SPECIAL REPORT

Shifting the Paradigm: A Population Health Approach to the Management of Direct Oral Anticoagulants

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ABSTRACT: Over the past decade, direct oral anticoagulants (DOACs) have contributed to a major paradigm shift in thrombosis management, replacing vitamin K antagonists as the most commonly prescribed anticoagulants in many countries. While DOACs provide distinct advantages over warfarin (eg, convenience, simplicity, and safety), they are frequently associated with inappropriate prescribing and adverse events. These events have prompted regulatory agencies to mandate oversight, which individual institutions may find difficult to comply with given limited resources. Veterans Health Administration (VHA) has leveraged technology to develop the DOAC Population Management Tool (PMT) to address these challenges. This tool has empowered VHA to update a 60-year standard of care from one-to-one provider-to-patient anticoagulation monitoring to a population-based management approach. The DOAC PMT allows for the oversight of all patients prescribed DOACs and leads to intervention only when clinically indicated. Using the DOAC PMT, facilities across VHA have maximized DOAC oversight while minimizing resource usage. Herein, we discuss how the DOAC PMT was conceived, developed, and implemented, along with the challenges encountered throughout the process. Additionally, we share the impact of the DOAC PMT across VHA, and the potential of this approach beyond anticoagulation and VHA.

Key Words: anticoagulant ■ anticoagulation ■ direct oral anticoagulant ■ DOAC management ■ population health ■ population management ■ veterans

Until a decade ago, vitamin K antagonists (VKAs) such as warfarin enjoyed nearly 60 years of market exclusivity as the only available oral anticoagulants. With their variable dosing, narrow therapeutic window, frequent laboratory monitoring, and a plethora of endogenous and exogenous factors impacting the quality of therapy, VKAs have represented a significant therapeutic challenge—requiring substantial resources to manage. Direct oral anticoagulants (DOACs) first appeared on the US market in 2010 and have reshaped the anticoagulation landscape. With fixed dosing, predictable pharmacokinetics, and no intensive therapeutic monitoring requirement, DOACs are generally considered safer and more convenient than VKAs. Despite these advantages, DOACs, are still associated with inappropriate prescribing and associated adverse events resulting in a concerted effort from regulatory agencies to improve anticoagulation safety.[1] The Joint Commission recently highlighted the need for DOAC vigilance via "Sentinel Event Alert 61" as well as updated National Patient Safety Goals (NPSGs) to "*Reduce the likelihood of patient harm associated with the use of anticoagulant therapy.*"[2,3] These safety concerns highlight that while DOACs do not require monitoring in the traditional sense (ie, frequent scheduled one-on-one interactions between anticoagulation care providers and individual patients), there is an increasing need for oversight. This increased demand presents a unique challenge for anticoagulation programs. Providing DOAC oversight within the traditional practice model, which was justifiable for VKA management, yields little clinical impact for DOAC oversight while

Nonstandard Abbreviations and Acronyms

DOAC	direct oral anticoagulant
PBM	Pharmacy Benefits Management
PMT	population management tool
SOC	standard of care
VA	Veterans Affairs
VHA	Veterans Health Administration
VKA	vitamin K antagonist

putting a significant strain on resources. Within the Veterans Health Administration (VHA), the shift from management to oversight became apparent, requiring a corresponding shift in the practice model paradigm. These shifts were the genesis for developing the DOAC PMT, which allowed anticoagulation programs within VHA to leverage the power of data and technology to efficiently meet DOAC oversight requirements of regulatory agencies and provide high-quality anticoagulation care. This paper aims to provide a roadmap of the tool's development, implementation, and impact with the hopes of encouraging the broader adoption of a population-based approach to DOAC oversight.

VHA AND DOACS

VHA consists of >170 medical centers and >1000 outpatient clinics serving the complete healthcare needs of >9 million veterans.[4] As of June 2021, >332 000 veterans were prescribed DOACs, with a continued rise in prescribing anticipated. It became apparent from numerous inquiries and forum discussions amongst anticoagulation providers across VHA that a significant need existed for an innovative practice model that would result in effective and efficient DOAC oversight. To maximize efficiency, this model would need to concentrate the efforts of anticoagulation providers on issues of significant clinical importance while minimizing extraneous steps. A standard performance improvement approach was taken to achieve this innovative practice model. This included establishing a project team consisting of anticoagulation providers, program managers, and subject matter experts who collaborated with pharmacy-trained data analytics experts to explore how a population management tool could be developed, validated, and diffused for implementation across VHA. The result was the DOAC PMT.

DOAC PMT: HISTORY AND IMPLEMENTATION

The DOAC PMT is an interactive clinical report that collates data from the VHA Corporate Data Warehouse, applying numerous algorithms across all patients prescribed DOACs in VHA. Building on established Veterans Affairs (VA) Pharmacy Benefits Management (PBM), Medical Advisory Panel, and Veterans Integrated Service Network Pharmacist Executive guidance on the oversight and monitoring of DOACs, the Subject matter experts and informaticists established logic designed to "flag" patients with issues of potential clinical concern. These flags are grouped categorically and highlight issues related to dose, indication, drug-drug interactions (including selected pharmacodynamic interactions such as concomitant dual antiplatelet therapy or non-steroidal anti-inflammatory agents), overdue or concerning laboratory results, medication non-adherence, prescriptions lacking documented indication, patient situations where DOACs are contraindicated or controversial (eg, the presence of a prosthetic heart valve; female of childbearing age without contraceptives), and DOAC orders requiring renewal soon (Figure). The algorithm used to determine dosing appropriateness has been published previously and remains in use with minimal modification over time.[5] As the Corporate Data Warehouse updates daily, this logic applies to the DOAC population anew each day. These flags allow all patients prescribed a DOAC through VHA to undergo evaluation for clinical issues each day the prescription is active—a goal that is unattainable in a standard practice model with scheduled periodic assessments.

The team's first collaborative task was to vision cast the project from inception to completion. Short-term goals included: (1) developing the tool based on sound clinical evidence and logic, (2) validating it amongst pilot facilities, and (3) identifying and sharing what types of workflow redesign allowed successful incorporation into practice at these pilot facilities. Longer-term goals included: (1) diffusion across VHA facilities, (2) adding additional enhancements, and (3) eventual collaboration and support via the VA PBM Center for Medication Safety.

The DOAC PMT was initially developed for Veterans Integrated Service Network 15, which primarily includes Kansas, Missouri, and parts of Illinois. The initial implementation was at the Kansas City VA Medical Center. Feedback was used to adjust the original logic and computer coding and add features. The Kansas City VA Medical Center established clinical practices that incorporated this population-based management approach. Additional subject matter experts from Veterans Integrated Service Networks 8, 9, and 19 were subsequently added to the project, and the tool was added to dozens of individual VA sites upon end-user request throughout 2017. By early 2018, the DOAC PMT was made nationally available to all interested VA medical centers. Extensive user feedback was incorporated into the tool, and a variety of practice models were reviewed, including primary care provider-driven, centralized anticoagulation clinics, and distributed pharmacy
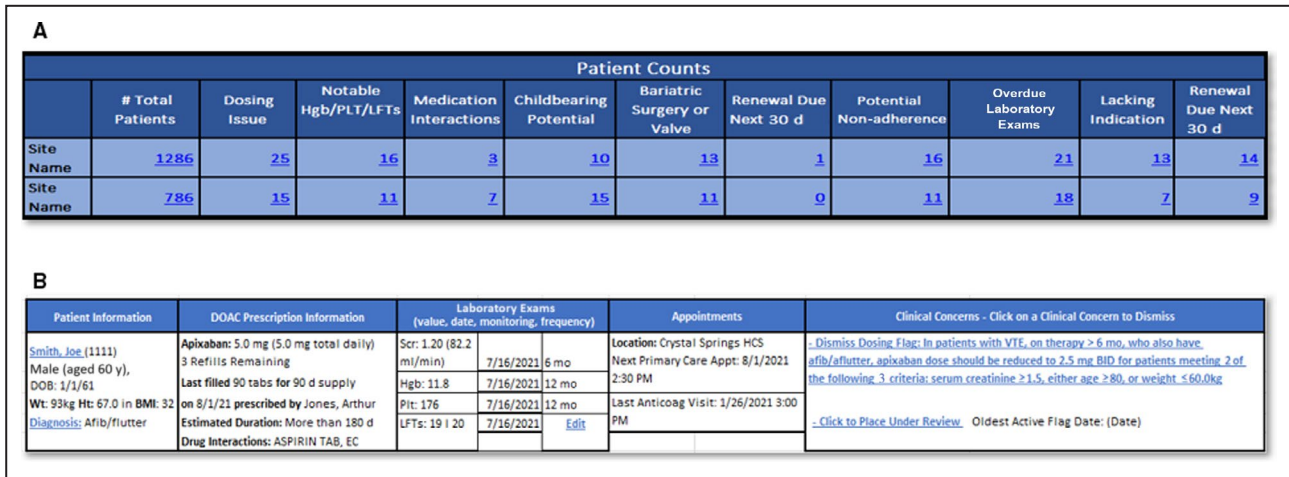
A

Patient Counts											
	# Total Patients	Dosing Issue	Notable Hgb/PLT/LFTs	Medication Interactions	Childbearing Potential	Bariatric Surgery or Valve	Renewal Due Next 30 d	Potential Non-adherence	Overdue Laboratory Exams	Lacking Indication	Renewal Due Next 30 d
Site Name	1286	25	16	3	10	13	1	16	21	13	14
Site Name	786	15	11	7	15	11	0	11	18	7	9

B

Patient Information	DOAC Prescription Information	Laboratory Exams (value, date, monitoring, frequency)		Appointments	Clinical Concerns - Click on a Clinical Concern to Dismiss
Smith, Joe (1111) Male (aged 60 y), DOB: 1/1/61 Wt: 93kg Ht: 67.0 in BMI: 32 Diagnosis: Afib/flutter	Apixaban: 5.0 mg (5.0 mg total daily) 3 Refills Remaining Last filled 90 tabs for 90 d supply on 8/1/21 prescribed by Jones, Arthur Estimated Duration: More than 180 d Drug Interactions: ASPIRIN TAB, EC	Scr: 1.20 (82.2 ml/min) Hgb: 11.8 Plt: 176 LFTs: 19 I 20	7/16/2021 6 mo 7/16/2021 12 mo 7/16/2021 12 mo 7/16/2021 Edit	Location: Crystal Springs HCS Next Primary Care Appt: 8/1/2021 2:30 PM Last Anticoag Visit: 1/26/2021 3:00 PM	- Dismiss Dosing Flag: In patients with VTE, on therapy > 6 mo, who also have afib/aflutter, apixaban dose should be reduced to 2.5 mg BID for patients meeting 2 of the following 3 criteria: serum creatinine ≥1.5, either age ≥80, or weight ≤60.0kg - Click to Place Under Review Oldest Active Flag Date: (Date)

Figure 1. Visualization of the direct oral anticoagulant population management tool.
A, Direct oral anticoagulants Population Management Tool home screen: provides an overview of the number of flags currently in play for each area of concern. This allows the healthcare team to prioritize and filter flags based on the reason for clinical concern. Each number serves as a hyperlink to the expanded Population Management Tool interface where patients are grouped based on the flag for a focused intervention. When a hyperlink number is clicked, it will expand and provide a more in-depth review of clinically relevant factors and the reason the patient is flagging. **B**, Expanded single-patient view: Each blue hyperlink allows the user to review the report in more detail or adjust monitoring frequencies. BMI indicates body mass index; DOAC, direct oral anticoagulants; and DOB, date of birth. *This is a representation using an erroneous patient record. No actual patient data are shown.*
• Patient name provides additional patient-specific detail (eg, refill history, flag dismissal history).
• Diagnosis provides a comprehensive list of patient diagnoses and gives the reviewer the ability to remove a diagnosis from being included in the report.
• Edit allows the reviewer to adjust monitoring frequency by complete blood count and serum creatinine.
• Clinical Concerns box includes the active flags (as hyperlinks) that require review. For the example provided, the patient is flagging for a potential dosing issue. After they have reviewed and addressed the concern, the user can dismiss the flag with 1 click.
• The Click to Place Under Review function marks a patient for further review at a future date.
aflutter, atrial flutter; AFib, atrial fibrillation; BID, bis in die, latin for "twice daily"; HCS, health care system; Hgb, hemoglobin; LFT, liver function test; PLT, platelets; VTE, venous thromboembolism.

surveillance. Business rules and best practices were carefully curated, documented, and shared across VHA via various modalities. These included sharing of information across internal VA anticoagulation email groups, posting of practice models on the DOAC PMT SharePoint, web-based conference calls and educational sessions, and individual facility (or one-on-one user) sessions conducted by the developers and subject matter experts. In 2019, the DOAC PMT was formally validated, endorsed, and adopted by VA PBM Center for Medication Safety, which released an updated version in February 2021. In addition, an official subject matter expert sub-committee was assembled through VA PBM Center for Medication Safety and meets regularly to review user feedback and emerging clinical data that may require updates or enhancements to the tool.

An ideal practice model involves a centralized anticoagulation management program in the review and management of these flags. The flags should be reviewed daily and prioritized based on the critical nature of the flag and the length of time the flag has been available for review with a goal to review each flag within 7 days of populating or as defined by the local facility anticoagulation program. The centralized anticoagulation management program may be staffed by clinical pharmacy specialists, advanced practice registered nurses, or other healthcare providers. However, to be optimally efficient and to promote each team member working at the top of their license, it is desirable that the clinician addressing the flags be able to manage any clinical consideration independently and make changes to the treatment plan as clinically indicated. Clinical pharmacy specialists within VHA practice in this manner via a medical center approved scope of practice. While standardization to this preferred practice approach would be ideal, the DOAC PMT is sufficiently flexible to support a multitude of practice models across VHA.

IMPACT AND SUCCESS OF THE INITIATIVE

The DOAC PMT's benefits on staffing and service efficiencies have been subjectively felt and objectively proven. These benefits were recently recognized when the team members leading this initiative received the 2019 Under Secretary for Health Pharmacy Benefits Management Innovation Award. As compared with a clinic-based model, Valencia et al demonstrated that

the DOAC PMT led to nearly a tripling of significant interventions made per patient encounter (0.55 versus 0.20, $P<0.001$). A patient encounter was defined as a scheduled visit (face-to-face or telephone) for the clinic-based model and as a review of a flag on the DOAC PMT for the DOAC PMT model. As a result of this improved efficiency, the time to generate an intervention (eg, flag review and subsequent intervention if appropriate versus patient visit, assessment and subsequent intervention) was reduced by 75% (16 minutes versus 64 minutes).[6] In a similar project, Chau reported that incorporating the DOAC PMT into their practice model resulted in a tripling in the number of clinical interventions occurring in 86% less time than standard clinic-based monitoring.[7] In 2017, May et al reported a 41% increase in pharmacy efficiency after a DOAC PMT-based practice model was implemented, reporting that the model "… allowed the CPS [clinical pharmacy specialists] to target interventions to high-risk patients and complete interventions by chart review rather than telephone encounter, thus reducing the workload of the CPS."[8] The same year, Tolley et al reported, "Clinical pharmacists were able to globally manage a large number of patients prescribed DOACs at the Ralph H. Johnson VA Medical Center and make 1142 interventions in 699 patients (56% of the DOAC population) within a 2.5 month time period."[9]

The full impact on clinical outcomes is yet to be fully elucidated but has the potential to be dramatic. Inappropriate DOAC dosing has been identified as a significant problem with rates in atrial fibrillation populations as high as 16% and considerable ties to major bleeding and thrombotic complications.[10] A study by Rossier et al evaluated the DOAC PMT's impact on questionable DOAC dosing rates in VHA, comparing 20 sites using the DOAC PMT to 20 non-use sites deemed "standard of care" (SOC). DOAC PMT use was associated with a 4.3% absolute reduction in questionable dosing rates compared with SOC (17.5% SOC versus 13.2% PMT, $P<0.001$). DOAC PMT use was associated with a statistically significant difference in questionable dosing of apixaban ($P<0.001$), dabigatran ($P=0.03$), and atrial fibrillation and venous thromboembolism ($P<0.001$) subgroups. In the atrial fibrillation subgroup, rates of questionable dosing in the SOC group were nearly double that of the DOAC PMT group (10.4% SOC versus 5.3% PMT, $P<0.001$).[5]

Acknowledging the advantages of this approach to DOAC oversight, VA PBM Center for Medication Safety formally assumed management and oversight of the tool in 2019, validating and promoting this practice model that many consider to be the new SOC. Additionally, national VA anticoagulation guidance has recently been updated with population health language.[11]

TRANSLATION TO OTHER SETTINGS

Given these experiences and the rapid climb in DOAC usage, over the past 3 years >80% of VHA medical centers have implemented a DOAC PMT-based practice model, shifting the 60-year paradigm within the field of anticoagulation from individual patient monitoring to a technology-based population health approach. This practice model has also resulted in additional opportunities for clinical pharmacy technicians to work at the top of their license and collaborate with anticoagulation providers. Clinical pharmacy technicians can target those PMT flags that point out patients who are overdue for laboratory monitoring as well as those overdue for medication refill, possibly identifying suboptimal medication adherence. The clinical pharmacy technicians can use standardized note boilerplates, templated scripts, and clinical algorithms with pre-defined criteria indicating when to elevate to the provider.

To the best of our knowledge, the VA's DOAC PMT represents the first widely used population health tool of its kind to be incorporated into a large health system for the purpose of managing anticoagulants (or, for that matter, any high-risk class of medications). We are aware of at least 1 similar DOAC population health management tool based on the VA's model being developed and implemented in a broadly available commercial electronic health record platform.[12]

Recognizing the advantages of this population health approach to DOAC oversight and targeting other high-risk medication, the tool's original developers collaborated with other VA pharmacy informatics colleagues to develop additional population health tools modeled after the DOAC PMT. Targeted specialties include anemia, cardiology, endocrinology, gastroenterology, geriatrics, mental health, neurology, oncology, rheumatology, and transplant. Examples within these specialties include antiarrhythmic monitoring for overdue ECGs, x-rays (amiodarone), laboratory measurements (electrolytes, renal function if applicable), baseline procedures (pulmonary function tests for amiodarone), and missed specialty appointments. For oncology, examples include specifics on adherence and compliance with prescription refills and renewals, laboratory monitoring (specific parameters established per drug given toxicity profile), required procedures for monitoring toxicity (pulmonary function tests, baseline cardiac assessments, vital signs), and follow-up with the prescribing service. SMEs across these specialties are working with clinical informaticists to develop, validate, and test logic and to determine the best method to incorporate these tools into their various practice settings.

SUMMARY OF THE EXPERIENCE, FUTURE DIRECTIONS, AND CHALLENGES

The introduction of DOACs ushered the world into a new era of anticoagulation. VKAs are admittedly cumbersome medications that require significant resources to manage. The more predictable pharmacokinetics and simplified monitoring criteria of DOACs, along with the continued improvement in data collection through electronic health records, have provided a fertile environment for innovation. Presently, each month more than 1000 pharmacists and clinical pharmacy technicians across VHA utilize the DOAC PMT's technology-based population health approach to efficiently optimize the efficacy and safety profile of DOACs. But the implications of this practice model extend well beyond the realm of anticoagulation within VHA. In the same way DOACs have moved to prominence in anticoagulation therapy, this practice model has the potential to become the standard for monitoring other classes of medications. Some challenges with DOAC PMT optimization remain, but overall, the DOAC PMT has been instrumental in the VHA's efforts to ensure that the benefits of DOACs are maximized, the risks are minimized, and that these goals are achieved in the most efficient manner possible. This approach should serve as a model for other healthcare systems and organizations facing similar challenges.

ARTICLE INFORMATION

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