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ORIGINAL RESEARCH

Evidence-Based Emergency Medicine

Effectiveness of an algorithm-based care pathway for patients with non-valvular atrial fibrillation presenting to the emergency department

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Abstract

Objective: Atrial fibrillation (AF) carries substantial morbidity and mortality. Evidence-based guidelines have been synthesized into emergency department (ED) AF care pathways, but the effectiveness and scalability of such approaches are not well established. We thus evaluated the impacts of an algorithmic care pathway for ED management of non-valvular AF (EDAFMP) on hospital use and care process measures.

Methods: We deployed a voluntary-use EDAFMP in 4 EDs (1 tertiary hospital, 1 cardiac hospital, 2 community hospitals) of an integrated delivery organization using a multifaceted implementation approach. We compared outcomes between patients with AF treated using the EDAFMP and historical and contemporaneous "usual care" controls, using a propensity-score adjusted generalized estimating equation. Patients with an index ED encounter for a primary visit reason of non-valvular AF (and no excluding concurrent diagnoses) were eligible for inclusion.

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Results: Preimplementation (January 1, 2016–December 31, 2016), 628 AF patients were eligible; postimplementation (September 1, 2017–June 30, 2019), 1296, including 271 (20.9%) treated with the EDAFMP, were eligible. EDAFMP patients were less likely to be admitted than both historical (adjusted odds ratio [aOR], 95% confidence interval [CI]: 0.45, 0.29–0.71) and contemporaneous controls (aOR, 95%CI: 0.63, 0.46–0.86). ED visits and hospital readmissions over 90 days subsequent to index ED encounters were similar between postimplementation EDAFMP and usual care groups. EDAFMP patients were more likely to be prescribed anticoagulation (38% v. 5%, $P < 0.001$) and be referred to a cardiologist (93% vs 29%, $P < 0.001$) versus the comparator group.

Conclusion: EDAFMP use is associated with decreased hospital admission during an index ED encounter for non-valvular AF, and improved delivery of AF care processes.

KEYWORDS
atrial fibrillation, clinical effectiveness, clinical variability, quality improvement

1 | INTRODUCTION

1.1 | Importance

Approximately 10 million Americans have atrial fibrillation (AF),[1] a condition that carries an annual rate of 165 emergency department visits per 100,000 persons,[2] and an annual incremental cost of $26 billion.[3] AF burden is expected to grow as the population ages and risk factors for the arrhythmia (including obesity, hypertension, and diabetes, among others) accumulate.[4] Despite recognition of AF as an impactful, high-cost condition (and the presence of widely accepted clinical guidelines),[5] there is significant variability in evidence-based care delivery, including use of oral anticoagulant therapy,[6] referral to cardiology or electrophysiology specialists,[7] and assessment for stroke risk.[8] Management of patients presenting to the ED with AF, and in particular, the decision to admit or discharge represents another area of major practice variation.[9,10] Admission rates from the ED for AF as a primary diagnosis are nearly twice as high in the United States as Canada.[11]

1.2 | Background

Interventions for patients presenting to the ED with AF (centered on rate control, thromboembolism prevention, and rhythm correction), including outpatient management, have been tested and shown to be efficacious and safe.[12–14] The AF practice guidelines and evidence base surrounding management of AF in the ED have been synthesized into algorithmic care pathways by several professional entities, including the Heart Rhythm Society (HRS) and the American College of Emergency Physicians (ACEP).[15] However, published data regarding specific programs for successful uptake of these pathways and their associated impacts on care delivery and health care use are limited. Prior studies evaluating similar NVAF pathways have generally involved relatively small sample sizes, a single hospital site, or sole use of a pre-post intervention study design.[12,16–18]

Structured quality improvement (QI) approaches can facilitate closure of gaps between clinical practice and provision of evidence-based care, reducing non-beneficial variability. Examples of effective QI interventions include combining care processes into an integrated bundle or pathway to accelerate adoption,[19,20] providing well-constructed clinical decision support and workflow enhancements (increasingly embedded in health information technology) to promote uptake and consistent use,[21–24] and timely performance feedback to drive change.[25,26] Education is a core component of any practice adoption endeavor, but its effects tend to be short lived if used in isolation.[27] Strategies that incorporate multiple approaches and allow tailoring to local context can further enhance adoption.[28,29]

1.3 | Goals of this study

AF, with its prevalence, costs, and demonstrated variations in care despite available guidelines and effective treatments, is a high-yield condition for QI initiatives. Focusing on patients presenting to the ED with a primary issue of non-valvular AF (NVAF), we deployed an AF care pathway based on HRS and ACEP management recommendations in the EDs of multiple hospitals across our health system using a structured QI approach. The QI work was paired with a study design to evaluate 2 research questions: (1) the impact of an implementation program on AF care pathway adoption; and (2) the effectiveness of the AF pathway on improving clinical process metrics and reducing inpatient hospital use for a primary diagnosis of AF relative to usual care without the pathway.

2 | METHODS

2.1 | Study setting

The study was conducted in the EDs of 4 hospitals within Baylor Scott & White Health (BSWH), a large integrated care delivery organization in north and central Texas. The Baylor Scott & White Research Institute Institutional Review Board approved the study to be conducted under a waiver of informed consent. Participating EDs were selected based on geographic proximity to cardiology specialty clinics (to promote timely post-ED discharge follow-up) and to capture a study population across a range of BSWH ED/hospital settings: a tertiary, academic medical center that also sees a large volume of community patients, a cardiac specialty hospital (the ED in this facility primarily sees patients with cardiac diagnoses), and 2 community hospitals. All 4 of the study EDs are staffed by emergency physicians from the same practice group and provide a full range of care services such that AF could be managed within the facility.

2.2 | Intervention and study design

The AF care pathway used in the study was derived from ED NVAF management algorithms endorsed by the HRS and ACEP.[15] Minor revisions were made based on recommendations from BSWH emergency physicians and electrophysiologists to better align with local workflows. The resulting study algorithm is provided in **Online Appendix 1**. Content from this algorithm was embedded into ED patient care workflows, orders, and documentation in the electronic health record (EHR, which for the participating BSWH EDs during the study period was MEDHOST), collectively comprising the ED AF management pathway (EDAFMP). A multifaceted implementation approach, grounded in Rogers' Diffusion of Innovation Theory[30] and summarized in **Table 1**, was used to deploy the EDAFMP.

The Bottom Line

This study evaluated the impact of an algorithmic care pathway for emergency department management of non-valvular atrial fibrillation (EDAFMP) ion hospital use and care process measures. EDAFMP use was associated with decreased hospital admission during an index ED visit. Return ED visits and hospital readmissions over 90 days after index ED encounters were similar between those treated with EDAFMP and those given "usual care." The EDAFMP patients were more likely to be prescribed anticoagulation (38% vs 5%) and referred to a cardiologist (93% vs 29%) from the ED.

The relationship of the EDAFMP intervention to outcomes was assessed during multiple comparison phases: (1) preimplementation versus postimplementation and (2) concurrent, prospective observational design within the postimplementation period (EDAFMP vs usual care). The preimplementation period was defined January 1, 2016–December 31, 2016, followed by an 8-month data accrual pause to allow completion of EHR modifications, referral workflows, and training necessary to enable use of the EDAFMP. The postimplementation period (ie, when the EDAFMP was considered fully active) was defined as September 1, 2017–June 30, 2019. The postimplementation study period was extended to 21 months to allow for reeducation on the EDAFMP and provision of peer feedback to emergency physicians on pathway use trends to help improve adoption to the a priori minimum goal rate of 20% in the total study population.

TABLE 1 Components of the Emergency Department Atrial Fibrillation Management Pathway implementation program

Tactic	Description
Engagement of physician champions	ED and electrophysiology physicians respected by their peers and highly invested in improving AF care in the ED were identified and tasked as physician champions. They took responsibility for local ownership, including promoting use of the EDAFMP to peers, disseminating pathway use data, and facilitating resolution of any related workflow or clinical issues.
Workflow	Documentation tools with the dual functions of supporting EDAFMP process delivery and data collection were embedded into the EHR. From the front-end, these tools appeared as discrete orderable items specific to AF care and structured note fields. This standardization also supported retrospective data extraction from the back end for reporting and outcomes analyses.
Clinical decision support	Prompts to perform CHA_2DS_2-VASc and HAS-BLED calculations were integrated into the clinical workflow documentation. Pertinent AF orders were placed in appropriate fields aligned with typical clinical workflow (eg, cardiology referral order placed in the discharge section).
Training	Over the 12 months before EDAFMP implementation, in-person and online tutorials were conducted for ED clinicians, explaining the rationale behind the EDAFMP and demonstrating its use. Completion of the module was an expected task; performance was tracked, and reminders given if incomplete.
Performance feedback	A monthly electronic data extract was collected from each site to track EDAFMP use. These data-populated performance reports were distributed to the EDAFMP champions at participating EDs. The EDAFMP champions used these reports as a coaching tool. Of note, use of the EDAFMP was voluntary.

Abbreviations: AF, atrial fibrillation; ED, emergency department; EDAFMP, Emergency Department Atrial Fibrillation Management Pathway; EHR, electronic health record.

2.3 | Patients

Patients 18 years or older presenting to 1 of the 4 study EDs with a primary diagnosis of NVAF (or atrial flutter) based on presence of *International Classification of Diseases, Ninth Revision* (ICD-9) codes 427.31 and 427.32 or *Tenth Revision* (ICD-10) codes I48.0, I48.1, I48.2, I48.3, I48.4, I48.9, I48.91, and I48.92, from January 1, 2016 through June 30, 2019 were potentially eligible for inclusion. Our case exclusion methodology for analysis selected accompanying present-on-admission ICD-9 and 10 codes available in an electronic data format, with a particular focus on concurrent diagnoses that would typically make patients ineligible for use of a general NVAF care pathway, would usually require inpatient management, or precluded outpatient anticoagulation (see **Online Appendix** 2).

2.4 | Outcome measures

EDAFMP use (as a "yes/no" categorical variable any element of the pathway was considered to an indicator of use) in eligible patients was tracked at the hospital and aggregated system levels to evaluate uptake. The primary effectiveness outcome for the EDAFMP was the patient's disposition in the index ED encounter (ED discharge vs hospital admission). This dichotomous outcome of patient disposition was selected to measure the impact of the pathway on inpatient hospitalizations attributable to AF. Additionally, we examined length of stay for admitted patients, as well as ED use and in-patient admission (within any BSWH facility) at 30, 60, and 90 days after the index encounter. Care process metrics assessed included the percentage of patients appropriately (concordant with documented stroke/bleeding risks: CHA_2DS_2-VASc ≥ 2 and HAS-BLED score low or moderate) prescribed anticoagulation at the index ED encounter, as well as referral to a cardiologist for outpatient follow-up at the time of ED disposition.

2.5 | Data collection

Patient demographics, comorbidities, and study outcomes were extracted from the BSWH EHR and administrative databases. Some care process measures were not available during the preimplementation phase in a structured data format suitable for electronic extraction and so were abstracted for a subset of study eligible historical cohort patients (selected randomly in a 1:3 ratio to be representative of the larger group) by experienced chart auditors using a standardized data collection form.

2.6 | Statistical analysis

Patient demographic characteristics, comorbidities (reported if prevalence > = 2%), and study outcomes were compared using *t* tests for continuous variables and chi-square tests or Fisher tests for categorical variables. We examined the possible association between EDAFMP use and hospital admission during the index encounter using unadjusted and adjusted generalized estimating equation (GEE) models that account for data clustering within facility. The same approach was used for the comparison between the preimplementation and postimplementation EDAFMP groups and between the 2 postimplementation groups (EDAFMP vs usual care). The multivariable adjusted GEE model included patient's age, sex, race, ethnicity, insurance, and comorbidities with more than 2% observed prevalence in the study population (peripheral vascular disease, hypertension, diabetes, chronic pulmonary disease, hypothyroidism, and obesity). We constructed a logistic regression model predicting the probability of a patient being treated using the EDAFMP versus usual care (pre- or postimplementation) using baseline characteristics, which yielded an area under the receiver operating characteristic curve (or c-statistic) of 0.703. Propensity scores for EDAFMP use were calculated for each patient and included in the multivariable GEE model. Inverse probability weighting was not performed because the GEE models did not allow it.

All analyses were performed using STATA 14.0 (Stata Corp, TX).

3 | RESULTS

There were 628 patients eligible for inclusion in the preimplementation phase and 1296 eligible postimplementation patients, 271 (20.9%) of whom were treated using the EDAFMP. **Table 2** displays baseline characteristics of the study cohorts. EDAFMP patients were younger than the postimplementation usual care group (65 vs 69 years, $P < 0.001$), but there were no other significant differences in demographics or insurance status between comparators. The EDAFMP group also had a statistically significant lower rate of comorbidities relative to preimplementation and postimplementation usual care groups. A larger proportion of patients ultimately receiving the EDAFMP presented to the ED at the tertiary medical center or specialty cardiac hospital (Table 2).

3.1 | Pathway uptake

At the study sites, 45 of 89 (51%) ED physicians practicing at those facilities used the EDAFMP at least once. **Figure 1** shows EDAFMP use on eligible cases during the postimplementation phase at each facility and at the aggregated system level. Adoption was low overall (system average < 25%) and variable during the first 12 months after implementation but began to trend upward during the subsequent 9 months. System EDAFMP use peaked at 40% of eligible cases in the final month of data collection, driven by increased adoption at the tertiary/academic medical center hospital and cardiac specialty hospital (57% and 41% use respectively in eligible cases that month). Deployment of the pathway at the individual physician level among those who used the EDAFMP at least once was also highly variable across all the study sites, ranging from 5% to 60% of their eligible cases.

TABLE 2 Characteristics of the study population before and after implementation of the Emergency Department Atrial Fibrillation Management Pathway, including comparison of postimplementation EDAFMP versus usual care groups

	Pre-EDAFMP implementation	Post-EDAFMP Implementation		EDAFMP versus Pre-implementation	EDAFMP versus usual care
	(n = 628)	Usual care (n = 1,025)	Pathway (n = 271)	*P* value	*P* value
Age (mean, SD), years	67 (14)	69 (14)	65 (13)	0.127	<0.001
Weight (mean, SD)[a], kg	88.1 (25.8)	88.8 (25.7)	89.3 (23.2)	0.571	0.776
Sex (n,%)					
Male	308 (49)	513 (50)	151 (55.7)	0.066	0.097
Female	320 (51)	512 (50)	120 (44.3)		
Race (n,%)					
White	552 (87.9)	891 (86.9)	238 (87.8)	0.062	0.678
African American	70 (11.1)	114 (11.1)	26 (9.6)		
Asian	6 (1)	14 (1.4)	4 (1.5)		
Other	0 (0)	6 (0.6)	3 (1.1)		
Hispanic (n,%)	31 (4.9)	54 (5.3)	18 (6.6)	0.301	0.38
Insurance (n,%)					
Medicare	378 (60.2)	671 (65.5)	158 (58.3)	0.688	0.181
Managed care	194 (30.9)	271 (26.4)	85 (31.4)		
Self/unknown	44 (7)	69 (6.7)	23 (8.5)		
Commercial/other government	12 (1.9)	14 (1.4)	5 (1.8)		
Comorbidity (n,%)[b]					
Peripheral vascular disease	24 (3.8)	22 (2.1)	9 (3.3)	0.714	0.26
Hypertension	403 (64.2)	535 (52.2)	96 (35.4)	<0.001	<0.001
Diabetes	113 (18)	148 (14.4)	24 (8.9)	<0.001	0.016
Chronic pulmonary disease	69 (11)	101 (9.9)	14 (5.2)	0.006	0.016
Hypothyroidism	89 (14.2)	85 (8.3)	11 (4.1)	<0.001	0.018
Obesity	51 (8.1)	80 (7.8)	16 (5.9)	0.245	0.288
Depression	39 (6.2)	31 (3)	5 (1.8)	0.005	0.293
Presenting facility (n,%)					
Community hospital A	78 (12.4)	198 (19.3)	8 (3)	<0.001	<0.001
Community hospital B	70 (11.1)	113 (11)	10 (3.7)		
Tertiary medical center	242 (38.5)	299 (29.2)	116 (42.8)		
Specialty cardiac hospital	238 (37.9)	415 (40.5)	137 (50.6)		

Abbreviation: EDAFMP, Emergency Department Atrial Fibrillation Management Pathway.

[a]In the postimplementation phase, data on weight available among 824 patients;.data on creatinine available among 935patients and it is initial creatinine measurement if patients have.multiple measurements but also the highest values.

[b]Comorbidity is reported if its prevalence > = 2% in the study population.

P values from *t* test for continuous variables and chi-square or Fisher exact tests for categorical variables.

3.2 | Hospital use comparisons

Univariate analyses (**Table 3**) showed that patients in the EDAFMP group were less likely to be admitted compared to both the preimplementation group (13% vs 34%, $P < 0.001$) and the postimplementation usual care group (13% vs 32%, $P < 0.001$). There were no significant differences in length of stay for admitted patients, nor in ED dwell time for patients discharged from the ED among the comparison groups. The EDAFMP group was more likely to have another ED visit within 30 or 60 days of the index visit compared to the preimplementation group but significantly less likely to be readmitted to the hospital within 90 days. There were no significant differences in ED use or hospital admission between the EDAFMP and postimplementation usual care groups during a 90-day follow-up period.

Results from multivariate GEE models (**Table 3**) confirmed that EDAFMP patients were less likely to be admitted to the hospital during their index NVAF visit compared to preimplementation (unadjusted odds ratio [OR]: 0.41, 95% confidence interval [CI]: 0.24–0.48) and

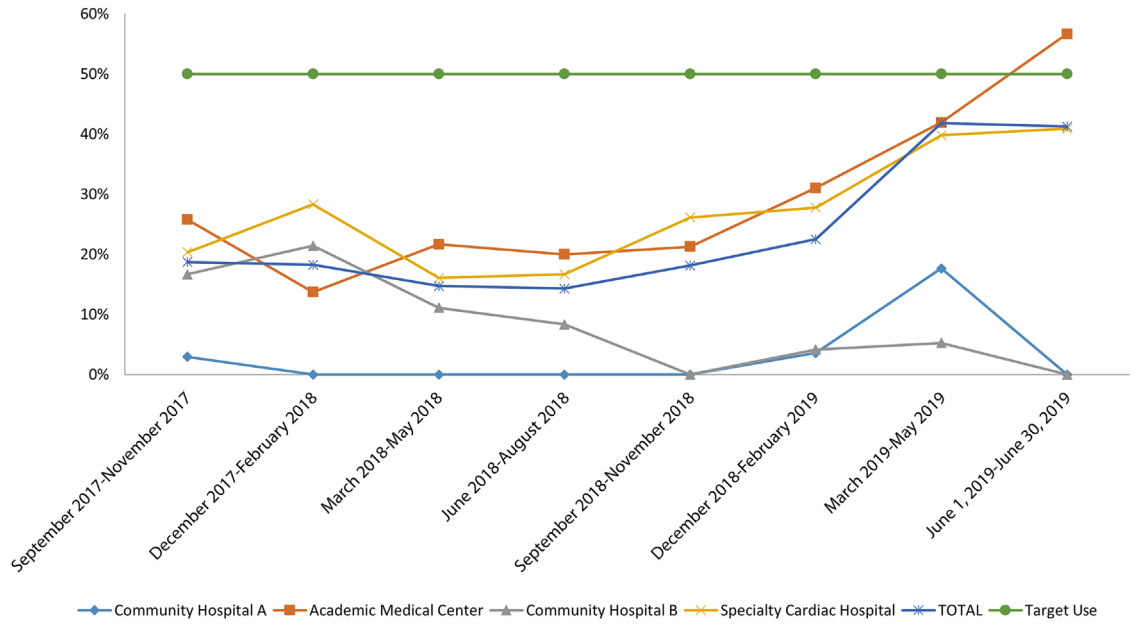

FIGURE 1 Emergency Department Atrial Fibrillation Management Pathway adoption trend by study facility (and aggregated system level). Usage rates are displayed in quarterly intervals

postimplementation usual care groups (unadjusted OR: 0.53, 95% CI: 0.31–0.89). This observation held after adjusting for potential confounding factors and propensity scores in the EDAFMP versus preimplementation group comparison (adjusted OR: 0.45, 95% CI: 0.29–0.71) as well as EDAFMP versus postimplementation group comparison (adjusted OR: 0.63, 95% CI: 0.46–0.86).

3.3 | Care process measures

Performance of AF specific process measures was compared between a random sample (N = 206) of the preimplementation group and all 271 patients treated under the EDAFMP in the postimplementation group. Patients in the EDAFMP were less likely to have an order for an in-ED cardiology consult during the index encounter (55% vs 67%, $P = 0.005$) and were more often discharged with a documented appropriate anticoagulant prescription (38% vs 5%, $P < 0.001$) from the ED versus preimplementation NVAF patients. Documented referral orders for a cardiology follow-up appointment within 72 hours after ED discharge were much higher for patients treated under the EDAFMP compared to the preimplementation group (93% vs 29%, $P < 0.001$).

4 | LIMITATIONS

This study has several considerations that should be taken into account when interpreting our findings. First, randomization of the EDAFMP at an individual patient or facility level was not feasible, so this study was conducted under an observational design. Use of the pathway was voluntary and highly variable at the hospital and individual physician level. Although we included a propensity score in our risk-adjusted models to address confounding by indication and potential selection bias for EDAFMP versus non-EDAFMP use in the concurrent postimplementation cohorts, it is possible that other unmeasured confounders at the patient, physician, and hospital level influenced the results observed. Second, eligibility for the EDAFMP was determined from a set of coded, electronically available data elements, and the exclusion criteria for our analysis was not all inclusive of other diagnoses and comorbidities that may have determined pathway use or disposition from the ED. Additional clinical factors influencing physician decisions on patient appropriateness for the EDAFMP not amenable to coded documentation (eg, acute physiologic changes like hemodynamic instability or hypoxemia), as well as whether the index ED visit for AF represented a new onset or existing diagnosis could not be reliably captured through extraction of the available electronic data set either. Third, the decision-support mechanism in the EDAFMP build around CHA2DS2-VASc and HAS-BLED scores involved a manual calculation as opposed to an automatically generated score. This process could potentially have been a factor in stroke-risk assessment and physician clinical decision-making regarding hospital admission and prescriptions for anticoagulation. Collectively with our study methodology, the denominator of truly eligible patients (ie, those without any contraindications to pathway use or appropriate for an outpatient disposition) may have been smaller than we observed, potentially overestimating the impact of the EDAFMP on likelihood of hospital admission during the ED index encounter. Future studies evaluating the AF pathway using a cluster randomized design would help reduce the number of potential confounders and provide a more definite answer on its effectiveness.

Although we included a range of ED types to capture different contexts in which NVAF patients are treated, all the included sites are members of a single integrated health care delivery system, postindex

TABLE 3 Health care use associated with the Emergency Department Atrial Fibrillation Management Pathway: Pre/Post-EDAFMP Implementation and Concurrent (EDAFMP vs Usual Care) Comparisons

	Pre-EDAFMP Implementation	Postimplementation		*P* value[a]		Unadjusted and adjusted odds ratio (95% CI)	
	(n = 628)	Usual care (n = 1025)	EDAFMP (n = 271)	EDAFMP versus Usual care	EDAFMP versus preim-plementation	EDAFMP versus pre-implementation	EDAFMP versus usual care
During index ED visit							
Disposition (n,%)							
ED discharge	414 (65.9)	701 (68.4)	236 (87.1)	<0.001	<0.001	1.00	1.00
Inpatient	214 (34.1)	324 (31.6)	35 (12.9)			0.41 (0.24-0.68)[b] 0.45 (0.29-0.71)[c]	0.53 (0.31-0.89)[b] 0.63 (0.46-0.86)[c]
Inpatient length of stay (mean, SD), days	2.8 (2.2)	3 (2.7)	3.1 (3)	0.767	0.525	–	–
ED dwell time (mean, SD), hours	4.22 (3.44)	3.87 (2.16)	3.82 (2.14)	0.752	0.108	–	–
After index ED visit							
ED use (n,%)						–	–
≤30 days postdischarge	0 (0)	13 (1.3)	5 (1.8)	0.463	0.002	–	–
≤60 days postdischarge	2 (0.3)	24 (2.3)	6 (2.2)	0.912	0.011	–	–
≤90 days postdischarge	4 (0.6)	30 (2.9)	6 (2.2)	0.535	0.075	–	–
with primary NVAF Dx	1 (0.2)	10 (1)	2 (0.7)	0.99	0.218	–	–
Hospital readmission (n,%)						–	–
≤30 days postdischarge	5 (0.8)	7 (0.7)	0 (0)	0.356	0.330	–	–
≤60 days postdischarge	8 (1.3)	7 (0.7)	0 (0)	0.356	0.114	–	–
≤90 days postdischarge	10 (1.6)	11 (1.1)	0 (0)	0.134	0.038	–	–
with primary NVAF Dx	5 (0.8)	3 (0.3)	0 (0)	0.99	0.330	–	–

Abbreviations: CI, confidence interval; ED, emergency department; GEE, generalized estimating equation; NVAF Dx, non-valvular atrial fibrillation diagnosis.
[a]*P* values from *t* tests for continuous variables or chi-square tests for categorical variables.
[b]Unadjusted GEE model.
[c]GEE logistic model adjusted for patient's age, sex, race, ethnicity, insurance, comorbidities (peripheral vascular disease, hypertension, diabetes, chronic pulmonary disease, hypothyroidism, and obesity), and propensity score.

ED visit use was captured only within the study system, and the physicians in these EDs are members of the same emergency medicine practice group. These factors may lessen generalizability of our findings. Lastly, near the end of the study period in 2019, updates in AF guidelines were published and some of the historical components used in the study EDAFMP do not reflect the most current management recommendations (eg, incorporating gender into stroke risk score assessment, among other changes).[5] The core features of the EDAFMP are decision support and structured workflow to ensure consistent delivery of specific care processes. The content should be adapted as clinical evidence on AF management evolves and to align with local resource availability.

5 | DISCUSSION

We used a structured implementation program to deploy a novel EDAFMP for NVAF across multiple EDs within a large, integrated care delivery system. After risk adjustment, use of the EDAFMP was associated with a one-half decrease in the likelihood of hospital admission during an index encounter compared to a preimplementation NVAF cohort and a one-third decrease in the likelihood of inpatient admission compared to a concurrent control group of ED patients with NVAF receiving usual care. ED visit rates over 90 days after the index encounter were similar between the EDAFMP and usual care groups, and no patients treated with the EDAFMP had a hospital inpatient admission within 90 days of the index encounter. Although adoption of the EDAFMP was relatively low during the study, our data suggest that this is an effective, safe intervention warranting further efforts to drive uptake and promote consistent use in ED environments.

Our results pertaining to hospital admission are in line with other published investigations examining AF management protocols for the ED, most of which used pathways or guidelines developed in house.[12,17,18,31–33] The magnitudes of impact on ED discharge versus hospital admission in these studies vary widely - from a 24% reduction in inpatient admissions reported by an institution that initiated a multidisciplinary collaborative project for management of AF in the ED[31 to a] 5-fold reduction in admissions (from 80% to 16%, $P < 0.001$) reported

by a hospital that implemented an AF treatment pathway codeveloped by electrophysiologists and emergency physicians.[12] Importantly, admission rates in the preimplementation group (34.1%) and postimplementation usual care group (31.6%) from our study were similar, and both were more than 2-fold higher than the EDAFMP group (12.9%, **Table 2**). The consistent effect size versus historical and concurrent comparator groups in our findings suggests that the decreased likelihood of hospital admission relates to the EDAFMP intervention rather than temporal trends and general changes in AF practice over the study period. Our investigation also had a slightly larger sample size than previous AF pathway evaluations and was conducted across 4 hospitals.

Previous studies have also assessed the relationship of AF care pathways with the other hospital use outcomes we measured. [16,32,34] In accord with these studies, within the concurrent, postimplementation group we observed no increase in return ED visits or hospital admissions associated with EDAFMP use at 30-,60-, and 90-day intervals. Likewise, there were no increases in ED dwell time or length of stay for admitted patients correlated with pathway use (**Table 2**). Based on these data, use of the EDAFMP at the index encounter did not lead to incremental downstream hospital use at future time points over the short term.

Use of the EDAFMP was associated with substantial increases in the performance of an established AF quality metric (appropriately prescribing anticoagulation)[35] and referral for post-ED discharge cardiac specialty care, which has also been associated with better adherence to AF clinical measures.[36] The improvement in these care process measures we observed was similar to previous reports, [16,32,34] although different in degree as the preimplementation group had low baseline performance. We attribute the increases to decision support, specific orderable items, and structured documentation embedded into the EDAFMP that facilitated delivery of these interventions. However, even with treatment under the EDAFMP, only 38% of patients had a recorded prescription for anticoagulation. Although it is possible additional patients received prescriptions for anticoagulation outside of the EHR (eg, a handwritten prescription, a direct call to a pharmacy that we could not capture with electronic extraction, or at a cardiology follow-up visit), there is an ongoing opportunity both within our system and across the United States to enhance appropriate use of anticoagulation for patients with AF. Among cardiology practices in the United States, the median treatment prevalence with oral anticoagulant therapy among eligible patients with AF is only 51.7%, with an interquartile range of 37.7% to 58.3%.[6] Discernment of anticoagulation benefit/risk at the patient level, and when clinically indicated, use of anticoagulation, should thus continue to be priority areas for AF QI initiatives.

Despite a multifaceted implementation program (**Table 1**), uptake of the EDAFMP was low and inconsistent across the study sites, and there was significant variability in use at the individual physician level. Over the postimplementation period (which ran for 21-months to allow for supplemental physician education and peer feedback on usage rates), only 21% of patients with NVAF overall deemed as eligible were treated with the EDAFMP, and aggregate use in each month never exceeded 40% (Figure 1). The EDAFMP represented a novel workflow for physicians, and its use was voluntary (feedback reports to physicians were informational). Clinical inertia to modifying practice, particularly without another behavioral modifier (eg, prioritization as a performance measure, financial incentives), has been well recognized as a barrier to consistent delivery of evidence-based care.[37] Likewise, because of the EDAFMP's nascence we did not have data showing local application and efficacy; this type of information can be a potent driver of practice adoption.[38] Interviews with a snowball sample of emergency medicine physicians at the study sites indicated several other causations for low usage rates–with lack of awareness of the EDAFMP, patients being clinically inappropriate for the EDAFMP, concern about the ability to secure timely outpatient cardiology follow-up after ED discharge, and disruption of existing ED referral patterns as the main issues identified. Our observed EDAFMP adoption rates reflect an established challenge in health care: slow and variable update of clinical practice guidelines. Bundling decision support, ordering workflows, and structured documentation for use in a voluntary manner like the EDAFMP is one intervention to facilitate practice uptake but should be paired with accountability measures to achieve delivery at a higher degree of reliability.

We demonstrated that patients presenting to EDs with NVAF treated under an algorithmic care pathway were less likely to be hospitalized during their index encounter and more likely to receive evidence-based processes of care. The EDAFMP appears to enhance care delivery at the population level, particularly in terms of reducing hospitalizations for NVAF for individuals who may be safely discharged home and followed in the ambulatory setting. Although our study was performed under an observational study design (with a set of limitations) and the aggregate EDAFMP use was relatively low, our results signal the pathway's effectiveness as a tool to improve care for patients with NVAF. Adoption and consistent use of similar standard care pathways for ED management of NVAF hold promise as a scalable and impactful QI intervention that could be disseminated broadly.

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AUTHOR CONTRIBUTIONS

Masica-study conception, study design, data analysis and interpretation, drafting manuscript, manuscript revisions for critically important intellectual content; Brown-study design, data acquisition and analysis; Farzad-study design, data analysis and interpretation; Garrett-study design, data analysis and interpretation; Wheelan-study design, data analysis and interpretation; Nguyen-data analysis and

interpretation; drafting manuscript, manuscript revisions for critically important intellectual content; Ogola-data analysis and interpretation; drafting manuscript, manuscript revisions for critically important intellectual content; Kudyakov-data acquisition and analysis; McDonald-data acquisition and analysis; Boyd-study design, data interpretation; Patel-study design, data interpretation, manuscript revisions for critically important intellectual content; Delaughter-study conception, study design, data analysis and interpretation.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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