American Journal of Emergency Medicine xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Original Contributions

Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011☆,☆☆,★,★★,☆☆☆

Michelle P. Lin, MD, MPH, SM [a,b,*], Jiemin Ma, PhD, MHS [b], Joel S. Weissman, PhD [b,c], Kenneth R. Bernard, MD, MBA [b], Jeremiah D. Schuur, MD, MHS [b,c]

[a] Department of Emergency Medicine, Icahn School of Medicine at Mount Sinai, Mount Sinai Beth Israel, 10 Nathan D. Perlman Place, New York, NY, 10003, USA
[b] Department of Emergency Medicine, Brigham and Women's Hospital, 75 Francis St, Boston, MA 02115, USA
[c] Harvard Medical School, Boston, MA, USA

ARTICLE INFO

Article history:
Received 5 May 2016
Received in revised form 14 July 2016
Accepted 15 July 2016
Available online xxxx

ABSTRACT

Background: Outpatient management of atrial fibrillation can be a safe alternative to inpatient admission after emergency department (ED) visits. We aim to describe trends and predictors of hospital admission for atrial fibrillation and determine the variation in admission among US hospitals.

Methods: We analyzed ED visits and hospital admissions for adult patients with a principal diagnosis of atrial fibrillation or atrial flutter in the Nationwide Emergency Department Sample 2006 to 2011. We identified patient and hospital characteristics associated with admission using hierarchical multivariate logistic regression. We analyzed admission rates overall and for patients at low risk of thromboembolic complications (CHA_2DS_2-VASc score 0). We compared hospital-level variance with residual variance to estimate the intraclass correlation in models with and without hospital characteristics.

Results: From 2006 to 2011, annual ED visits for atrial fibrillation and atrial flutter increased by 30.9% and admission rates decreased from 69.7% to 67.4% ($P = .02$). Admission was associated with setting (metropolitan teaching vs nonmetropolitan, odds ratio = 1.93 [1.62-2.29]) and region (Northeast vs West, odds ratio = 2.09 [1.67-2.60]). Among patients with 0 CHA_2DS_2-VASc score, the national average admission rate was 46.4%. The intraclass correlation was 20.7% adjusting for patient characteristics and hospital clustering, and 19.2% after additionally adjusting for hospital variables.

Conclusions: From 2006 to 2011, ED visits for atrial fibrillation in the United States increased by almost a third, with a minimal change in ED admission rates. One-fifth of variation in admission rates is due to hospital site and not explained by hospital characteristics. Hospital-specific practice patterns may identify opportunities to increase outpatient management.

1. Background

Atrial fibrillation (AF) is the most common clinically significant cardiac arrhythmia, affecting 1% of the adult US population, with increasing incidence with age [1]. The condition affects 9% of those older than 80 years, representing an increasing public health problem for the growing elderly population [2]. National health expenditures for the care of AF total $26 billion, most of which is attributed to more frequent inpatient hospitalization [3,4]. There is growing evidence to suggest that outpatient management is a safe and effective alternative to hospital admission for the management of many patients with acute AF or atrial flutter (AF/AFL) [5-9]. Protocols for early rhythm control, clinical decision rules to guide the decision to initiate antithrombotic therapy, and low molecular weight heparin and direct oral anticoagulants have reduced the need for acute inpatient hospitalization [10-14].

Atrial fibrillation is a frequent cause of emergency department (ED) visits and hospital admission. In 2004, there were 2.7 million ED visits for AF, representing a doubling in the population-adjusted rate of ED visits compared with 1993 [15]. Over the same period, the rate of ED admission for AF nationwide remained stable at 64%, varying from 48% to 76% across regions in the United States [15].

It is unclear whether the growing evidence in support of outpatient management of AF has translated to clinical practice in the United States. Prior studies have demonstrated significant regional variation

☆ Funding: This research was supported through a research grant from the Massachusetts Blue Cross Blue Shield Foundation (501c3).
☆☆ Disclosure: None.
★ The original research in this manuscript was conducted while Drs Lin, Ma, and Bernard were at Brigham and Women's Hospital and Harvard Medical School in Boston, MA.
★★ Journal subject codes: health services; quality and outcomes; atrial fibrillation.
☆☆☆ Prior presentation: A preliminary analysis was presented at the Society of Academic Emergency Medicine's Annual Meeting in May 2014 and published as an abstract in Academic Emergency Medicine, Supplement April 2014.
* Corresponding author at: Department of Emergency Medicine, Mount Sinai Beth Israel Hospital, 10 Nathan D. Perlman Place, New York, NY, 10003. Tel.: +1 949 891 1135; fax: +1 212 420 2863.
E-mail address: michelle.lin@mail.harvard.edu (M.P. Lin).

http://dx.doi.org/10.1016/j.ajem.2016.07.023
0735-6757/

in ED admission rates for AF, as well as variation within hospitals by physician specialty; however, the proportion of variation attributable to hospitals is unknown [16,17]. We used national data on ED visits to describe trends in admission after ED visits for AF, identify patient and hospital characteristics that predict hospital admission for AF, describe trends in admission for patients at low risk of thromboembolic events, and determine the variation in ED admission rates for AF/AFL among US hospitals.

2. Methods

We conducted a cross-sectional analysis of the Nationwide Emergency Department Sample (NEDS) using multiple variable hierarchical logistic regressions to identify predictors of admission after ED visits for AF/AFL.

2.1. Data source

The NEDS is an approximate 20-percent stratified sample of hospital-based EDs in the United States. It is a component of the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality [18]. The NEDS contains data from billing records of 26 to 29 million ED visits per year from about 950 annually selected hospitals; details available in NEDS include patient demographics, visit disposition (home, transfer to another facility, admitted to hospital, or died), and up to 15 diagnoses from the final location (ie, from the hospital bill if admitted or from the ED bill), and hospital characteristics. By incorporating sampling weights provided in NEDS, we were able to generate national estimates for ED utilization at both hospital- and visit-level in the United States.

2.2. Study population

We included ED visits by adult patients who had an *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) code for AF (427.31) or AFL (427.32) as the principal diagnosis. We include AFL because the acute management of AFL is similar to that of AF, and risk-based guidelines for antithrombotic therapy in AFL are the same as those for AF [19,20]. We excluded patients under age 18 because AF and AFL are rare in this population, and the safety and efficacy of outpatient treatment of AF and AFL for these patients have not been well studied. In sensitivity analyses, we included ED visits where AF and AFL were a secondary diagnosis and where the principal diagnosis was thought to be AF/AFL-related, for example, “palpitations” (Appendix A).

We excluded patients who had a disposition of neither discharge nor admission (left against medical advice, “not admitted, destination unknown,” who died in the ED; overall 0.9%) or presented with concomitant acute myocardial infarction, respiratory failure, sepsis, or shock because of the higher likelihood of hospital admission for such critically ill patients (Appendix B) [21]. We excluded hospitals with <10 cases (8.2% of hospitals; 0.3% of visits) because low hospital volumes result in unstable estimates of ED admission rates.

2.3. Study outcome and variables

The outcome of interest was hospital admission after an ED visit. We classified patients as admitted if they were hospitalized or transferred to another short-stay hospital, because the decision to transfer a patient represents a similar higher use of resources rather than discharging the patient to outpatient management. Patients were classified as discharged if their disposition was “routine ED discharge,” “transfer to skilled nursing or intermediate care facility,” “home health care,” or “discharge or transfer to court or law enforcement.” In sensitivity analysis, we tested how hospital variation changed when transfers to short-stay hospitals were excluded as admissions (Appendix G and H).

2.4. Patient variables

Patient predictors included age, sex, insurance status (private, Medicare, Medicaid, self-pay/no charge, and other), median household income (national quartile within the patient's home ZIP code), and comorbid illness using the index described by Elixhauser et al [22] and with the addition of Clinical Classifications Software (CCS) codes for coronary artery disease (CCS 101), structural or valvular heart disease (CCS 96, 97, and 213), and other arrhythmia or conduction disorder (CCS 105 and 106, excluding AF and AFL), which were coded as dummy variables. We defined low-risk patients as those with CHA_2DS_2-VASc scores of 0 (age less than 65, male, no history of CHF, diabetes mellitus, hypertension, stroke, transient ischemic attack, or thromboembolic disease) as such patients have a low risk of embolic stroke, little net benefit for antithrombotic therapy and low likelihood of having abnormal diagnostic testing [23,24].

2.5. Hospital variables

Hospital characteristics included each hospital's ED volume (less than 20 000; 20 000 to 50 000; greater than 50 000 annual visits), teaching status and setting (metropolitan teaching, metropolitan nonteaching, nonmetropolitan), and geographic region (Northeast, Midwest, South, West).

2.6. Statistical analysis

National estimates of ED visits and admission rates for AF and AFL were estimated accounting for NEDS' complex sampling design and sampling weights. Trend in admission rates from 2006 to 2011 was tested by logistic regression modeling with year as independent variable.

To account for increased correlation of probability of admission among patients presenting to the same hospital ED, we used hierarchical multivariate logistic regression to assess the associations of patient and hospital characteristics with admission rates and hospital variation in admission. As hospital identifiers are not linked across years, we limited our analysis of hospital predictors to the 2011 NEDS dataset to prevent underestimating hospital variance due to overestimating the number of hospitals. As suggested by the Healthcare Cost and Utilization Project, sampling weights were not used in multilevel modeling [25].

To account for different patient mix across hospitals, risk-standardized admission rate (RSAR) is used to describe hospital variations. To calculate RSAR, we calculated the ratio of predicted to expected admissions for each hospital (RSAR ratio) and multiplied by the crude national admission rate. A hospital's predicted admissions were the sum of admission probabilities for all patients in the hospital, assuming this hospital had a specific hospital effect on admission. Expected admissions were the sum of admission probabilities for the same patient mix if the hospital had experienced a national average hospital effect on admission. The 95% confidence intervals (CIs) of RSAR ratios were estimated by bootstrapping 1000 times. In each round of bootstrap, we sampled 864 hospitals with replacement and fit a hierarchical model using all patients within each sampled hospital. Then, we generated a hospital specific effect by sampling from the distribution of random intercepts obtained from the model and calculated the ratio for each hospital. The 95% CI of RSAR for each hospital was then determined by identifying the 2.5th and 97.5th percentiles of the estimates obtained from the 1000 analyses.

Finally, we compared hospital factor variance with residual variance to estimate intraclass correlation and determine the amount of variation explained by hospital-specific effects on admission probability. We applied this to models with and without adjustment for hospital characteristics. All analyses were performed in SAS 9.3 (SAS; Cary, NC). The study was exempt from Institutional Review Board review.

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023

3. Results

From 2006 to 2011, the mean admission rate was 69.9% (95% CI, 69.3%-70.5%). Emergency department visits for AF and AFL increased from 434 382 in 2006 (or 1.45 visits per 1000) to 568 561 in 2011 (or 1.82 visits per 1000), representing a 30.9% increase over 6 years ($P<$ .01; Fig. 1 and Appendix C). Adjusting for population, this represents an increase from 1.45 ED visits per 1000 in 2006 to 1.82 visits per 1000 in 2011 [26]. Emergency department admission rates varied between 2006 and 2011, but overall decreased from 69.7% to 67.4% ($P=$ .02 for trend).

In 2011, there were 568 561 ED visits for AF/AFL. Mean patient age was 69 years. Most of ED visits for AF/AFL were among female patients (51.1%) and those with Medicare insurance (63.4%); a plurality occurred at metropolitan teaching hospitals (46.3%) and was in the Southern region of the United States (42.1%) (Table 1).

Patient sociodemographic and clinical factors had varying effects on likelihood of ED admission (Table 2). Increased age was associated with increased likelihood of admission. Female sex was associated with decreased likelihood of admission. All but one of the conditions in the modified Elixhauser comorbidity index (presence of ulcer, odds ratio (OR), 4.56 with 95% CI, 0.68-30.33) were associated with increased likelihood of admission (Appendix D). Patients classified as self-pay or other nonprivate insurance types (eg, worker's compensation) were more likely to be admitted compared with patients with Medicare. Income was not significantly associated with ED admission.

In 2006, there were 46 650 ED visits for AF/AFL among patients with a low thromboembolic risk (CHA_2DS_2-VASc score of 0), with an admission rate of 47.1%. In 2011, there were 49 675 ED visits for AF/AFL by patients with low risk for thromboembolic complications and 44.1% were admitted (Table 3). This represents a 6.5% increase in ED visits among low-risk patients from 2006 to 2011, without a significant change in admission rates over time ($P=$ .05 for trend).

3.1. Hospital variation

Among hospital characteristics, teaching status and region, but not annual ED visit volume, were independently associated with higher admission rates (Table 2). In particular, ED visits for AF/AFL presenting to metropolitan teaching and metropolitan nonteaching hospitals had 1.59 (95% CI, 1.36-1.87) and 1.43 (95% CI, 1.15-1.78) times greater likelihood of ED admission compared with nonmetropolitan hospitals, respectively. Emergency department visits in the Northeast (OR, 2.16; 95% CI, 1.73-2.69), Midwest (OR, 1.42; 95% CI, 1.18-1.72), and South (OR, 1.53; 95% CI, 1.28-1.83) were associated with increased likelihood of admission compared with the West. After adjusting for patient and hospital-level variables, ED volume was not associated with hospital admission.

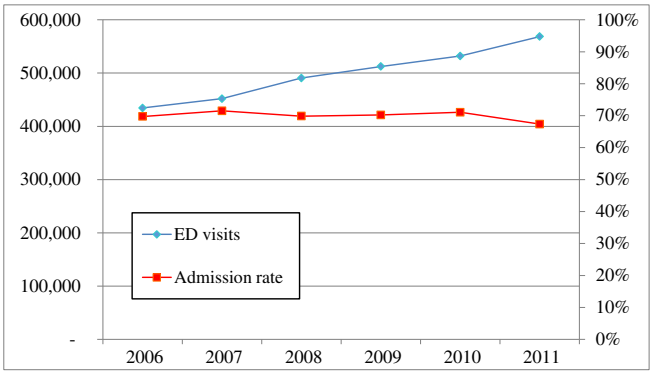

Fig. 1. National trend in ED volume and admission rate for AF and AFL, NEDS 2006 to 2011. *Emergency department visits increased by 30.9% ($P<$ .01). Emergency department admissions decreased from 69.7% to 67.4% ($P=$ .02 for trend). See Appendix C for values.

Table 1
Patient and hospital characteristics for AF and AFL ED visits 2011

	N	%
Mean age (SD)	122 338	69.3 (0.04)
Female	62 441	51.1
Insurance		
Medicare	77 234	63.3
Medicaid	5 357	4.4
Private insurance	31 881	26.1
Self-pay/no charge	4915	4.0
Other	2720	2.2
Income		
First quartile	28 951	24.2
Second quartile	30 259	25.3
Third quartile	30 993	25.9
Fourth quartile	29 499	24.6
Region		
Northeast	22 303	18.2
Midwest	24 832	20.3
South	51 420	42.0
West	23 783	19.4
Teach_UR		
Metropolitan, nonteaching	56 649	46.3
Metropolitan, teaching	44 234	36.2
Nonmetropolitan	21 455	17.5
Volume		
<20 000	14 329	11.7
20 000-49 999	46 272	37.8
≥50 000	61 737	50.5

* National quartile of the median household income of the patient's home ZIP code.

Among 816 hospitals with ≥10 ED visits, the median hospital RSAR was 67.6% (5th%, 36.0; 25th%, 56.0; 75th%, 75.7; 95th%, 85.0). The lowest RSAR was observed in the Western region with an RSAR of 62.3% (interquartile range [IQR], 47.5-72.5) and the highest RSAR was observed in the Northeast at 73.1% (IQR, 64.6-78.0). Other RSARs were 67.5% (IQR, 55.9-74.5) in the Midwest and 67.2% (IQR, 58.0-76.4) in the South (Fig. 2). The greatest variation in hospital RSARs was in the Western region, as evidenced by the wide IQR.

The residual intraclass correlation coefficient (ICC) for variance in ED admission rate by hospital site was 20.7% after adjusting for patient characteristics and hospital clustering. After additionally adjusting for hospital variables, the residual ICC was 19.2%, indicating that nearly one-fifth of variation in ED admission rates is attributable to an institution-specific effect, whereas hospital characteristics explained only a small part of the variation.

3.2. Sensitivity analysis

We performed sensitivity analysis to evaluate the potential effect of including ED visits for which AF/AFL was listed as a secondary diagnosis and the principal diagnosis was thought to be AF/AFL-related, for example, “dizziness” or “palpitations” (Appendix A). Comparing models with and without these visits, we find that 782 hospitals (90.5%) have the same classification group; 26 hospitals (3%) move from an average admission rate to below average and 21 hospitals (2.4%) move from an average admission rate to above average (Appendix E). No hospitals moved from above to below average or vice versa. There was strong correlation of RSARs between models excluding and including these ED visits (Pearson and Spearman correlation coefficients of 0.977 and 0.973, respectively; Appendix F).

We performed sensitivity analysis to determine whether transfer classification explained hospital variation in admission rates by rerunning the model excluding all transfers, instead of classifying “transfer to short stay facility” as admission (Appendix G). Excluding transfer did not affect the classification of most of hospitals by admission group. Five hundred thirty six hospitals (62%) have the same classification group;

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023

Table 2
Patient and hospital level predictors of ED admission rates for AF and AFL 2011

	ED visits (N)	Admission rate (%)	OR (95% CI)	
			Bivariate	Multivariate
Age				
10-year increase			1.20 (1.19-1.21)	1.06 (1.04-1.07)
Sex				
Male	59 870	65.2	0.88 (0.86-0.91)	1.07 (1.03-1.10)
Female	62 441	67.8	Reference	Reference
Insurance				
Medicare	77 234	70.1	Reference	Reference
Medicaid	5357	72.5	0.94 (0.88-1.01)	0.99 (0.91-1.08)
Private insurance	31 881	57.2	0.59 (0.57-0.60)	1.04 (0.99-1.08)
Self-pay/no charge	4915	64.9	0.72 (0.67-0.77)	1.12 (1.03-1.22)
Other	2720	65.1	0.79 (0.72-0.86)	1.17 (1.05-1.29)
Income				
First quartile	28 951	69.1	1.33 (1.27-1.40)	1.06 (1.00-1.13)
Second quartile	30 259	65.0	1.22 (1.17-1.28)	1.04 (0.99-1.10)
Third quartile	30 993	65.6	1.11 (1.06-1.16)	1.00 (0.95-1.05)
Fourth quartile	29 499	66.6	Reference	Reference
Hospital region				
Northeast	22 303	74.6	2.09 (1.67-2.60)	2.16 (1.73-2.69)
Midwest	24 832	68.2	1.27 (1.05-1.54)	1.42 (1.18-1.72)
South	51 420	66.7	1.60 (1.34-1.91)	1.53 (1.28-1.83)
West	23 783	56.6	Reference	Reference
Teaching status and location				
Metropolitan, nonteaching	56 649	68.8	1.85 (1.61-2.13)	1.59 (1.36-1.87)
Metropolitan, teaching	44 234	67.2	1.93 (1.62-2.29)	1.43 (1.15-1.78)
Nonmetropolitan	21 455	58.9	Reference	Reference
Total ED visits				
<20 000	14 329	59.2	Reference	Reference
20 000-49 999	46 272	69.2	1.89 (1.64-2.19)	1.05 (0.90-1.24)
≥50 000	61 737	66.2	1.85 (1.57-2.17)	0.84 (0.68-1.04)

*Bivariate and multivariate models include predictors from the Elixhauser comorbidity index, shown in Appendix A.

61 hospitals (7.1%) move from an average admission rate to below average and 93 hospitals (10.8%) move from an average admission rate to above average. Three hospitals (0.3%) moved from above average admission rate to below average admission and no hospitals moved from below average to above average. The observed change in classification in the sensitivity analysis excluding transfers as admissions predominantly resulted in lower RSARs among hospitals with fewer ED visits and increased RSARs among hospitals with more ED visits (Appendix H). Of note, in the multivariate model, hospital variation persists after adjusting for ED volume, and ED volume is not a significant predictor of hospital admission (Table 2). The correlation between RSAR in models excluding transfers compared with classifying transfers as admissions had Pearson and Spearman correlation coefficients of 0.71 and 0.76, respectively (Appendix H).

4. Discussion

To determine the role of patient and hospital characteristics in hospital admission after ED visits for AF/AFL, we analyzed a large US all-payer hospital claims dataset. Emergency department visits for AF/AFL increased from 2006 to 2011, whereas ED admission rates have experienced a small decrease. Our findings are consistent with and build upon prior studies identifying hospital region and the presence of patient-level comorbidities as strong predictors of admission, while furthering existing evidence by examining hospital-level effects [16,27]. In addition to region, metropolitan teaching status was an independent predictor of increased ED admission. However, these hospital-level predictors accounted for a relatively small proportion of the observed variation; after adjusting for both patient and hospital characteristics, one-fifth of variation in likelihood of admission after an ED visit for AF/AFL depends on the hospital a patient visits.

Metropolitan teaching and metropolitan nonteaching hospitals were associated with increased likelihood of ED admission, consistent with prior national studies on variation in ED and hospital admission rates across multiple conditions [16,28,29,30]. Higher admission rates at urban teaching facilities may be related to case mix and socioeconomic factors not fully captured by standard comorbidity indices or administrative data or may be due to less efficient practice patterns described at teaching facilities [31]. The same factors that account for increased admission rates among patients with AF at metropolitan teaching hospitals may also explain the higher readmission rates observed at safety-net hospitals, which are more likely to be penalized by the Centers for Medicare and Medicaid Services Hospital Readmission Reduction Program [32].

Significant regional variation exists in admission patterns for AF and AFL, consistent with prior studies examining variation in utilization of

Table 3
ED admission rate for AF and AFL among patients with 0 CHA_2DS_2-VASc score.

Year	National estimate of ED visits	ED visits (N)	Admitted (n)	Weighted admission rate	95% CI Lower	95% CI Upper	Test for trend in admission rate (*P* value)
2006	46 650	9513	4534	47.1	45.1	49.2	
2007	45 396	9457	4655	48.8	46.6	50.9	
2008	48 317	10 592	4862	45.0	42.8	47.2	
2009	46 090	10 039	4666	46.0	43.7	48.4	
2010	48 511	10 406	5012	47.6	45.4	49.9	
2011	49 675	10 716	4737	44.1	41.9	46.2	
Overall	47 440	10 121	4744	46.4	45.5	47.3	*P*= .05

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023

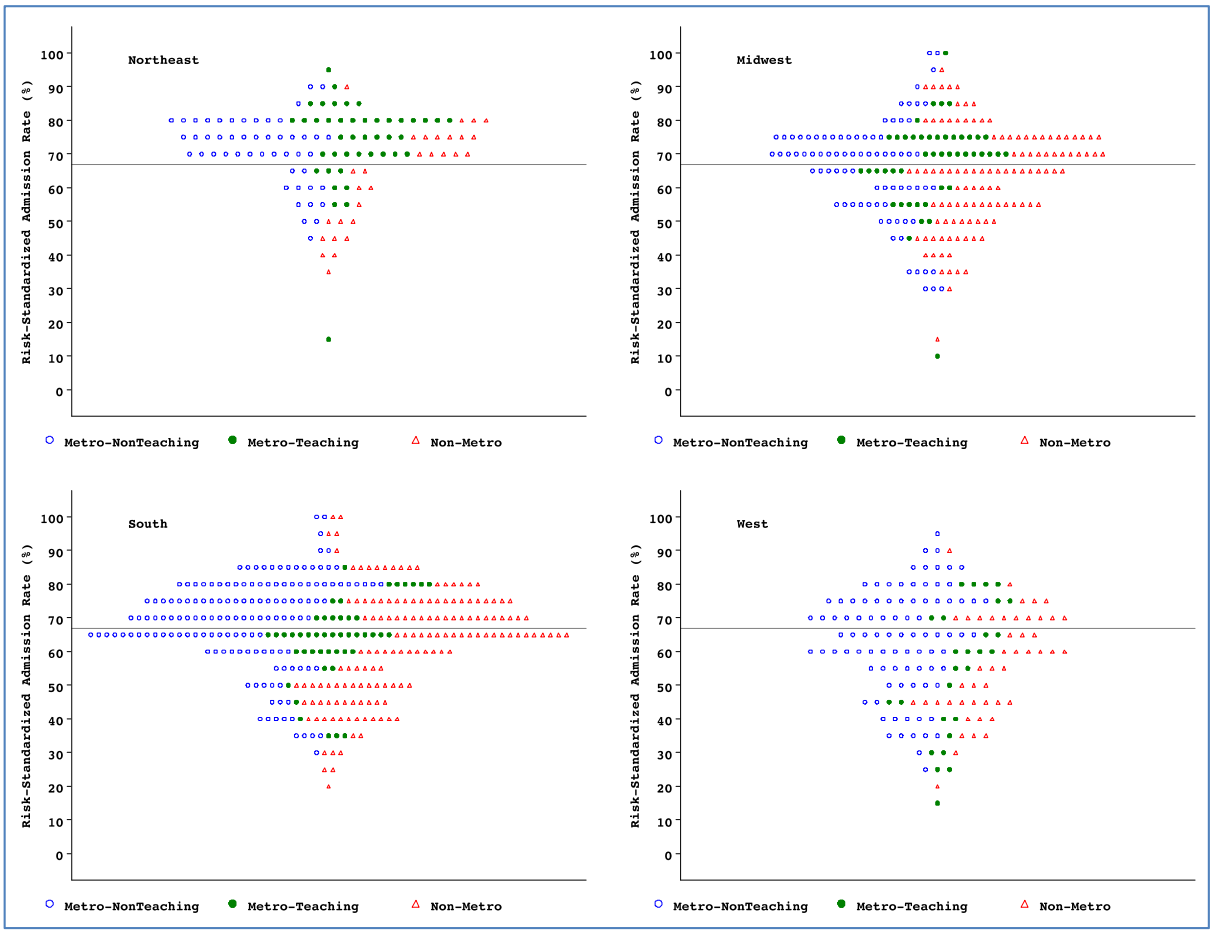

Fig. 2. Risk-standardized admission rate for AF and AFL by region. *Each symbol represents 10 hospitals. Metropolitan teaching hospitals indicated by red triangles. Metropolitan nonteaching hospitals indicated by green solid circles. Nonmetropolitan, nonteaching hospitals indicated by blue circles.

hospital services for AF/AFL and other conditions [16,33]. Higher ED admission rates for AF and AFL in these areas may be driven by higher inpatient-based and specialist-oriented patterns of care, greater bed availability, and physician supply, which have been identified as drivers of variation in Medicare expenditures [34]. The observed regional variation may account for national variation in ED admission rates, as evidenced by the differing distribution and shape of regional turnip plots (Fig. 2). However, these hospital predictors accounted for only a small proportion of the observed variation.

After adjusting for hospital and patient-level characteristics, we observed that around one-fifth of the variance in ED admission rates (ICC of 19.2%) was attributed to individual hospital effects, suggesting that which hospital's ED a patient presents to accounts for an important source of variation in admission. Unmeasured hospital or physician level factors such as institution-specific practice patterns related to physician risk tolerance may explain this residual variation. Prior studies have shown that rate control, followed by admission for anticoagulation and rhythm control or discharge with rate control, is the preferred approach among US emergency physicians [35]. Emergency physicians may be concerned that outpatient discharge is associated with greater risk of undiagnosed near-term stroke or other serious underlying pathology such as concurrent acute myocardial ischemia, diagnosed in up to 5% of patients admitted for AF [36]. Hospitals that have adopted clinical pathways promoting ED cardioversion and discharge with outpatient follow-up may have lower admission rates [37]. For example, in Canada, where greater emphasis is placed on outpatient pathways, ED admission rates for patients with recent-onset AF ranged from 10% to 27% at academic medical centers [5,38]. Variation in admission of patients who are at low risk of thromboembolic complications may also account for the unexplained residual variation.

Nearly half of low-risk patients (CHA_2DS_2-VASc score of 0) were admitted with minimal decrease in admission rates from 2010 (when the CHA_2DS_2-VASc risk stratification tool was published) to 2011. Before the widespread use of direct anticoagulants and low-molecular-weight heparin, patients with AF/AFL were admitted to initiate anticoagulation with IV heparin therapy. However, patients with CHA_2DS_2-VASc scores of 0 are at low risk for associated cardiovascular and thromboembolic events and are unlikely to benefit from antithrombotic therapy [4,8,9,14,24,25]. Although a proportion of these patients may have been admitted for other reasons (eg, evaluation for underlying cause of arrhythmia, including acute coronary syndrome or pulmonary embolism), the lack of change in admission rates over time suggests practice patterns have been slow to incorporate risk stratification pathways such as CHA_2DS_2-VASc scores. Further, the mean admission rate of 46.4% among these low-risk patients in 2011 is over 70% higher than the admission rate for all patients presenting with acute AF to Canadian EDs, consistent with prior comparisons, suggesting that there is potential to safely increase outpatient management of acute AF [38,39].

Although outpatient management of AF and AFL has been demonstrated to be a safe and effective alternative to inpatient hospitalization,

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023

there is no evidence to indicate what is an "optimal" or "appropriate" ED admission rate for AF/AFL. However, the minimal change in ED admission rates despite increasing numbers of ED visits raise several policy implications. First, these data make the case for developing measures of variation in hospital admission and integrating into Medicare's Hospital Value-Based Purchasing program, which currently focuses on hospital 30-day readmission. Avoidable initial hospitalizations for AF/AFL represent an opportunity to reduce cost and avoid patient harm. As patients presenting with acute AF/AFL are older and have multiple comorbid conditions than those unaffected by AF/AFL, they are more likely to experience adverse events related to inpatient hospitalization [40]. Prior research has demonstrated that higher all-cause admission is the strongest predictor of readmission for acute myocardial infarction, congestive heart failure, and pneumonia [41]. Among patients admitted for AF/AFL, up to 25% are readmitted within 30 days [42]. Reducing variation and increasing outpatient management of acute fibrillation and flutter—particularly among patients at lowest risk of thromboembolic events—have the potential to prevent morbidity and cost associated with potentially avoidable hospital admission and readmission.

Our findings suggest a need for additional research to identify institutional practices that account for widespread variation in admission rates for AF/AFL. Further research is needed to determine if variation in ED admission rates is associated with quality and patient outcomes. It would be particularly interesting to examine institutions with low admission rates and high performance on short-term outcome metrics to identify potential best practices. For example, shared decision-making regarding initiation of anticoagulation therapy in AF improves decision quality and better reflects patient preferences; the application of novel risk stratification tools for AF/AF to guide the decision to admit or discharge a patient who visits the ED for AF/AFL could have a similar effect [43,44].

4.1. Limitations

Our findings are subject to several limitations. Atrial fibrillation or flutter encompasses a broad clinical spectrum and the NEDS administrative dataset does not include clinical data regarding patients' hemodynamic status or severity at the time of initial ED presentation, such as their vital signs, which would contribute to the decision to admit. However, we risk adjusted with the Elixhauser score, a well validated predictor of inhospital mortality and there is a broad range of clinical severity across all institutions [11]. Second, the CHA_2DS_2-VASc score was published 2010 as a prediction tool for annual risk for thromboembolic disease and need for oral anticoagulation and incorporated into guidelines for management of AF/AFL in 2014. Although not originally intended as a risk stratification tool to assess need for hospitalization, other studies have demonstrated the association of elevated CHA_2DS_2-VASc score with increased likelihood of hospitalization and mortality [45,46]. By defining low-risk patients as those with CHA_2DS_2-VASc score of 0, we are excluding female patients, which may limit the generalizability of this secondary analysis. Third, administrative data are subject to misclassification of the diagnosis of AF/AFL or ED disposition, as well as secondary diagnoses included in the Elixhauser risk adjustment. Prior studies on the reliability of ICD-9 codes for AF and AFL have demonstrated high sensitivity (73%), specificity (99%), and positive predictive value (95%) [47]. The sensitivity analyses examining ED visits for which AF and AFL were listed as secondary and where the principal diagnosis was thought to be AF/AFL-related did not find materially different results. Fourth, NEDS provides visit-level data without data on revisits or outcomes; therefore, we were unable to ascertain whether variation in admission was associated with 30-day mortality or whether patients returned to the ED after discharge, suggesting that they should have been admitted at the initial ED visit. Some patients may have accounted for multiple visits within the sample, but these account for a small proportion of the overall visit total. We were further unable to determine ED visits related to recent hospital discharges or revisits for the same condition, which may be associated with admission. Further, NEDS includes only ED visits; therefore, our analysis is limited to patients admitted to the hospital through the ED. Patients who are admitted directly to the hospital (eg, from a clinic) are not analyzed. Although observation is an increasingly used pathway for the management of conditions that do not necessarily warrant inpatient admission, the NEDS does not separately classify observation care after an ED visit because observation is an outpatient level of care [48-50]. This likely had little effect on results, as in 2011 and preceding years, observation care made up a small proportion of hospitalizations and AF/AFL was not frequent observation diagnoses [51].

5. Conclusion

From 2006 to 2011, ED visits for AF and AFL increased whereas admission rates decreased slightly; however, nearly half of low-risk patients (CHA_2DS_2-VASc score 0) continue to be admitted, with no change over time. Emergency department admission rates for AF and AFL are strongly associated with metropolitan teaching status and geographic region. However, hospital predictors explained only a small proportion of the wide variation; after adjusting for these characteristics, the specific hospital ED that a patient visits explains around a fifth of the variation in the likelihood of admission. As outpatient management of AF and AFL can be safe and less expensive than hospital admission, further research to better characterize if patient outcomes are associated with institutional variation in ED admission rates and whether strategies to reduce such variation could improve the value of acute medical care for patients with AF and AFL.

Appendix A-H. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ajem.2016.07.023.

References

[1] Go AS, Hylek EM, Phillips KA, Chang Y, Henault LE, Selby JV, 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.
[2] Wattigney WA, Mensah GA, Croft JB. Increasing trends in hospitalization for atrial fibrillation in the United States, 1985 through 1999 implications for primary prevention. Circulation 2003;108:711–6.
[3] Kim MH, Johnston SS, Chu B-C, Dalal MR, Schulman KL. Estimation of total incremental health care costs in patients with atrial fibrillation in the United States. Circ Cardiovasc Qual Outcomes 2011;4:313–20.
[4] Wodchis WP, Bhatia RS, Leblanc K, Meshkat N, Morra D. A review of the cost of atrial fibrillation. Value Health 2012;15:240–8.
[5] Stiell IG, Clement CM, Perry JJ, Vaillancourt C, Symington C, Dickinson G, et al. Association of the Ottawa Aggressive Protocol with rapid discharge of emergency department patients with recent-onset atrial fibrillation or flutter. CJEM 2010;12:181–91.
[6] Stiell IG, Macle L, CCS Atrial Fibrillation Guidelines Committee. Canadian cardiovascular society atrial fibrillation guidelines 2010: management of recent-onset atrial fibrillation and flutter in the emergency department. Can J Cardiol 2011;27:38–46.
[7] von Besser K, Mills AM. Is discharge to home after emergency department cardioversion safe for the treatment of recent-onset atrial fibrillation? Ann Emerg Med 2011;58:517–20.
[8] Decker WW, Smars PA, Vaidyanathan L, Goyal DG, Boie ET, Stead LG, et al. A prospective, randomized trial of an emergency department observation unit for acute onset atrial fibrillation. Ann Emerg Med 2008;52:322–8.
[9] Conti A, Canuti E, Mariannini Y, Viviani G, Poggioni C, Boni V, et al. Clinical management of atrial fibrillation: early interventions, observation, and structured follow-up reduce hospitalizations. Am J Emerg Med 2012;30:1962–9.
[10] Chen J-Y, Zhang A-D, Lu H-Y, Guo J, Wang F-F, Li Z-C. CHA2DS2 versus CHA_2DS_2-VASc score in assessing the stroke and thromboembolism risk stratification in patients with atrial fibrillation: a systematic review and meta-analysis. J Geriatr Cardiol 2013;10:258–66.
[11] van Walraven C, Hart RG, Wells GA, Petersen P, Koudstaal PJ, Gullov AL, et al. A clinical prediction rule to identify patients with atrial fibrillation and a low risk for stroke while taking aspirin. Arch Intern Med 2003;163:936–43.
[12] Gage BF, Waterman AD, Shannon, Boechler M, MW R, MJ R. Validation of clinical classification schemes for predicting stroke: results from the national registry of atrial fibrillation. JAMA 2001;285:2864–70.

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023

[13] Gage BF, van Walraven C, Pearce L, Hart RG, Koudstaal PJ, Boode BSP, et al. Selecting patients with atrial fibrillation for anticoagulation stroke risk stratification in patients taking aspirin. Circulation 2004;110:2287–92.

[14] Lip GYH, Nieuwlaat R, Pisters R, Lane DA, Crijns HJ. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. Chest 2010;137:263–72.

[15] McDonald AJ, Pelletier AJ, Ellinor PT, Camargo Jr CA. Increasing US emergency department visit rates and subsequent hospital admissions for atrial fibrillation from 1993 to 2004. Ann Emerg Med 2008;51:58–65.

[16] Barrett TW, Self WH, Jenkins CA, et al. Predictors of regional variations in hospitalizations following emergency department visits for atrial fibrillation. Am J Cardiol 2013;112:1410.

[17] Funk AM, Kocher KE, Rohde JM, et al. Variation in practice patterns among specialties in the acute management of atrial fibrillation. BMC Cardiovasc Disord 2015;15:1.

[18] HCUP Nationwide Emergency Department Sample (NEDS). Healthcare Cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality; 2007, 2008, 2009 [Available at: www.hcup-us.ahrq.gov/nedsoverview.jsp].

[19] Blomström-Lundqvist C, Scheinman MM, Aliot EM, Alpert JS, Calkins, Camm AJ, et al. ACC/AHA/ESC guidelines for the management of patients with supraventricular arrhythmias—executive summary a report of the American College of Cardiology/American Heart Association task force on practice guidelines and the European Society of Cardiology Committee for practice guidelines (writing committee to develop guidelines for the management of patients with supraventricular arrhythmias). Circulation 2003;108:1871–909.

[20] You JJ, Singer DE, Howard PA, Lane DA, Eckman MH, Fang MC, et al. Antithrombotic therapy for atrial fibrillation: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2012;141:e531S–75S.

[21] Petersen LA, Wright S, Normand SL, Daley J. Positive predictive value of the diagnosis of acute myocardial infarction in an administrative database. J Gen Intern Med 1999;14:555–8.

[22] Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. Med Care 1998;36:8–27.

[23] Taillandier S, Olesen JB, Clémenty N, Lagrenade I, Babuty D, Lip GYH, et al. Prognosis in patients with atrial fibrillation and CHA_2DS_2-VASc score = 0 in a community-based cohort study. J Cardiovasc Electrophysiol 2012;23:708–13.

[24] Barrett TW, Abraham RL, Self WH. Usefulness of a low CHA2DS2 or CHA_2DS_2-VASc score to predict normal diagnostic testing in emergency department patients with an acute exacerbation of previously diagnosed atrial fibrillation. Am J Cardiol 2014;113:1668–73.

[25] HCUP. Methods Series. Hierarchical modeling using HCUP data. Report no. 2007–01. Agency for Healthcare Research and Quality: Rockville, MD; 2007 Available at: http://www.hcup-us.ahrq.gov/reports/methods/2007_01.pdf.

[26] United States Census Bureau Population Estimates. Historical data. Available at: http://www.census.gov/popest/data/historical/index.html.

[27] Pang PS, Schuur JD. Emergency departments, acute heart failure, and admissions: one size does not fit all. JACC Heart Fail 2014;2(3):278–80.

[28] Pines JM, Mutter RL, Zocchi MS. Variation in emergency department admission rates across the United States. Med Care Res Rev 2013;70:218–31.

[29] Capp R, Ross JS, Fox JP, Wang, Desai MM, Venkatesh AK, et al. Hospital variation in risk-standardized hospital admission rates from US EDs among adults. Am J Emerg Med 2014;32:837–43.

[30] Chaudhry SA, Tariq N, Majidi S, Afzal MR, Hassan AE, Watanabe M, et al. Rates and factors associated with admission in patients presenting to the ED with TIA in the United States—2006 to 2008. Am J Emerg Med 2013;31:516–9.

[31] Rosko MD. Performance of US teaching hospitals: a panel analysis of cost inefficiency. Health Care Manag Sci 2004;7:7–16.

[32] Joynt KE, Jha AK. Characteristics of hospitals receiving penalties under the hospital readmissions reduction program. JAMA 2013;309:342–3.

[33] Skinner JS, Gottlieb DJ, Carmichael D, Bronner KK. A new series of Medicare expenditure measures by hospital referral region: 2003-2008. A report of the Dartmouth atlas project; 2011 [Available at: http://www.dartmouthatlas.org/downloads/reports/PA_Spending_Report_0611.pdf].

[34] Fisher ES, Wennberg JE, Stukel TA, Skinner JS, Sharp SM, Freeman JL, et al. Associations among hospital capacity, utilization, and mortality of US Medicare beneficiaries, controlling for sociodemographic factors. Health Serv Res 2000;34:1351–62.

[35] Rogenstein C, Kelly A-M, Mason S, Schneider S, Lang E, Clement CM, et al. An international view of how recent-onset atrial fibrillation is treated in the emergency department. Acad Emerg Med 2012;19:1255–60.

[36] Zimetbaum PJ, Josephson ME, McDonald MJ, McClennen S, Korley V, Ho KK, et al. Incidence and predictors of myocardial infarction among patients with atrial fibrillation. J Am Coll Cardiol 2000;36:1223–7.

[37] Atzema CL, Barrett TW. Managing atrial fibrillation. Ann Emerg Med 2015 May;65(5):532–9. http://dx.doi.org/10.1016/j.annemergmed.2014.12.010 [Epub 2015 Feb 18. Review].

[38] Stiell IG, Clement CM, Brison RJ, Rowe BH, Borgundvaag B, Langhan T, et al. Variation in management of recent-onset atrial fibrillation and flutter among academic hospital emergency departments. Ann Emerg Med 2011;57:13–21.

[39] Barrett TW, Vermeulen MJ, Self WH, Jenkins CA, Ferreira AJ, Atzema CL. Emergency department management of atrial fibrillation in the United States versus Ontario, Canada. J Am Coll Cardiol 2015;65(20):2258–60.

[40] Levinson DR, Inspector General. Adverse events in hospitals: national incidence among Medicare beneficiaries. Department of Health & Human Services; 2010 [Available at: http://sma.org/michaelcgosney/files/2010/11/HHS_IG_AdverseHospEvents.pdf].

[41] Epstein AM, Jha AK, Orav EJ. The relationship between hospital admission rates and rehospitalizations. N Engl J Med 2011;365:2287–95.

[42] Amin AN, Jhaveri M, Lin J. Hospital readmissions in US atrial fibrillation patients: occurrence and costs. Am J Ther 2013;20:143–50.

[43] Seaburg L, Hess EP, Coylewright M, Ting, McLeod CJ, Montori VM. Shared decision making in atrial fibrillation: where we are and where we should be going. Circulation 2014;129:704–10.

[44] Barrett TW, Jenkins CA, Self WH. Validation of the risk estimator decision aid for atrial fibrillation (RED-AF) for predicting 30-day adverse events in emergency department patients with atrial fibrillation. Ann Emerg Med 2015;65:13–21.e3.

[45] Apiyasawat S, Tangcharoen T, Wisaratapong T, Yamwong S, Wiboonpolprasert S, Sritara P. CHA_2DS_2-VASc scores predict mortality after hospitalization for atrial fibrillation. Int J Cardiol 2015;185:293–6.

[46] Naccarelli GV, Panaccio MP, Cummins G, Tu N. CHADS2 and CHA_2DS_2-VASc risk factors to predict first cardiovascular hospitalization among atrial fibrillation/atrial flutter patients. Am J Cardiol 2012;109(10):1526–33.

[47] 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.

[48] Decker, Smars PA, Vaidyanathan L, Goyal DG, Boie ET, Stead LG, et al. A prospective, randomized trial of an emergency department observation unit for acute onset atrial fibrillation. Ann Emerg Med 2008;52:322–8.

[49] Ross MA, Davis B, Dresselhouse A. The role of an emergency department observation unit in a clinical pathway for atrial fibrillation. Crit Pathw Cardiol 2004;3:8–12.

[50] Venkatesh AK, Geisler BP, Gibson Chambers JJ, Baugh CW, Bohan JS, Schuur JD. Use of observation care in US emergency departments, 2001 to 2008. PLoS One 2011:e24326.

[51] Wright S. Memorandum report: hospitals' use of observation stays and short inpatient stays for Medicare beneficiaries, OEI-02-12-00040. Department of Health and Human Services, Office of Inspector General: Washington (DC); 2013 Available at: http://oig.hhs.gov/oei/reports/oei-02-12-00040.pdf.

Please cite this article as: Lin MP, et al, Hospital-level variation and predictors of admission after ED visits for atrial fibrillation: 2006 to 2011, Am J Emerg Med (2016), http://dx.doi.org/10.1016/j.ajem.2016.07.023