area

Prior Work

Summary of Findings

We recently performed a retrospective cohort study of 3,556 patients admitted to all St. Michael's Hospital units between 2010-2014 (using a novel **semi-**automated informatics techniques to extract data from existing data repositories) and found that **guideline-indicated anticoagulation in patients with documented atrial fibrillation was prescribed at discharge to less than 60% of eligible patients, and under some services, was less than 10%.** There is a clear need to address this important care gap and substantially reduce the incidence of preventable stroke in a population at recognized high risk.

The full manuscript is in preparation, but we present pertinent details of the methods, results, and conclusions of the needs assessment:

Methods

The St. Michael's Hospital ECG database was searched to identify individuals with a 12-lead ECG diagnosis of AF as confirmed by a faculty cardiologist (January 1, 2010 - December 31, 2014). This timeframe was selected to capture the period preceding direct-acting OACs (DOAC) approval in Canada and leading up to several CCS AF guideline revisions favouring DOACs and a more aggressive stroke prevention strategy. All ECGs obtained from the ambulatory or emergency department settings were eliminated. To optimize the likelihood that OACs are appropriate in our study cohort, we excluded the following individuals: (i) <65 years old and $CHADS_2$=0, (ii) contraindication to OAC (namely active bleeding or history of life-threatening bleed), (iii) death during admission, (iv) insufficient patient records, and (v) those with potentially reversible causes of AF such as individuals admitted to a critical care unit (coronary, cardiovascular, medical surgical) at the time of the ECG. The visit corresponding to the first ECG showing AF during the study period was used for assessment. A comparison cohort was selected for manual review as part of the validation component of the study. A convenience sample size of 27 patients, randomly identified from each of the study years, was analysed (N=135).

Data Extraction

The *GE Muse*® database was initially used to search for 12-lead ECGs with a diagnosis of "atrial fibrillation". This generated a list with corresponding dates/times, ECG locations, and patient medical record numbers (MRNs). These MRNs were then imported into the *Microsoft SQL*® server to then query (via SQL statements) other source system databases to extract data from them in an automated manner. For instance, *Cerner MS4/ADT* was the database used to obtain patient demographics including patient age, gender, birth/death date, and information relating to all hospital visits (visit type, date/time, most responsible service, length of stay). The *Xcelera* database was used for echocardiogram and nuclear cardiology results. The Medical Records Coding System, which uses ICD-10 coding, was used to gather information on patient

comorbidities. The Lab System was searched for pertinent results on the last day of admission such as INR. Finally, *EDischarge*, which is an application developed by our institution, was used to collect discharge medications (and dosages) as well as corroborate patient comorbidities. All the data in the SQL server database was linked together via patient MRN and exported into *Microsoft Excel* for analysis. To avoid assumptions, bias, or unfamiliarity in extraction, a validation team was established which consisted of clinical informatics clinicians who are trained in data analysis and familiar with the applications used for this study as well as cardiologists who are familiar with the content being extracted.

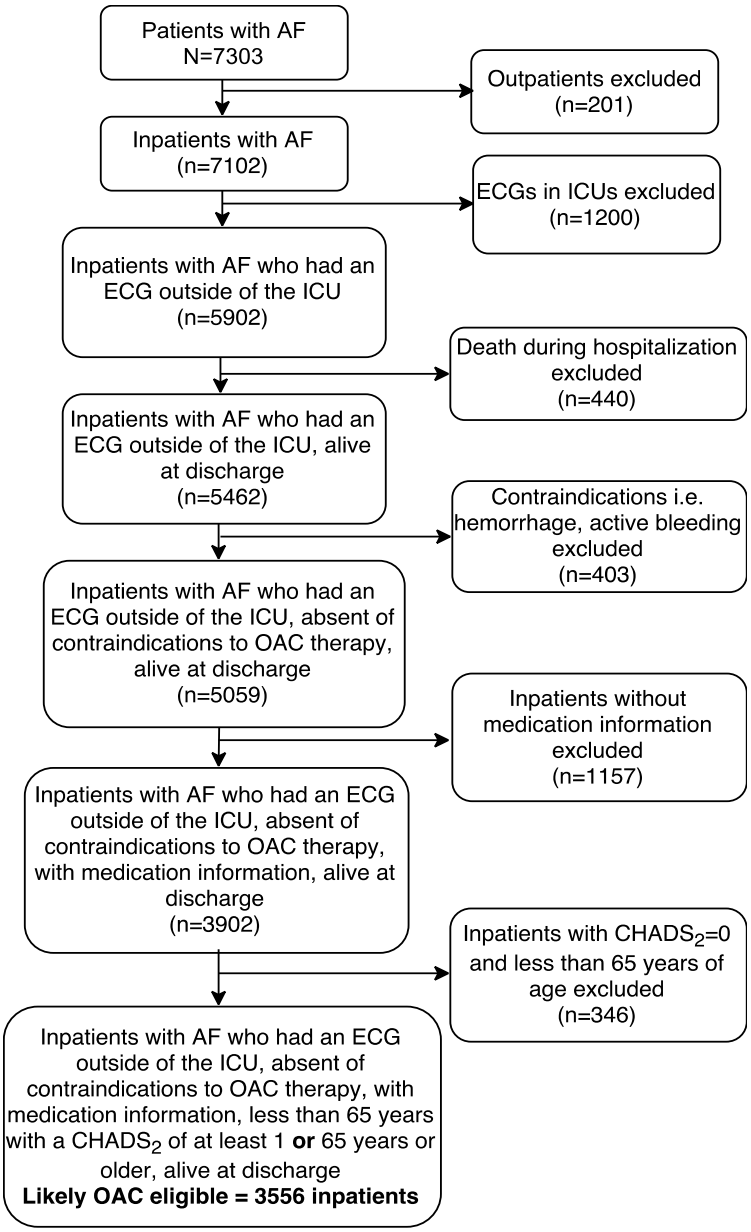

Figure 1. Subset of AF patients who were identified as likely appropriate for OAC. (N=3556).

A manual chart abstraction of the 135 patients was also performed for the study. This involved a comprehensive review of the *Cerner Soarian* hospital electronic medical record including admission and scanned progress notes, discharge summaries, as well as labs and the results of all investigations.

Results

Automated Data Extraction Validation

A total of 43,374 ECGs from 7303 patients showing AF were identified. From these, only 3556 individuals met the inclusion criteria for the study (Mean age: 77.9±7.7 years, 58.5% male). Baseline characteristics for the patients analyzed by the automated method as well as those from the manual chart abstraction were similar with respect to age at ECG and gender. However, there was a marked difference in reported comorbidities in nearly all categories, with the automated method, which relies on administrative ICD-10 coding, underestimating $CHADS_2$ risk factors. Nevertheless, the proportion of patients on an OAC at discharge were similar (automated: 49.4% vs. manual: 55.2%).

Anticoagulation rates in AF

OAC usage at hospital discharge for AF inpatients with a guideline indication for OAC was 49.4%. The proportion on OACs did not change over time. However, DOAC use has gradually replaced warfarin, with DOACs representing only 0.3% of all OACs at discharge in 2010 and 37.0% in 2014**.** Among patients on an OAC, 45.7% (22.6% of total study population) were also on at least one antiplatelet. For patients not on an OAC, 37.1% were on at least one antiplatelet. The remaining 13.5% had no stroke prevention.

Inpatients not on anticoagulation for AF

To gain insight into potential causes for suboptimal anticoagulation rates, we stratified study patients based on the admitting service. The highest proportion of AF inpatients were admitted to internal medicine (28.9%), cardiovascular surgery (27.8%), and cardiology (22.7%), with the lowest on psychiatry (0.1%) and neurology (0.2%). Cardiology and neurology had the highest proportion patients discharged on OAC with 70.7% and 83.3%, respectively, compared to a composite of surgical services which had the lowest (9.2%).

A manual chart review allowed for a more comprehensive assessment of why patients were not on OAC at discharge. Of the 135 patients reviewed, 61 (45.2%) were not on anticoagulation. Figure 2 indicates that the most common reason for not introducing an OAC among these individuals was that the admitting physician never acknowledged an ECG with a diagnosis of AF (43.1%). This was followed by physicians emphasizing the rate or rhythm aspect of AF management but neglecting to discuss stroke prevention strategies (13.8%) and the MRP deferring the decision on OAC initiation to the primary care physician (13.8%). Other reasons such as bleeding, falls risk, or patient refusal represented a much smaller component.

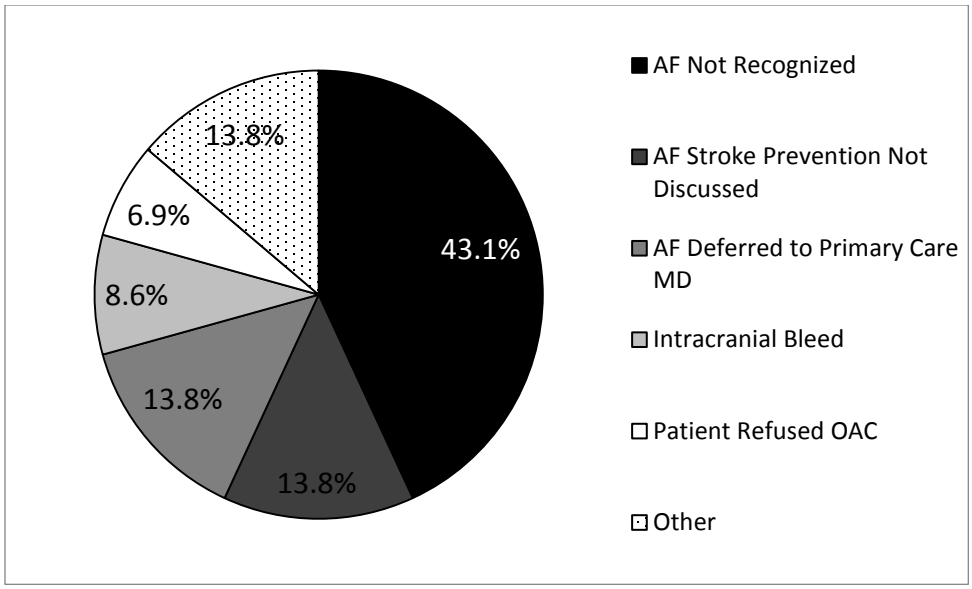

Figure 2. Reasons for not anticoagulating patients with AF based on manual chart abstraction from a sample population (N=61).

This study highlights several clinically important features of AF stroke prevention practices at a Canadian academic hospital. First, we validated a semi-automated electronic tool to rapidly survey the OAC treatment rates among all inpatients with a 12-lead ECG confirmed diagnosis of AF and likely guideline indications for anticoagulation from 2010-2014. This allowed us to recognize that warfarin remains common, but is being exponentially replaced by DOACs. However, the rate of OAC use in inpatients at discharge has not improved over time despite more treatment options and guideline amendments. We also identified that the service in which the patient was admitted to notably influenced the likelihood that they would be discharged on an OAC, with the lowest rates among surgical services. A manual review of a sample population further suggested that patients were largely not being anticoagulated due to physician error, namely not recognizing AF or the importance of stroke prevention in AF.

Target Audience

The primary audience for this project is current and future patients admitted to St. Michael's Hospital with an acute medical or surgical illness, and who are found to be in AF/AFL and eligible for OAC. The targets for intervention are the medical/surgical teams (and most responsible physician) caring for these patients.

Our initiative aims to improve a system of care, and as such does not require specific prior commitment from patients or their primary care providers per se. Thousands of ECGs are performed daily on inpatients across the country, and hospitals nearly universally lack an "atrial fibrillation alert" system of physician notification akin to critical laboratory test results. We are entering an era in which machine learning and advanced analytic technology will become more

routinely available to inform medical practice. Our innovative algorithm will be scalable to any hospital motivated to use insights from existing data to improve routine clinical care. Unlike a novel medication, diagnostic modality, or treatment, our proposed intervention makes use of existing data to trend and reduce an essential care gap in stroke prevention.

Project Design and Methods

St. Michael's Hospital has established an Enterprise Data Warehouse built on IBM's PureData for Analytics system, that includes data from hospital and primary care (family physician) electronic health records, pharmacy, laboratory, imaging, and enterprise resource planning. Twelve-lead ECGs (performed in outpatient areas, emergency room, or wards) are automatically interpreted by the GE Healthcare MUSE Cardiology Information System immediately after they are performed, and subsequently over-read by staff cardiologists. These ECGs are stored in a retrievable data repository, which allows sorting by location in the hospital.

The proposed intervention will involve an computer algorithm acting as a surveillance system ("AF Alert") that generates a daily list of patients with current or prior AF/AFL who are inpatients at St. Michael's Hospital, to the electrophysiology consult service (AF alert coordinator), and who are deemed to be candidates for OAC therapy, but not receiving therapy with OAC (using the real-time pharmacy database of all prescribed medications). Patients who are identified by MUSE and/or staff cardiologist over-readers to have AF/AFL are candidates for the intervention. Their linked data from the St. Michael's Enterprise Data Warehouse is analyzed to estimate both the stroke risk (CHADS-65 score, i.e. presence or prior history of congestive heart failure, hypertension, diabetes, stroke or transient ischemic attack, or age ≥65 years old) and bleeding risk (HAS-BLED score, i.e. uncontrolled hypertension, renal disease, liver disease, stroke, major bleeding or predisposition, labile INR, age >65 years old, medication use predisposing to bleeding, alcohol use ≥8 drinks/week). Patients already on any form of therapeutic OAC or with low stroke risk (CHADS-65=0) are excluded from the AF Alert list.

A final populated AF Alert list will be produced each day, reflecting AF/AFL ECG diagnoses made over the preceding 24 hours. Data will be presented to the Electrophysiology Consult service (AF alert coordinator) using the Tableau Desktop interface, which can also display trends in all relevant metrics for the intervention. The AF alert coordinator, with the assistance from an Electrophysiology fellow or staff physician if needed, will perform a quick assessment of each patient for whom an AF Alert was triggered. All patients deemed to be appropriately identified for potential anticoagulation are then triaged for same-day consultation by either the Electrophysiology service (if admitted under a medical unit) or Internal Medicine Consults service (if admitted under a surgical unit) for more comprehensive evaluation. We will develop standardized educational material, that will be made publicly available, and will be provided to the most responsible physician's team and to the family physician upon patient discharge.

The primary outcome of interest is the proportion of patients with AF/AFL and eligible for OAC based on CCS Guideline recommendations who receive treatment with OAC at the time of hospital discharge. See Figure 3 for study flow.

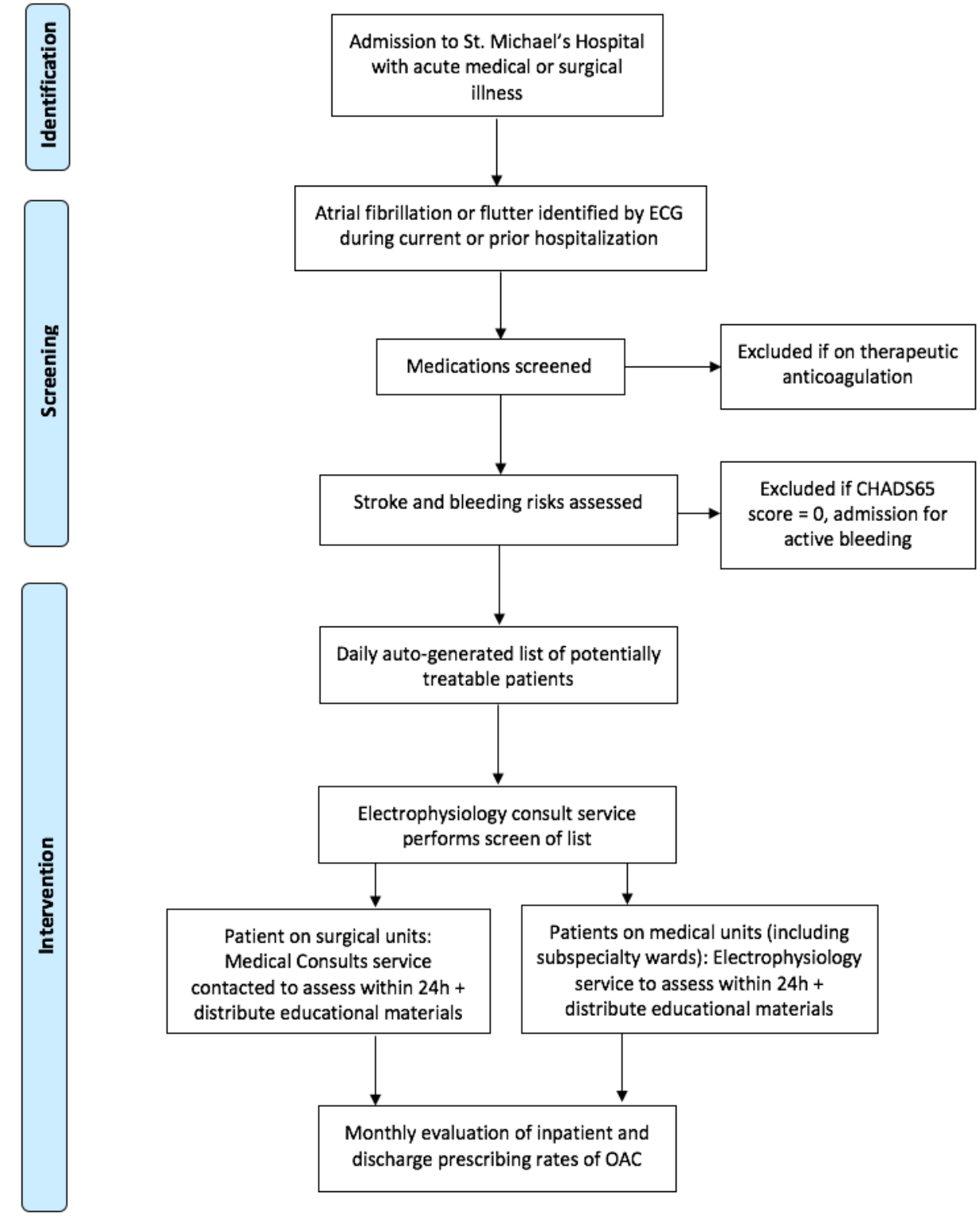

Figure 3. Summary of IMPROVE-AF project design

Evaluation Design

As previously indicated, our primary aim is to increase the rate of guideline-indicated oral anticoagulant usage at hospital discharge among St. Michael's Hospital inpatients identified as having AF/AFL on ECGs by 50% within 6 months. We will monitor this outcome using a run chart and Shewhart chart (See Fig. 4). Based on identified non-random variation in the data, we can conduct further continuous quality improvement through serial Plan-Do-Study-Act cycles.

The nature of our project's integration with real-time hospital data analysis has several distinct advantages for this type of QI initiative:

1) Practice gap and improvements can be assessed on an ongoing and near-instantaneous basis
2) Data is collected and analyzed (automated output on OAC use/prescriptions on discharge summaries can be converted seamlessly into a run chart) in real-time
3) Frequent data points enable robust evaluation of non-random variation in the data, to determine that the results are related to the intervention and its subsequent modifications

We plan to more broadly disseminate the project outcomes in the form of national/international cardiology and quality improvement conference presentations and eventual publication in a Quality Improvement peer-reviewed scientific journal. The methodology is also scalable to other targeted initiatives at St. Michael's Hospital in which access to the Enterprise Data Warehouse can enable identification and risk stratification of specific patient subgroups.

Detailed Work Plan and Deliverables Schedule

Timeline	Deliverable
June 2018	-Complete preliminary algorithm for data exploration and case testing -Finalize notification protocols with St. Michael's Hospital IT department
July-Sept 2018	-Iterative algorithms to refine sensitivity and specificity of AF Alert detection -Begin rollout of intervention including active consultation by EP and internal medicine -Real-time collection of outcome data -Finalize educational materials for distribution to MRP/family physician during admission and upon discharge
October-December 2018	-Continue to analyze weekly run/Shewhart charts of OAC prescription practices on

	discharge to further improve AF Alert and target educational programming around specific units as needed -Periodic surveys of medical and surgical unit most responsible physicians and consultant physicians to ensure that consultations and educational materials are providing value (process and balancing measures) -Establish sustainable format for AF Alert notification to EP service (e.g. Tableau Desktop)
January 2019 – June 2019	-Test the finalized intervention over a 6-month period

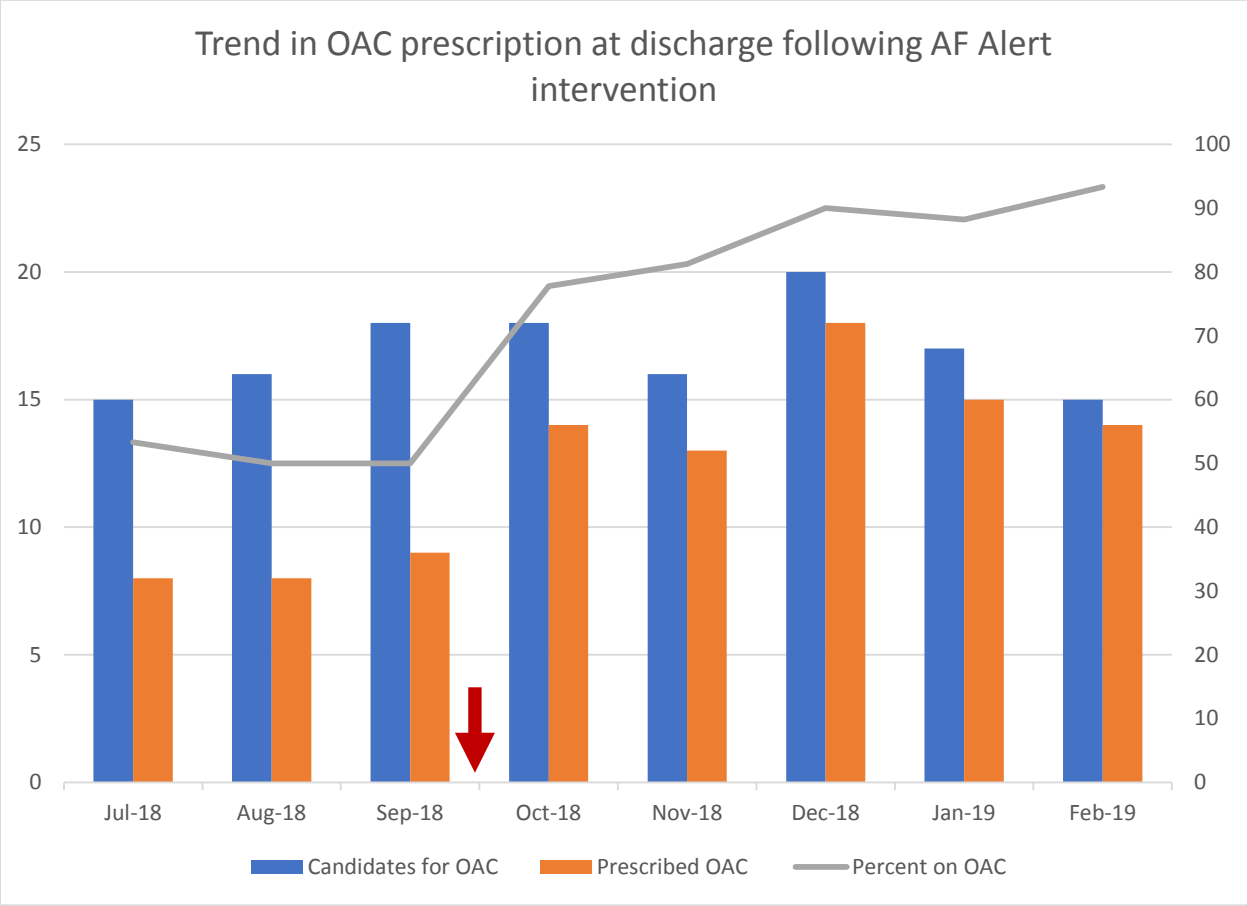

Figure 4: Conceptual trends with initiation of IMPROVE-AF intervention (red arrow denotes onset of intervention).