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Original Article

Centre-Specific Variation in Atrial Fibrillation Ablation-Treatment Rates in a Universal Single-Payer Healthcare System

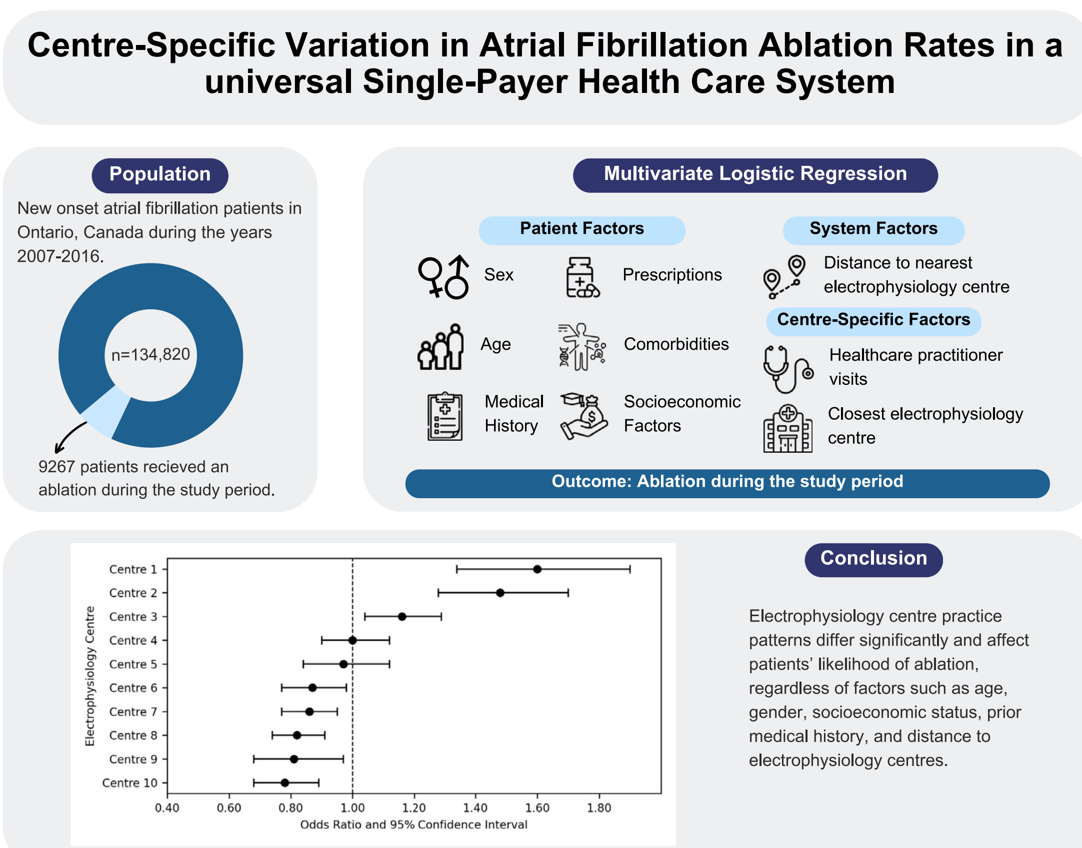
Christina Seo, MASc,[a,‡] Sameer Kushwaha, MD,[b,c,‡] Paul Angaran, MD,[b,c] Peter Gozdyra, MA,[d] Katherine S. Allan, PhD,[c] Husam Abdel-Qadir, MD, PhD,[b,c] Paul Dorian, MD, MSc,[b,c] and Timothy C.Y. Chan, PhD[a]

[a] *Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, Ontario, Canada*

[b] *Department of Medicine, University of Toronto, Toronto, Ontario, Canada*

[c] *Division of Cardiology, St. Michael's Hospital, Toronto, Ontario, Canada*

[d] *ICES, Toronto, Ontario, Canada*



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ABSTRACT

Background: Disparities in atrial fibrillation ablation rates have been studied previously, with a focus on either patient characteristics or systems factors, rather than geographic factors. The impact of electrophysiology (EP) centre practice patterns on ablation rates has not been well studied.

Methods: This population-based cohort study used linked administrative datasets covering physician billing codes, hospitalizations, prescriptions, and census data. The study population consisted of patients who visited an emergency department with a new diagnosis of atrial fibrillation, in the period 2007-2016, in Ontario, Canada. Patient characteristics, including age, sex, medical history, comorbidities, socioeconomic factors, closest EP centre within 20 km, and distance to the nearest centre, were used as predictors in multivariable logistic regression models to assess the relationship between living in a location around specific EP centres and ablation rates.

Results: The cohort included 134,820 patients, of whom 9267 had an ablation treatment during the study period. Patients undergoing ablation treatment were younger, had a lower **C**ongestive Heart Failure, **H**ypertension, **A**ge, **D**iabetes, **S**troke/Transient Ischemic Attack ($CHADS_2$) score, lived closer to EP centres, and had fewer comorbidities than those who did not receive ablation treatment. Wide variation occurred in ablation rates, with adjacent census divisions having ablation rates up to 2.6 times higher. Multivariate regression revealed significant differences in ablation rates for patients who lived in a location around certain EP centres. The odds ratios for living in a location closest to specific centres ranged from 0.78 (95% confidence interval: 0.68-0.89) to 1.60 (95% confidence interval:1.34-1.90).

Conclusions: Living near specific EP centres may significantly affect a patient's likelihood of receiving ablation treatment, regardless of factors such as age, gender, socioeconomic status, prior medical history, and distance to EP centres.

RÉSUMÉ

Contexte : Les disparités dans les taux d'ablation de la fibrillation auriculaire ont été étudiées précédemment, en mettant l'accent soit sur les caractéristiques des patients, ou sur les facteurs systémiques, plutôt que sur les facteurs géographiques. L'impact des pratiques des centres d'électrophysiologie (EP) sur les taux d'ablation n'a pas été bien étudié.

Méthodes : Cette étude de cohorte basée sur la population a utilisé des ensembles de données administratives couplées couvrant les codes de facturation des médecins, les hospitalisations, les prescriptions et les données de recensement. La population étudiée était constituée de patients ayant consulté un service d'urgence pour un nouveau diagnostic de fibrillation auriculaire, au cours de la période 2007-2016, en Ontario, au Canada. Les caractéristiques des patients, notamment l'âge, le sexe, les antécédents médicaux, les comorbidités, les facteurs socio-économiques, le centre d'EP le plus proche dans un rayon de 20 km et la distance par rapport au centre le plus proche, ont été utilisées comme prédicteurs dans des modèles de régression logistique multivariée pour évaluer la relation entre le fait de vivre dans un endroit situé près de centres d'EP spécifiques et les taux d'ablation.

Résultats : La cohorte comprenait 134 820 patients, dont 9 267 avaient subi une ablation au cours de la période d'étude. Les patients ayant subi une ablation étaient plus jeunes, avaient un score $CHADS_2$ plus faible (évaluant l'insuffisance cardiaque congestive, l'hypertension, l'âge, le diabète, et les antécédents d'accident vasculaire cérébral ou d'ichémie cérébrale transitoire), vivaient plus près des centres d'EP et avaient moins de comorbidités que les patients n'ayant pas reçu de traitement par ablation. Les taux d'ablation varient considérablement, les zones de recensement limitrophes ayant des taux d'ablation jusqu'à 2,6 fois plus élevés. La régression multivariée a révélé des différences significatives dans les taux d'ablation pour les patients qui vivaient à proximité de certains centres d'EP. Les rapports de cotes pour le lieu de résidence le plus proche de certains centres spécifiques variaient de 0.78 (intervalle de confiance à 95 % : 0,68-0,89) à 1,60 (intervalle de confiance à 95 % : 1,34-1,90).

Conclusions : Le fait de vivre à proximité de centres d'EP spécifiques peut affecter de manière significative la probabilité d'un patient de recevoir un traitement par ablation, indépendamment de facteurs tels que l'âge, le sexe, le statut socio-économique, les antécédents médicaux et la distance par rapport aux centres d'EP.

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia, affecting approximately 59.7 million people worldwide.[1] AF is associated with an increased risk of stroke and heart failure. Managing AF necessitates a multidimensional approach, including lifestyle modifications, pharmacotherapy, anticoagulation treatment, and in a subset of patients, catheter ablation treatment. With improvements in technology and expertise, both the effectiveness and frequency of ablation as an early treatment for AF have increased over time.[2-5] Clinical practice is directed by Canadian Cardiovascular Society guidelines supporting use of AF ablation treatment in patients for whom a rhythm-control strategy is preferred, generally as a second-line therapy in cases in which pharmacologic rhythm control has been ineffective, or in highly symptomatic individuals.[4-8] More-contemporary evidence has advanced early rhythm-control strategies as a means of reducing morbidity and mortality from AF, further elevating the potential importance of ablation treatment in contemporary AF management.[9,10] Patients who present to the emergency department (ED) with undiagnosed AF may be more symptomatic than those diagnosed with AF in other outpatient settings; therefore, a rhythm-control strategy may be more likely to be beneficial in these patients.

As the demand and wait times for AF ablation treatment increase,[11] the variability in ablation rates across the population is important to understand. Several factors may affect ablation-treatment rates, including patient factors

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‡Co−first authors.

Corresponding author: Christina Seo, University of Toronto, 5 King's College Rd, Toronto, Ontario M5S 3G8, Canada. Tel.: +1-416-978-3040.

E-mail: christinajoyseo@gmail.com

Twitter: @SameerKush, @pgozdyra, @katie_s_allan, @husam247, @paul_dorian

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(eg, symptom burden, age, sex, comorbidities), hospital factors (eg, frequency of scheduled follow-up appointments, number and type of therapies attempted, centre practice patterns), and system factors (eg, general healthcare accessibility, distance to closest hospital, rurality). Previous studies have assessed the relationship between patient factors and AF ablation-treatment rates.[12-16] System factors, such as rurality, also have been explored.[17] These prior studies have found variability in ablation-treatment rates. However, the impact of individual hospital practice patterns (an important "hospital factor") on ablation-treatment rates has not been well studied.

We conducted a population-based cohort study to test the hypothesis that significant geographic variation is present in the ablation-treatment rates of those living near different electrophysiology (EP) centres in Ontario, Canada, among patients presenting to the ED with new-onset AF. In particular, we aimed to investigate the degree of heterogeneity in AF ablation-treatment rates as it relates to the specific EP centre that an individual patient lives closest to, while adjusting for patient and system factors.

Materials and Methods

Data sources

The data sources used in this study are a mix of Ontario administrative health data and census data. The data were compiled from administrative databases and registries maintained by Ontario Health and Statistics Canada. The Ontario Health dataset included data from the Discharge Abstract Database (DAD), the National Ambulatory Care Reporting System (NACRS), the Ontario Drug Benefit Formulary, the Ontario Health Insurance Plan (OHIP), the Registered Persons Database, and the Ontario Cancer Registry. Statistics Canada provided the publicly accessible Ontario Marginalization Index (ON-Marg), and this study utilized 3 composite dimensions (residential instability, material deprivation, dependency) related to socioeconomic status. A full description of each registry can be found in Supplemental Table S1. The 2016 version of the ON-Marg dataset was used. The ON-Marg data were combined with the Ontario Health data, based on patients' postal codes at the census division level, for initial exploratory analysis, and based on the smallest geographic unit available—the dissemination area—for multivariate regression analysis.

EP centres are public hospitals that perform AF catheter ablations and are primarily tertiary- or quaternary-care hospitals located in large cities. These procedures are free for patients, as Canada operates as a universal, single-payer healthcare system.

Ontario, Canada has 10 major EP centres each associated with a major university. They are all located in Southern Ontario. Centre 1 is part of a 2-hospital network and is the largest hospital (500+ beds) in a city with a population of approximately 150,000. Centre 4 is part of a 3-hospital network in a city with a population of approximately 1,000,000. Centre 5 is part of a 2-hospital network in a city with a population of approximately 400,000. Centre 6 is a hospital in a 7-hospital network in a city with a population of approximately 600,000. Centres 7, 9, and 10 are located in the city of Toronto (in a densely populated urban environment; city population, 2.7 million), whereas centres 2, 3, and 8 are located in cities or townships that are on the periphery of the Greater Toronto Area, a region with a population of approximately 6.7 million.

Research Ethics Board approval was obtained from Unity Health Toronto, in Toronto, Ontario (study number 19-227).

Study population

The patient population included all adults in Ontario who had a new diagnosis of AF, based on the criteria outlined below. Patients were included in the cohort if they presented at an ED in Ontario, Canada with a new diagnosis of AF during the period 2007-2016. Individuals were identified as having new AF if they had an ED visit during which AF was among the top 2 reasons for the visit, and if no prior diagnosis of AF had been made in the 2 years leading up to the visit. A diagnosis of AF was defined as a recorded International Classification of Diseases (ICD) code for AF (I48 in ICD, revision 10 [ICD-10] and 427.3 in ICD, revision 9 [ICD-9]) in NACRS or DAD data. The ICD code I48 for AF has been validated previously, with a positive predictive value of 93.0% (95% confidence interval [CI] 91.6%-94.2%), and a sensitivity level of 96.6% (95% CI 94.1%-98.2%).[18] The following exclusion criteria were applied: having stage-4 cancer; being pregnant; receiving palliative care; being aged < 18 years; having had an ablation within 60 days of AF diagnosis; having developed AF within 72 hours of coronary artery bypass graft or valve surgery; having a primary home address outside of Ontario; having died during their AF diagnosis visit; or having < 2 years of follow-up care. Patients receiving ablation treatment within the first 60 days after AF diagnosis were excluded, to allow a minimum period prior to the ablation treatment, in which the quantity and type of physician follow-up care could be assessed. Prior anticoagulant use was not an exclusion criterion, as other comorbidities (eg, venous thromboembolic disease, mechanical valve replacement) could necessitate anticoagulant use. Of note, the diagnoses of AF and atrial flutter, as well as ablation treatment for these conditions, are grouped together in the available administrative databases.

Study variables

All the variables included in the analyses can be categorized into patient, EP centre, and system factors. Patients' postal codes and the addresses of EP centres were converted to geographic coordinates. The shortest driving distances from each patient's home to each EP centre were calculated, using Quantum Geographic Information System (QGIS) software, version 3.22 (QGIS.org). For all patients, we identified the closest EP centre to their home, if one was located within 20 km. To capture the number of healthcare practitioner visits that occurred in the time leading up to the ablation treatment, we calculated the number of cardiologist, internist, and family physician visits that occurred within 60 days of AF diagnosis, for each patient.

Variables included in this study can be grouped as follows: patient factors (age at diagnosis, sex, postal code, past medical history, comorbidities, prior interventions, social determinants of health); EP centre factors (closest EP centre, number of healthcare practitioner visits within 60 days of diagnosis); and system factors (distance to nearest EP centre, rurality).

Outcomes

Our goal was to understand how living in a geographic location near certain EP centres affected a patient's likelihood of getting an ablation treatment.

The primary outcome of interest was the difference in the likelihood of ablation treatment at any point after the initial AF diagnosis by the patient's closest EP centre (within 20 km). Secondarily, we analyzed the relationship between the number of healthcare practitioner visits and ablation-treatment rates.

Analysis

We conducted multiple analyses, first to get an understanding of our population and ablation-treatment rates, and second, to understand the specific relationship between living near an EP centre and receiving ablation treatment.

We compared baseline characteristics for patients who did vs did not have AF ablation treatment, using a χ^2 test, for percentages, and a *t* test, for continuous values. Overall population values also were reported. Numerical variables were described using the mean and standard deviation, and binary variables were described as counts and percentages.

All statistical tests used a *P*-value of < 0.05 to indicate significance. All statistical analysis was completed using Python 3 (School of Computer Science at Carnegie Mellon University, Pittsburgh, PA).

Choropleth mapping. Age- and sex-adjusted rates of follow-up ablation treatment per 100,000 people were calculated for each census division, by quintiles, using QGIS. Patient counts and population counts also were plotted by census division for comparison.

Multivariate logistic regression. We developed a multivariate logistic regression model to determine the association between closest EP centre to a patient's residence and the likelihood of that patient receiving follow-up AF ablation treatment, controlling for patient and system factors. The variance inflation factor was calculated to test for multicollinearity between variables. All variables besides known risk factors (age; **C**ongestive Heart Failure, **H**ypertension, **A**ge, **D**iabetes, **S**troke/Transient Ischemic Attack [$CHADS_2$] score at diagnosis; previous diabetes; previous hypertension; distance to nearest EP centre) and our variables of interest (closest EP centre, 60-day healthcare practitioner visits) were candidates for removal. We removed variables that had a variance inflation factor > 5.

Sensitivity analysis. Three sensitivity analyses were conducted to assess the robustness of our results; the multivariate logistic regression model was run separately with each of these modifications. First, we tested the sensitivity to the closest EP centre assignment. For patients who lived within 20 km of multiple centres, random assignment to one of them was made. Assignment probabilities were inversely proportional to the distances of patients' residences from each centre, with distances of < 0.5 km rounded to 0.5 km for numerical stability. The second sensitivity analysis increased the distance limit to 40 km for the calculation of the closest EP centre. The third sensitivity analysis changed the follow-up period to 2 years after AF diagnosis, as this was the maximum follow-up time available for all patients.

Results

The cohort included a total of 134,820 patients. Of these, 9267 patients (6.9%) received an ablation treatment after their initial diagnosis. The average follow-up period for the population was 5.3 years. The median distance between patients' residences and their nearest EP centre was 31.9 km (quartile 1: 10.0 km; quartile 3: 85.4 km). Overall, 87.0% of patients had at least one family physician visit within 60 days of their diagnosis, whereas only 57.3% and 47.2% had at least one internist and cardiologist visit in the same time period, respectively. Compared to patients who did not have an ablation treatment, patients that had an ablation treatment were younger, had lower $CHADS_2$ scores at diagnosis, had lower ON-Marg scores, lived closer to EP centres, were more likely to be male, and had fewer comorbidities. All of these differences were statistically significant.

Patients who underwent ablation treatment saw cardiologists and internists more often in the first 60 days of their diagnosis, but they saw family physicians less often. A comparison of only the subset of patients aged ≥ 65 years (for whom prescription drug information is available) showed that patients who underwent ablation treatment had a significantly higher level of baseline use of beta-blockers, direct oral anticoagulants, warfarin, and antiarrhythmics, but they had significantly lower rates of prior calcium-channel—blocker prescription. The rates of prior antiplatelet prescription (excluding for acetylsalicylic acid) were not significantly different (Table 1).

The baseline characteristics of the cohort, grouped by their closest EP centre within 20 km of their residence, are given in Supplemental Table S2, with no clear sustained patterns among patient groups. The mean and median number of days to ablation treatment for patients who lived near each centre can be found in Supplemental Table S3. Centres 1, 5, and 9 had the shortest number of days between diagnosis and ablation treatment. The largest difference in number of days to ablation treatment for patients living near one vs another EP centre was found for centre 1 (median number of days to ablation = 523) and centre 10 (median number of days to ablation = 752).

Choropleth mapping

A wide range of ablation-treatment rates occurred across Ontario census divisions. Marked differences were present in ablation-treatment rates across Ontario (Fig. 1), with the highest rates, per capita, in the south, where the majority of the population lives. However, even within southern Ontario, ablation-treatment rates showed substantial variation, ranging from 44.1 to 180.9 events per 100,000 individuals; neighbouring census divisions had rates of ablation treatment that were up to 2.6 times higher. The geographic distribution of patients with newly diagnosed AF in our cohort, as well as those who underwent AF ablation treatment, was qualitatively similar to the overall population distribution.

Table 1. Baseline characteristics of patient population, overall, and stratified by whether ablation treatment was received

Characteristics	Had ablation treatment (n = 9267)	Did not have ablation treatment (n = 125,553)	*P*	Overall (n = 134,820)
Age, y	60.02 ± 13.03	71.60 ± 14.37	< 0.01	70.80 ± 14.58
Male sex	5836 (63.0)	62,447 (49.7)	< 0.01	68,283 (50.6)
Distance to nearest EP centre, km	83.41 ± 200.87	102.87 ± 235.66	< 0.01	101.53 ± 233.49
Comorbidities and clinical history				
$CHADS_2$ score 0−6	0.61 ± 0.80	1.14 ± 0.98	< 0.01	1.11 ± 0.98
Positive previous history				
Cancer	439 (4.7)	9622 (7.7)	< 0.01	10,061 (7.5)
Heart failure	542 (5.8)	10,705 (8.5)	< 0.01	11,247 (8.3)
Hypertension	2898 (31.3)	49,951 (39.8)	< 0.01	52,849 (39.2)
Diabetes	839 (9.1)	15,698 (12.5)	< 0.01	16,537 (12.3)
Pacemaker	34 (0.4)	467 (0.4)	1.00	501 (0.4)
ON-Marg factors				
Residential Instability*	−0.02 ± 0.95	0.20 ± 1.06	< 0.01	0.18 ± 1.05
Dependency*	0.18 ± 1.08	0.40 ± 1.29	< 0.01	0.39 ± 1.28
Material deprivation*	−0.17 ± 0.90	0.00 ± 0.96	< 0.01	−0.01 ± 0.96
Outpatient follow-up care by specialist, after AF diagnosis within 60 d, # of visits				
Cardiologist	1.48 ± 1.65	0.91 ± 1.44	< 0.01	0.95 ± 1.46
Family physician	2.98 ± 2.91	3.34 ± 3.77	< 0.01	3.32 ± 3.72
Internist	1.67 ± 2.13	1.42 ± 2.28	< 0.01	1.44 ± 2.27
Medication use at baseline†	Had ablation treatment (n = 3529)	Did not have ablation treatment (n = 90,740)	*P*	Overall (n = 94,269)
Beta-blocker	1280 (36.3)	29,649 (32.7)	< 0.01	30,929 (32.8)
Calcium-channel blocker	760 (21.5)	24,449 (26.9)	< 0.01	25,209 (26.7)
Antiarrhythmic	122 (3.5)	569 (0.6)	< 0.01	691 (0.7)
Direct oral anticoagulant	195 (5.5)	3645 (4.0)	< 0.01	3840 (4.1)
Antiplatelet (excluding acetylsalicylic acid)	236 (6.7)	6465 (7.1)	0.34	6701 (7.1)
Warfarin	441 (12.5)	10,370 (11.4)	0.05	10,811 (11.5)

Values are mean ± standard deviation, or n (%), unless otherwise indicated.

$CHADS_2$, **C**ongestive Heart Failure, **H**ypertension, **A**ge, **D**iabetes, **S**troke/Transient Ischemic Attack; EP, electrophysiology; ON-Marg, Ontario Marginalization Index.

*The ON-Marg dimensions are given as factor scores that can take positive and negative values, with larger positive numbers indicating a higher degree of marginalization.

†Medication use data were available for only those patients aged ≥ 65 years.

Multivariate logistic regression

Living around specific EP centres significantly affected a patient's likelihood of getting an ablation treatment.

Patients living in the areas surrounding centres 1-3 were more likely to receive an ablation treatment than those living elsewhere, after adjusting for covariates. Living near centres 4 and 5 did not significantly affect the likelihood of undergoing ablation treatment, whereas living near centres 6-10 was associated with a decreased likelihood of receiving an ablation treatment (Fig. 2).

Attending a higher number of cardiologist (odds ratio [OR]: 1.14, 95% CI: 1.13-1.16) and internist (OR: 1.05, 95% CI: 1.04-1.06) visits in the first 60 days after AF diagnosis was associated with a higher likelihood of undergoing an AF ablation treatment. The number of family physician visits was not significantly associated with receiving ablation treatment (OR: 1.01, 95% CI: 1.00-1.01). The full multivariate regression results are provided in Supplemental Table S4.

Sensitivity analysis

In the sensitivity analyses, the main results were robust to changes.

In all 3 sensitivity analyses, the directionality and ordering of the ORs were similar, as shown in Figure 2, with the caveat that in a few cases, borderline significant variables became insignificant, and vice versa (Supplemental Table S5).

Discussion

In this study, we found marked variation in AF ablation-treatment rates across Ontario, Canada. Our study cohort included primarily those patients with new diagnoses of AF, and its demographics were similar to those of cohorts in other major AF trials,[4,19] with regard to average age and proportion of male patients, with a slightly lower burden of $CHADS_2$ risk factors. Areas in northern Ontario, which were furthest from any EP centre in the province, had low rates of ablation treatment, whereas southern Ontario had clusters of both high and low ablation-treatment rates. The results of the multivariate analysis showed that wide variation was present in the adjusted ORs for the rate of ablation treatment across the 10 EP centres. The significant relationship between ablation-treatment rate and whether patients lived near specific EP centres suggests that EP centre-specific practice patterns, rather than important patient-specific clinical factors alone, are an important determinant of whether a patient receives an AF ablation treatment. We found that if a patient lived in a geographic location around certain centres, this increased the likelihood of that patient receiving ablation treatment; if a

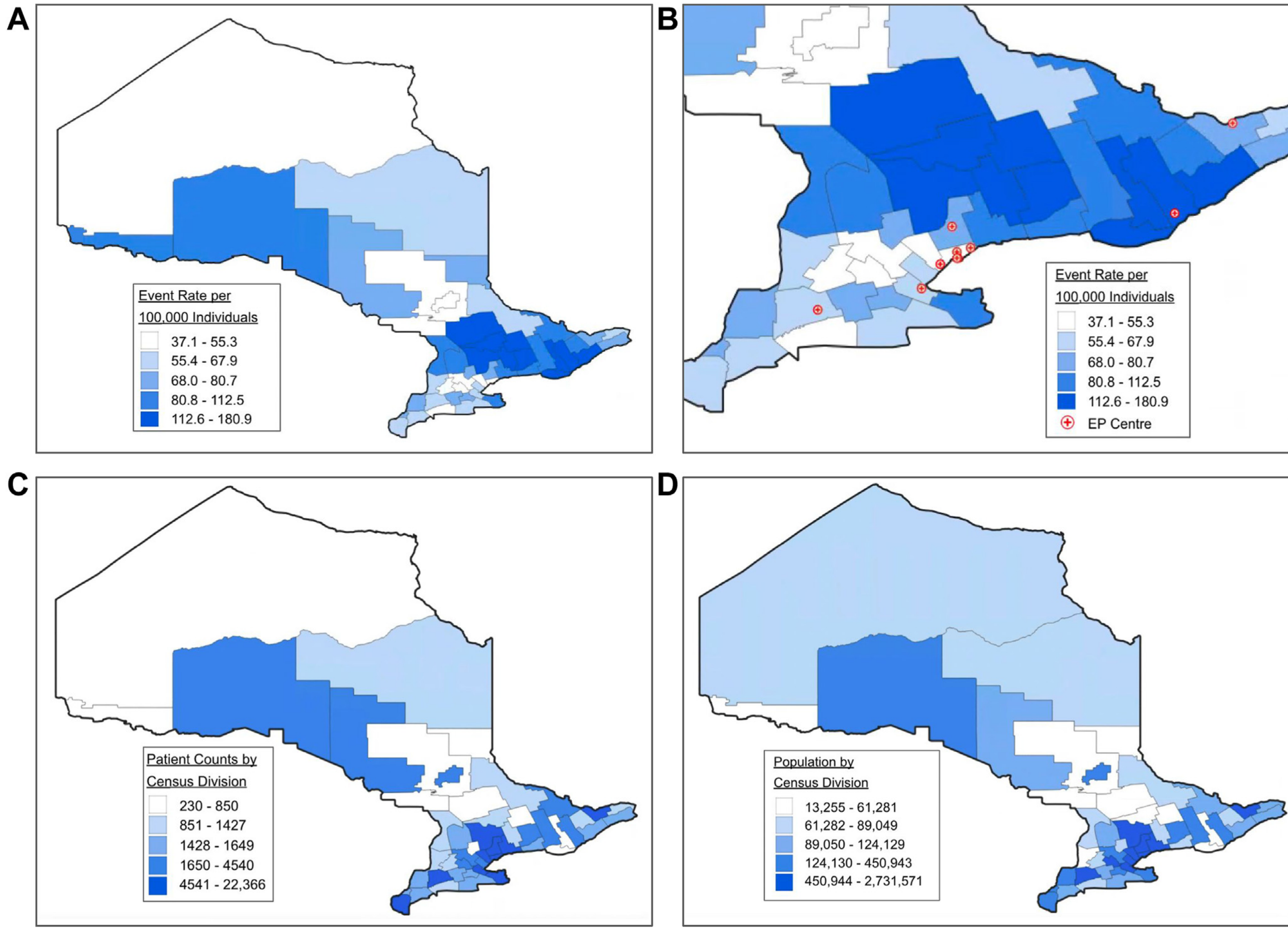

Figure 1. Choropleth maps of Ontario, showing ablation-treatment rates and population distribution by census-division quintiles across Ontario. (**A**) Age- and sex-adjusted ablation-treatment rates per 100,000 people, across the entire province. (**B**) A magnified view of Southern Ontario, with EP centres indicated. (**C**) Patients in our cohort (all patients diagnosed with new atrial fibrillation in an emergency department). (**D**) Total population, based on 2016 census data. EP, electrophysiology.

patient lived in a location around certain other centres, this had no effect on the likelihood; and if a patient lived in a location around still other centres, this decreased the likelihood of that patient having an ablation treatment. The 2 centres associated with the highest likelihood of receiving an ablation treatment were in areas with the smallest populations, whereas the opposite was true for the centres associated with the lowest likelihoods. We also found that seeing a cardiologist more frequently in the first 60 days after receiving a diagnosis of AF was associated with a higher likelihood of undergoing an ablation treatment. This correlation is likely indirect, and it is more of a measure of clinical involvement. In Ontario, patients who undergo an ablation treatment generally need to consult with a cardiologist or another healthcare practitioner before they are referred to an electrophysiologist. The electrophysiologist is the one who makes the final decision regarding whether ablation is performed.

The geographic variation found in our study is consistent with findings in prior studies. Rates of EP assessments and catheter-ablation procedures have been found to differ between AF patients who live in rural vs urban areas.[17] A study of older patients in the US has shown a marked regional variability in AF ablation-treatment rates, across hospital referral regions, that is unassociated with AF burden.[20] Geographic variation in AF ablation-treatment rates across referral regions also was found in Norway.[12] The relationships between patient factors and the likelihood of undergoing ablation treatment also was consistent with results of prior studies investigating socioeconomic status,[12,13,16] age,[12] prior clinical history,[14] and gender.[15] Our study adds to this body of work, as it is the first that analyzes geographic variation in ablation-treatment rates as a function of hospital-specific practice patterns. By analyzing ablation-treatment rates by EP centre, instead of by prior, set geographic subregions, we were able to identify local patterns and adjust the distance window, based on what is considered a reasonable distance to travel for care. Our sensitivity analyses revealed that our findings remained consistent even when we changed the distance window.

To ensure consistent quality of care across the province, having an understanding of what drives this variation is imperative. Differing AF ablation-treatment rates for patients

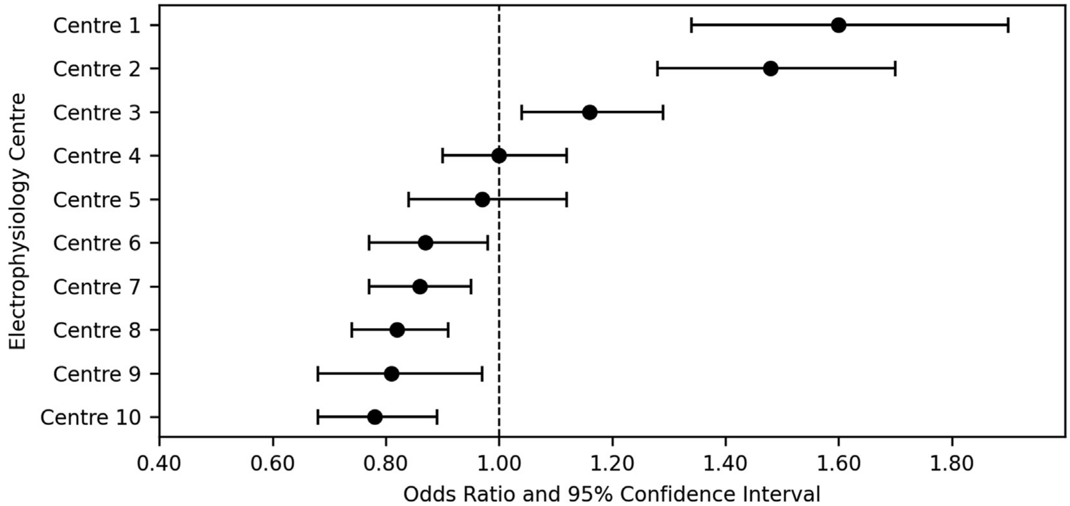

Figure 2. Multivariate logistic regression results—odds ratios and confidence intervals for the electrophysiology centre indicators, adjusting for patient and system factors.

who live in proximity to certain centres may reflect differences in the practice patterns of physicians at those centres, and they cannot be explained fully by an observational study. These patterns could reflect differences in local experience and comfort with AF ablation treatment, decision-making models (eg, whether decisions are made by individual cardiologists or are shared among a group of healthcare providers), the level of penetration and uptake of clinical guidelines, or the incentives for performing procedures. Some of these observations also may be due to differing referral patterns from other physicians who work near specific EP centres. We do not know whether some centres refer more patients for consideration of ablation treatment, whether a higher proportion of patients who are referred to subspecialized electrophysiologists for management of AF, ultimately undergo ablation, or whether both occur. To ensure that care is delivered equitably and appropriately, a better understanding is needed of the factors that drive these differences.

Limitations

The literature continues to evolve regarding the efficacy and benefits of AF ablation, compared to those of other rate- and rhythm-control strategies. This study illustrates the existence of marked centre-specific differences, but it does not allow comment on "ideal" ablation rates. Absolute ablation-treatment rates likely have increased since 2016, with awareness of ablation procedures increasing, and with technical advancements (eg, cryoballoon ablation) that reduce procedural time. However, more contemporary data on AF ablation-treatment rates in Canada are not available publicly, and the difference in ablation-treatment rates among centres likely persists. Newer ablation technologies have not reduced the incidence of mortality or morbidity from AF,[19] compared to other methods of AF rhythm control, and this clinical equipoise continues to be reflected in the Canadian clinical guidelines.[10]

We used previously validated ICD codes to identify AF, and excluded patients who were likely to have carried a previous diagnosis of AF. The use of administrative data means that some patients could have been misclassified. Although we tried to exclude patients with preexisting AF, using a 2-year lookback period, a longer lookback window might have revealed more cases of preexisting AF. We also do not know the proportion of patients who had a prior diagnosis of AF, outside of an ED, who never presented to an ED and had AF documented in the NACRS or DAD. The available administrative databases, which are commonly used for AF research in Ontario, categorize AF and atrial flutter together, as well as ablation procedures for the 2 conditions, despite differences in their procedural complexity and success rates. The prescription data used contain information for only those patients aged $\geq$ 65 years. However, the mean age of our cohort was $>$ 65 years, so this incompleteness affected a minority of patients.

Another limitation of this study is residual confounding, due to the lack of data on certain variables. Variables such as AF subtype, burden, left ventricular ejection fraction, left atrial size, and valvular heart disease are clinically important variables, but data on these were not available in this study. Also, data on the identity of the specific cardiologist that a patient visited for follow-up care or who performed an ablation were not available, but these may provide additional insight into variations in practice patterns.

Possibly, our results overestimate centre-specific effects, as differences relating to the specific EP centre could be attributed partially to a specific cardiologist's practice patterns, incomplete medication information, or other confounding factors. However, given the stability of our results, as shown through the various sensitivity analyses, we believe that these EP-centre effects do exist, with the directionality and significance found in the study described in this article.

Conclusions

Marked geographic variation is present in AF ablation-treatment rates in Ontario, Canada. Whether a patient lives in a geographic location near specific EP centres may affect that patient's likelihood of receiving ablation treatment significantly, regardless of factors such as age, gender, socioeconomic status, prior medical history, and distance to EP centres. The mechanisms of these findings remain unknown, and further research is needed to understand whether they are driven by clinician practice patterns, patient preferences, or other factors.

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Ethics Statement

Research Ethics Board approval was obtained from Unity Health Toronto, in Toronto, Ontario, Canada (study number 19-227).

Patient Consent

The authors confirm that patient consent is not applicable to this article. This is a retrospective study using de-identified data; therefore, the research ethics board did not require consent from the patients.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

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