Journal of the American Heart Association

ORIGINAL RESEARCH

Association of Cardiology Billing Amounts With Health Care Utilization and Clinical Outcomes in Patients With Atrial Fibrillation

R. Sacha Bhatia, MD, MBA; Cherry Chu, MSc; Anna Kaoutskaia, BSch; Dennis T. Ko, MD, MSc; Kaveh G. Shojania, MD; Paul Dorian, MD, MSc; Bing Yu, PhD; Mohammed Shurrab, MD, MSc; Jiming Fang, PhD; Heather Ross, MD; Peter C. Austin, PhD, MSc; Zachary Bouck, MPH; Shaun G. Goodman, MD; Eugene Crystal, MD

BACKGROUND: The relationship between health care utilization and outcomes in patients with atrial fibrillation is unknown. The objective of this study was to investigate whether cardiologists' billing amounts in a fee-for-service environment are associated with better patient-level clinical outcomes.

METHODS AND RESULTS: A retrospective cohort study was conducted using administrative claims data of cardiologists in Ontario, Canada between April 1, 2011 and March 31, 2016. The cardiologists were stratified into quintiles based on their median billing patterns per patient over the observation period. The primary outcomes were patient-level receipt of repeat visits, cardiac diagnostic tests, and medications ≤1 year of index date. The secondary clinical outcomes were death, emergency department visits, and all-cause hospitalization 1-year post-index visit. The patient cohort comprised 182 572 patients with atrial fibrillation (median age 74 years, 58% male) from 467 cardiologists. Patients with atrial fibrillation seen by higher-billing cardiologists were 26% more likely to have an echocardiogram (adjusted odds ratio [aOR], 1.26 [95% CI, 1.10–1.43] for quintile 5 versus 2), 28% a stress test (aOR, 1.28 [1.12–1.46] for quintile 5 versus 2), 25% continuous electrocardiographic monitoring (aOR, 1.25 [1.08–1.46] for quintile 4 versus 2), and 79% more likely to get a stress echocardiogram (aOR, 1.79 [1.32–2.42] for quintile 5 versus 2). They also had a higher rate of all-cause hospitalization (aOR, 1.13 [1.07–1.20]). Mortality rates were similar across cardiologists billing quintiles (eg, aOR, 0.98 [0.87–1.11] for quintile 4 versus 2).

CONCLUSIONS: Higher-billing cardiologists ordered more diagnostic tests per patient with atrial fibrillation but these are not associated with improvements in outcomes.

Key Words: antiarrhythmia agent ■ atrial fibrillation arrhythmia ■ cost-effectiveness ■ outcome ■ outcome and process assessment

Efforts to manage the rising costs of health care have focused in recent years on the reduction of low-value care. For example, campaigns such as Choosing Wisely have attempted to curb low-value service use through clearly defined clinical recommendations.[1] However, these contemporary efforts have not addressed the contribution of discretionary clinical services to overall health care spending.[2] This is important because prior research has demonstrated that differences between higher- and lower-spending regions in the United States are driven by variation in discretionary clinical decision making.[3–5]

Atrial fibrillation (AF) is the most common clinical cardiac arrhythmia, with an increasing burden of health system utilization.[6] In patients with AF, only a few therapies, such as anticoagulation for stroke prevention,[7] and catheter ablation in patients with AF with concurrent cardiovascular disease,[8,9] are proven to reduce mortality and morbidity, and the majority of clinical decision making, including rate versus rhythm control, are

Correspondence to: Dr Eugene Crystal, 2075 Bayview Ave, D377, Toronto, Ontario, Canada M4N 3M5. E-mail: Eugene.crystal@sunnybrook.ca

Supplementary Material for this article is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.120.020708

For Sources of Funding and Disclosures, see page 9.

JAHA is available at: www.ahajournals.org/journal/jaha

CLINICAL PERSPECTIVE

What Is New?

- Patients with atrial fibrillation seen by high-billing cardiologists had significantly higher rates of diagnostic testing compared with lower-billing cardiologists, but these were not associated with lower rates of hospitalization or death.
- Previous research analyzes the relationship of billing status to clinical activity, whereas our study assesses the relationship between total billing amounts, clinical activity, and outcomes at the individual provider level within a fee-for-service system.

What Are the Clinical Implications?

- Variation in atrial fibrillation investigations and management are common, and do not necessarily lead to differences in patient outcomes.
- These results suggest the importance of aligning reimbursement incentives with health system goals, because fee-for-service reimbursement may influence physician ordering behavior.

Nonstandard Abbreviations and Acronyms

FFS	fee-for-service
OHIP	Ontario health insurance plan

directed toward symptom management. AF management is an example of a disease where discretionary clinical services are used for symptom management, rather than impacting morbidity and mortality in the large majority of patients.

The drivers of discretionary care are multifactorial, including clinical guidelines, culture, physician and hospital supply, and individual practice settings; however, it may be that financial incentives play a role in discretionary care.[10,11] For example, prior research has demonstrated an association between ownership of cardiac stress testing equipment and performance of routine stress tests post–percutaneous coronary intervention.[12] Most research to date has focused on total health spending in a geographical region, but not on the economic incentives for individual physicians. In Canada, as in most of the United States, physicians are predominantly paid on a fee-for-service (FFS) reimbursement model. Under this method of reimbursement, individual physicians' total billing amounts are calculated as the product of price per service and volume of services provided. In Ontario, Canada, in contrast to the US health care system, the price per service is fixed; thus, variation in physicians' billing is driven solely by the number of medical services rendered, whether those services are physician visits, cardiac tests, or procedures conducted and interpreted by the billing physician. Investigating billing variation among individual physicians treating clinical conditions that lack strict clinical guidelines may provide insight into how economic incentives influence the use of discretionary services.

In this population-based study, we aimed to determine whether there was an association between individual physician billings and their utilization of cardiac services, and clinical outcomes in patients with AF. We hypothesize that physicians who bill more per patient with AF will order more discretionary cardiac services for those same patients with no discernable impact on their clinical outcomes.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Study Design and Data Sources

We conducted a population-based, retrospective cohort study of cardiologists and general internists who practice cardiology who treat patients with AF, using routinely collected administrative claims data from Ontario, Canada. We used the following databases housed at the Institute for Clinical Evaluative Sciences (ICES): (1) Registered Persons Database, which provides basic demographic information for Ontario residents covered under the provincial health insurance plan (ie, the Ontario Health Insurance Plan); (2) Discharge Abstract Database, which includes clinical, demographic, and administrative information on hospital discharges; (3) National Ambulatory Care Reporting System, containing data on hospital- and community-based ambulatory care, including emergency department visits and same-day surgeries; (4) Ontario Health Insurance Plan (OHIP) database, which records all billing claims made by physicians for services provided to Ontario residents covered under OHIP (the majority of the population); (5) ICES Physician Database, detailing demographic information for physicians in the province; (6) Ontario Drug Benefit (ODB), which captures prescription drug dispensations at outpatient pharmacies that are reimbursed (at least partially) by the province under the ODB program; (7) CorHealth Cardiac Registry, containing clinical, administrative, and procedure-specific details (including findings and complications) for patients receiving a cardiac procedure in the province; and (8) various ICES-derived, disease-specific registries (eg, HYPER for identifying hypertensive patients). All of these data sets were linked using unique, encoded identifiers and analyzed at ICES. ICES is an independent, nonprofit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement. Use of these databases for the purposes of this study was authorized under §45 of Ontario's Personal Health Information Protection Act, which does not require review by a research ethics board.

Participants

We included cardiologists providing cardiovascular care in the study if they billed for services between April 1, 2011 and March 31, 2016, as documented in the OHIP database, and at least 80% of their billings during each year of practice were FFS payments. Other payments to the physicians, including stipends and salary support for research or administrative activities, were not captured as part of this study.

Patients included in the cohort were those seen by eligible cardiologists meeting the above criteria. First, we identified all OHIP claims dated between April 1, 2011 and March 31, 2016 for an outpatient visit to 1 of the study physicians. Using an ICES-validated algorithm,[13] we then identified visits concerning a patient with a primary diagnosis of AF (ie, patient met at least 1 of the following criteria within the 3 years before their index visit): (1) ≥1 hospitalization or emergency department visit with an *International Classification of Diseases, Tenth Revision* (*ICD-10*) code I48 listed as the most responsible diagnosis but not also as a type II diagnosis; (2) ≥1 prescription of a rhythm control medication (amiodarone HCl, flecainide acetate, propafenone, propafenone HCl); (3) ≥1 prescription for an anticoagulant (warfarin sodium, or direct-acting oral anticoagulant) accompanied by an OHIP claim for AF; or (4) ≥1 cardioversion (OHIP code Z437) accompanied by an OHIP claim for AF. If patients had multiple eligible visits on their index date, we excluded all visits that day if at least 2 of those visits were with different physicians. We identified the earliest visit per unique patient and set the corresponding date as their index date. Patients were excluded if they had invalid or missing information for their health card number, age, sex, or neighborhood income quintile (derived from postal code using Statistics Canada's Postal Code Conversion File+), were non-Ontario residents, <18 or >105 years old, residents of a long-term care home, or were not eligible for OHIP within 3 years before their visit.

On the basis of the resulting pool of eligible patients, we finalized our study population by excluding those physicians (and their corresponding patients) who saw <25 patients with AF during the study window. This volume-based exclusion was applied with the intention of limiting our study to physicians with sufficient volumes of patients with AF. In addition to analyzing all patients with AF seen by physicians, we also conducted subgroup analyses of new AF consults, defined as first visits to the cardiologist, and follow-up patients with AF, which are subsequent visits to the same cardiologist after the initial consultation.

Covariates

The following physician characteristics were collected based on each physician's first day of billing during the study period: sex, years since medical school graduation, international medical graduate status, and workload (based on full-time equivalents worked). We included a variable indicating whether the physician was an electrophysiologist, defined as having submitted at least 1 OHIP billing claim for ablation in the year before cohort entry.

Patient sociodemographic variables included age, sex, rurality, and neighborhood income quintile. The following medical complications within 3 years before the index visit were captured using *ICD-10* and Canadian Classification of Health Interventions codes: myocardial infarction, coronary revascularization, heart failure, renal dysfunction, stroke, and peripheral vascular disease. Any history of chronic obstructive pulmonary disease, hyperlipidemia, diabetes, and hypertension before cohort entry was identified using disease-specific registries.

The primary exposure was cardiologists' median annual billing per patient, for all patients in their practice per year. This was calculated using OHIP billing claims for services coded using professional fee codes. Median annual billing amounts per patient were stratified into quintiles, from lowest- (bottom 20%) to highest-billing physicians (top 20%). We also conducted a sensitivity analysis that considered income as a continuous variable.

Outcomes

The main outcomes of interest were patient-level cardiac diagnostic and therapeutic procedures. We identified whether patients had at least 1 claim for each of the following: transthoracic echocardiogram, stress testing, continuous electrocardiographic monitoring, and stress echocardiogram, cardioversion, and ablation. Additionally, we independently captured whether patients received at least 1 dispensation for each of the following drug classes: β-blockers, calcium-channel blockers, digoxin, anti-arrhythmic drugs, direct oral anticoagulant drugs, and warfarin. We quantified the number of outpatient visits with a primary care physician, cardiologist, or electrophysiologist. Clinical services were measured within 365 days of the index visit and re-measured annually for up to 5 years.

The following clinical outcomes were also ascertained: AF hospitalizations, emergency department visits for AF, stroke hospitalization, hospitalization for cardiovascular disease, and death. Clinical outcomes were measured within 365 days of the index visit and re-measured annually thereafter until the end of the follow-up period, for up to 5 years (death was measured once, 1 year from the index visit).

Statistical Analysis

Bivariate analyses of baseline characteristics and unadjusted outcomes were performed for the first year of follow-up among the cardiologist billing quintiles using Kruskal–Wallis tests for continuous variables and χ^2 tests for categorical variables. Adjusted analyses were conducted using mixed-effects logistic regression for dichotomous outcomes and mixed-effects Poisson regression for count-based outcomes. For mixed-effects regression analyses, we regressed a given outcome on the primary exposure while adjusting for all baseline patient and physician characteristics listed previously. Both physician- and patient-specific random effects were respectively included to account for clustering of patients within physicians and repeated measurements per patient. With respect to the primary exposure, the second physician income quintile was chosen as the reference category because the first income quintile appeared substantially different (eg, comprising a higher proportion of electrophysiologist physicians and academic physicians) compared with the other 4 quintiles. We also conducted 2 sensitivity analyses in addition to the main analyses. In the first sensitivity analysis we excluded electrophysiologist physicians and only included general cardiologists in an assessment of cardiac testing utilization and outcomes. In addition, we considered income as a continuous variable in our adjusted analysis.

All analyses were performed in SAS 9.4 (SAS Institute) with a 2-tailed P value ≤0.05 deemed a statistically significant result.

RESULTS

Participant Characteristics

After applying the eligibility criteria, 467 cardiologists were deemed eligible and included in our study. Physician characteristics are detailed in Table 1. The median annual billings per patient with AF varied from $89 in quintile 1 (lowest) to $463 in quintile 5 (highest). The lowest quintile consisted of a significantly higher proportion of electrophysiologists (18%) than any of the other quintiles. There was no difference in physician age, number of patients with AF per physician, or International Medical Graduate status, across the quintiles.

Figure S1 describes the flow of patients with AF into the study. After exclusions, 182 572 patients with AF were identified. Baseline patient characteristics are detailed in Table 2. Patients of physicians belonging to quintile 5 had a higher rate of acute myocardial infarction, coronary revascularization, and diabetes, but a lower rate of heart failure and renal dysfunction, compared with patients of physicians in quintile 2.

Cardiac Service Utilization

Figure shows the unadjusted utilization rate of cardiac service utilization by billing quintile. The proportion of patients with AF who had echocardiograms, continuous ECG monitoring, and stress echocardiograms increased from billing quintile 1 to 5. Cardioversion rates were similar across billing quintiles, and quintile 1 patients had higher rate of ablation therapies than the other quintiles. This pattern of test utilization was similar for all 7 years of study follow-up.

Table 3 lists the adjusted odds ratios (aOR) of use of cardiac services for the entire AF cohort, along with new and follow-up patients. Compared with patients with AF of physicians in billing quintile 2, patients of physicians in higher-billing quintiles were more likely to receive an echocardiogram (aOR, 1.26 [95% CI, 1.11–1.43] for quintile 5) and stress test (aOR, 1.28 [95% CI, 1.12–1.46] for quintile 5), continuous ECG monitoring (aOR, 1.25 [95% CI, 1.08–1.46] for quintile 4), and stress echo (aOR, 1.79 [95% CI, 1.32–2.42] for quintile 5) at 1 year. Conversely, patients of physicians in billing quintile 1 had higher adjusted rates of electrophysiologist appointment (aOR, 1.23 [95% CI, 1.03–1.47] for quintile 1) and ablation (aOR, 1.25 [95% CI, 1.07–1.47] for quintile 1). There was no difference in cardioversion utilization between billing quintiles. A similar utilization pattern was found for both new and follow-up patients, except follow-up patients with AF in quintile 1 did not have a higher rate of ablation.

Table S1 shows the aOR for physician visits. There was no difference in primary care visits and cardiology visits between billing quintiles.

Medication Use

Table S2 shows the aOR for medication use in patients with AF >65 years old across billing quintiles. Lower β-blocker use was found in billing quintile 1 (aOR, 0.89 [95% CI, 0.80–0.98]) and lower digoxin use was seen in billing quintile 5 (aOR, 0.97 [95% CI, 0.77–0.99]). Otherwise there was no difference in medication use across billing quintiles, including warfarin and direct oral anticoagulant use.

Clinical Outcomes

Table 4 shows the adjusted clinical outcomes across billing quintiles. There was no statistically significant difference in deaths or emergency department visits across billing quintiles. Patients with AF in billing

Table 1. Baseline Cardiologist Characteristics by Billing Quintile

Variable	Median quintile based on billings per patient						
	Total (n=467)	1 (n=94)	2 (n=93)	3 (n=94)	4 (n=93)	5 (n=93)	*P* value
Billings per patient, median (IQR)	$212 ($147–$319)	$89 ($62–$109)	$161 ($148–$176)	$213 ($200–$228)	$280 ($262–$319)	$463 ($405–$568)	<0.0001
Total billings, median (IQR)	$693 508 ($456 668–$980 482)	$519 067 ($418 626–$734 975)	$717 139 ($422 302–$928 054)	$801 347 ($520 333–$1 052 397)	$769 115 ($525 061–$1 087 203)	$690 726 ($503 415–$1 069 176)	<0.0001
Age, y, median (IQR)	44 (38–55)	47 (39–57)	45 (37–57)	45 (37–52)	44 (38–55)	44 (38–52)	0.3097
Male, n (%)	395 (84.6%)	84 (89.4%)	79 (84.9%)	72 (76.6%)	76 (81.7%)	84 (90.3%)	0.0566
Number of AF patients, median (IQR)	343 (160–584)	417 (187–595)	408 (144–626)	378 (150–583)	341 (165–613)	257 (148–408)	0.0675
Years since MD graduation, median (IQR)	19 (11–29)	22 (13–33)	16 (10–28)	17 (8–25)	18 (13–29)	19 (13–27)	0.0228
International medical graduate, n (%)	62 (13.3%)	11 (11.7%)	10–14*	11 (11.7%)	16 (17.2%)	10–14*	0.1125
Workload (FTE based on adjusted pay), mean (SD)	1.13 (0.44)	0.98 (0.38)	1.06 (0.39)	1.21 (0.49)	1.21 (0.41)	1.16 (0.49)	0.0022
Electrophysiologist, n (%)†	29 (6.2%)	17 (18.1%)	1–5‡	1–5‡	1–5‡	1–5‡	<0.0001

AF indicates atrial fibrillation; FTE full-time equivalent; and IQR, interquartile range.
*Range of numbers because of missing data.
†Within 1 year before cohort entry.
‡Small cells (≤6) suppressed.

quintile 5 had a higher risk of hospitalization (aOR, 1.13 [95% CI, 1.07–1.20]) compared with billing quintile 2.

Sensitivity Analyses

We conducted a sensitivity analysis where we excluded electrophysiologists from the analyses. Adjusted rates of electrophysiologist visits and ablation were now not significantly different across the quintiles. Otherwise, the sensitivity analysis did not change the trends in utilization, physician visits, medication use, and clinical outcomes. We have included a table that demonstrates these adjusted rates as Table S3.

A similar pattern of increased echocardiography, stress testing, and stress echocardiography utilization was observed when billing amounts were treated as a continuous variable. In addition, hospitalization rates were also higher with higher billing amounts, similar to when we conducted the analysis using billing quintiles. We have included these results in Table S4.

DISCUSSION

In this large, population-based cohort study, we observed substantial cardiac testing variation that was positively associated with physician billings. Patients with AF seen by higher-billing physicians were more likely to receive diagnostic services such as echocardiograms or continuous ECG monitoring but did not have more medical visits than patients with AF seen by lower-billing physicians. There were differences in β-blocker and digoxin use, but not other medications such as anticoagulants, across billing quintiles, and no difference in cardioversion use. Importantly, likelihood of death and emergency room visits was no different across billing groups and hospitalizations were higher among patients with AF seen by higher-billing cardiologists. In summary, the practice of higher-billing cardiologists is reflected in higher utilization of testing in patients with AF.

Prior research has demonstrated that economic incentives impact physician ordering behavior.[14–16] The ownership of cardiac diagnostic equipment has been associated with higher rates of stress test use after revascularization.[12] Physicians in high spending regions of the United States are more likely to order discretionary care, such as increased frequency of physician visits, compared with lower-spending regions.[2] FFS payment models are known to incentivize the greater use of health services, including physician visits and diagnostic tests. The prior research analyzes the relationship of billing status to clinical activity, whereas our study assesses the relationship between total billing amounts, clinical activity, and outcomes at the individual provider level within an FFS system.

Table 2. Baseline Patient Characteristics by Billing Quintile

Variable	Total (n=182 572)	Median quintile based on billings per patient					*P* value
		1 (n=39 003)	2 (n=38 900)	3 (n=37 109)	4 (n=37 048)	5 (n=30 512)	
Age, y, median (IQR)	74 (66–81)	73 (65–81)	75 (67–81)	75 (66–82)	74 (66–81)	74 (66–81)	<0.0001
Male, n (%)	106 528 (58.3%)	23 564 (60.4%)	22 609 (58.1%)	20 866 (56.2%)	21 514 (58.1%)	17 975 (58.9%)	<0.0001
Income quintile, n (%)							<0.0001
1	32 922 (18.0%)	6775 (17.4%)	7288 (18.7%)	6750 (18.2%)	6351 (17.1%)	5758 (18.9%)	
2	36 793 (20.2%)	7449 (19.1%)	7930 (20.4%)	7873 (21.2%)	7219 (19.5%)	6322 (20.7%)	
3	36 146 (19.8%)	7301 (18.7%)	7859 (20.2%)	7404 (20.0%)	7351 (19.8%)	6231 (20.4%)	
4	36 958 (20.2%)	7789 (20.0%)	7662 (19.7%)	7385 (19.9%)	7989 (21.6%)	6133 (20.1%)	
5	39 753 (21.8%)	9689 (24.8%)	8161 (21.0%)	7697 (20.7%)	8138 (22.0%)	6068 (19.9%)	
Rural, n (%)	350 (0.2%)	77 (0.2%)	47 (0.1%)	0 (0.0%)	0 (0.0%)	226 (0.7%)	<0.0001
Acute MI*, n (%)	15 091 (8.3%)	2862 (7.3%)	3412 (8.8%)	2868 (7.7%)	2825 (7.6%)	3124 (10.2%)	<0.0001
Coronary revascularization*, n (%)	19 304 (10.6%)	3613 (9.3%)	4131 (10.6%)	3744 (10.1%)	4083 (11.0%)	3733 (12.2%)	<0.0001
Heart failure*, n (%)	34 700 (19.0%)	7845 (20.1%)	7757 (19.9%)	7020 (18.9%)	6444 (17.4%)	5634 (18.5%)	<0.0001
Renal dysfunction*, n (%)	15 913 (8.7%)	3573 (9.2%)	3320 (8.5%)	3456 (9.3%)	3075 (8.3%)	2489 (8.2%)	<0.0001
Stroke*, n (%)	8717 (4.8%)	1838 (4.7%)	1895 (4.9%)	1693 (4.6%)	1765 (4.8%)	1526 (5.0%)	0.0821
PVD*, n (%)	9110 (5.0%)	1991 (5.1%)	1969 (5.1%)	1799 (4.8%)	1795 (4.8%)	1556 (5.1%)	0.2396
COPD†, n (%)	27 751 (15.2%)	5530 (14.2%)	6265 (16.1%)	5632 (15.2%)	5562 (15.0%)	4762 (15.6%)	<0.0001
Hyperlipidemia†, n (%)	120 984 (66.3%)	25 155 (64.5%)	25 105 (64.5%)	24 719 (66.6%)	25 117 (67.8%)	20 888 (68.5%)	<0.0001
Diabetes†, n (%)	62 779 (34.4%)	12 651 (32.4%)	13 186 (33.9%)	13 014 (35.1%)	12 872 (34.7%)	11 056 (36.2%)	<0.0001
Hypertension†, n (%)	149 411 (81.8%)	30 543 (78.3%)	31 860 (81.9%)	30 603 (82.5%)	30 749 (83.0%)	25 656 (84.1%)	<0.0001
Charlson Comorbidity Index*, n (%)							<0.0001
0	102 405 (56.1%)	21 673 (55.6%)	21 337 (54.9%)	20 813 (56.1%)	21 390 (57.7%)	17 192 (56.3%)	
1	28 801 (15.8%)	6204 (15.9%)	6298 (16.2%)	5835 (15.7%)	5704 (15.4%)	4760 (15.6%)	
2+	51 366 (28.1%)	11 126 (28.5%)	11 265 (29.0%)	10 461 (28.2%)	9954 (26.9%)	8560 (28.1%)	
CHAD-VASc score, n (%)							<0.0001
0	7891 (4.3%)	2290 (5.9%)	1550 (4.0%)	1450 (3.9%)	1490 (4.0%)	1111 (3.6%)	
1	16 860 (9.2%)	4379 (11.2%)	3291 (8.5%)	3295 (8.9%)	3297 (8.9%)	2598 (8.5%)	
2	28 903 (15.8%)	6452 (16.5%)	6235 (16.0%)	5603 (15.1%)	5860 (15.8%)	4753 (15.6%)	
3	45 712 (25.0%)	9269 (23.8%)	9897 (25.4%)	9334 (25.2%)	9419 (25.4%)	7793 (25.5%)	
4	46 885 (25.7%)	9275 (23.8%)	9976 (25.6%)	9900 (26.7%)	9732 (26.3%)	8002 (26.2%)	
5	23 957 (13.1%)	4825 (12.4%)	5165 (13.3%)	5000 (13.5%)	4836 (13.1%)	4131 (13.5%)	
6	8740 (4.8%)	1756 (4.5%)	2001 (5.1%)	1812 (4.9%)	1718 (4.6%)	1453 (4.8%)	
7	2733 (1.5%)	583 (1.5%)	591 (1.5%)	540 (1.5%)	525 (1.4%)	494 (1.6%)	
8	734 (0.4%)	147 (0.4%)	158 (0.4%)	147 (0.4%)	143 (0.4%)	139 (0.5%)	
9	157 (0.1%)	27 (0.1%)	36 (0.1%)	28 (0.1%)	28 (0.1%)	38 (0.1%)	

COPD indicates chronic pulmonary obstructive disease; IQR, interquartile range; MI, myocardial infarction; and PVD, peripheral vascular disease.
*Within 3 years before cohort entry.
†Any time before cohort entry.

It is well known that patients with chronic disease who live in regions with higher per capita spending experience more specialty visits, tests, and hospitalizations than lower-spending regions, but with no differences in quality of care or outcomes.[17] Discretionary care, such as testing in conditions such as chest pain, was found

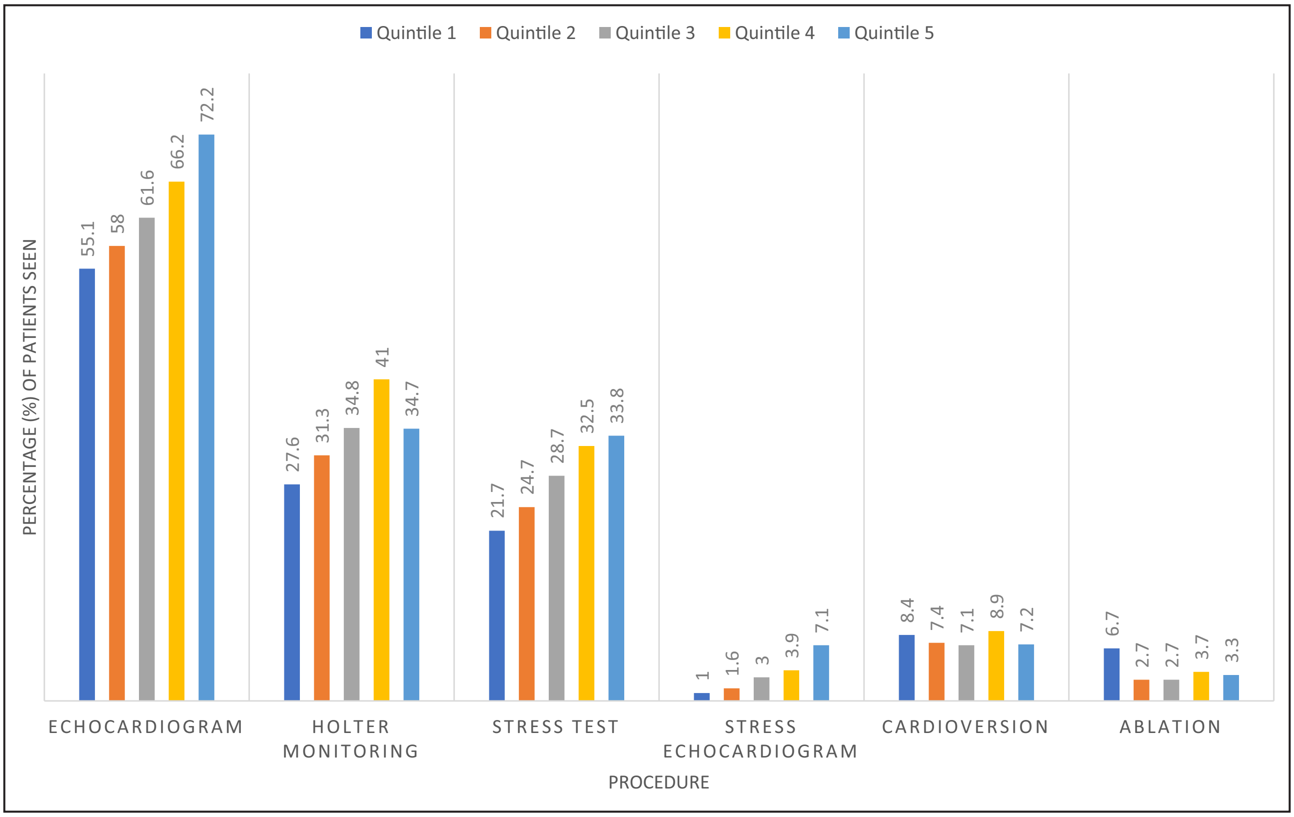


Figure. **Unadjusted utilization rate of cardiac service utilization by billing quintile.**

to be higher in higher-spending regions than lower-spending regions.[2] Variation in AF investigations and management are common, and do not necessarily lead to differences in patient outcomes.[18,19] The drivers of this variation are not well described, and may be driven by reimbursement, but could also be driven by practice style, local norms, or patient expectations. Our results demonstrate that substantial physician billing variation is predominantly driven by cardiac testing, not physician visits, which did not seem to drive differences in treatment utilization or outcomes. If anything, greater cardiac testing, seen in the higher physician billing quintile, may have led to a greater number of significant findings, leading to hospital admissions but not mortality differences. While administrative data cannot determine the reasons for test ordering, testing differences either for financial gain or to assess symptoms did not seem to impact treatment outcomes, suggesting opportunities to eliminate some of this discretionary testing.

It is important to note that the patterns of cardiac service utilization were similar for both new patients and follow-ups, except for use of ablation, which is lower in follow-up patients. This trend was maintained throughout the 7-year follow-up period. While we cannot ascertain the indication for test ordering, most clinical guidelines are focused on recommendations for cardiac testing in newly diagnosed AF,[7,20,21] but recommendations are less certain on follow-up cardiac testing, particularly in stable outpatients. The lack of outcome differences in patients with AF seen by higher-billing cardiologists who order more cardiac services does raise questions regarding what the optimal testing strategy is, in both new patients and follow-ups.

The results of this study have important implications for clinical redesign of health care services to contain health costs. Our study suggests that some of this discretionary care in patients with AF (testing in particular) may have a little impact on health outcomes, both in new consults and follow-up patients. These results suggest that further outcomes-oriented research into the optimal testing and management strategies—at the time of diagnosis and longitudinally—is required to ensure care is patient-centered and cost effective. Furthermore, these results suggest the importance of aligning reimbursement incentives with health system goals, because FFS reimbursement may influence physician ordering behavior. In particular, new models of physician funding, including bundled care models or shared saving plans, may be opportunities to shift financial incentives away from discretionary care.[22,23]

Table 3. Adjusted Results for Dichotomous Health Care Utilization Outcomes in 1 Year*

Outcome	Median billing quintile	All patients aOR (95% CI)	New consults aOR (95% CI)†	Follow-up patients aOR (95% CI)
Echocardiogram	1	0.86 (0.76–0.98)‡	0.87 (0.78–0.99)‡	0.88 (0.76–1.02)
	3	1.12 (0.99–1.27)	1.10 (0.98–1.23)	1.16 (1.01–1.34)‡
	4	1.15 (1.01–1.31)‡	1.14 (1.01–1.28)‡	1.15 (0.99–1.34)
	5	1.26 (1.11–1.43)‡	1.26 (1.12–1.41)‡	1.30 (1.12–1.51)‡
Stress test	1	0.92 (0.81–1.06)	0.91 (0.80–1.04)	0.92 (0.79–1.07)
	3	1.04 (0.92–1.19)	1.07 (0.94–1.22)	1.02 (0.88–1.18)
	4	1.25 (1.10–1.43)‡	1.26 (1.10–1.44)‡	1.26 (1.08–1.47)‡
	5	1.28 (1.12–1.46)‡	1.29 (1.13–1.47)‡	1.22 (1.05–1.42)‡
Holter monitoring	1	0.86 (0.74–1.00)	0.87 (0.75–1.01)	0.85 (0.71–1.01)
	3	1.02 (0.88–1.18)	0.98 (0.85–1.13)	1.05 (0.89–1.24)
	4	1.25 (1.08–1.46)‡	1.22 (1.05–1.41)‡	1.26 (1.06–1.50)‡
	5	0.91 (0.79–1.06)	0.91 (0.78–1.05)	0.91 (0.76–1.08)
Stress echocardiogram	1	0.74 (0.54–1.01)	0.63 (0.45–0.88)‡	0.80 (0.56–1.14)
	3	1.19 (0.88–1.60)	1.24 (0.91–1.69)	1.17 (0.83–1.65)
	4	1.26 (0.93–1.70)	1.26 (0.92–1.72)	1.37 (0.97–1.93)
	5	1.79 (1.32–2.42)‡	1.75 (1.28–2.40)‡	1.77 (1.24–2.53)‡
Cardioversion	1	1.00 (0.88–1.13)	1.06 (0.92–1.21)	0.94 (0.81–1.09)
	3	0.95 (0.84–1.07)	0.90 (0.79–1.03)	0.94 (0.81–1.08)
	4	1.06 (0.93–1.19)	1.05 (0.92–1.20)	1.04 (0.90–1.20)
	5	0.90 (0.79–1.02)	0.90 (0.79–1.03)	0.90 (0.78–1.05)
Ablation	1	1.25 (1.07–1.47)‡	1.32 (1.10–1.59)‡	1.19 (0.99–1.42)
	3	1.09 (0.94–1.27)	1.01 (0.84–1.21)	1.10 (0.92–1.31)
	4	1.13 (0.97–1.32)	1.07 (0.89–1.29)	1.13 (0.94–1.35)
	5	1.01 (0.87–1.19)	1.05 (0.87–1.26)	0.96 (0.80–1.16)
Electrophysiologist visit	1	1.23 (1.03–1.47)‡	…	1.07 (0.87–1.31)
	3	1.02 (0.86–1.21)	…	1.10 (0.91–1.34)
	4	1.03 (0.85–1.22)	…	0.97 (0.79–1.19)
	5	0.97 (0.80–1.16)	…	0.96 (0.78–1.19)

aOR indicates adjusted odds ratio.
*Reference level is quintile 2.
†Model for electrophysiologist visit did not converge.
‡Values that are statistically significant.

Our results need to be interpreted within the context of some important limitations. As mentioned previously, administrative data used in our study lack the clinical granularity to determine appropriateness of testing, although even clinical documentation of appropriateness may be unreliable.[24,25] As a result, we do not know whether the care ordered was clinically indicated, though we know some care, such as echocardiography in a newly diagnosed patient with AF, is recommended by guidelines. The lack of clinical, laboratory, and cardiac testing data may also mean that we have underestimated the severity of illness in some groups, but some crude markers of clinical severity such as list of medications and/or cardioversions used were mostly similar. Our physician billing data do not include any additional income as derived from on-call activities, administrative or academic stipends, and regional supplemental pay; thus we may be underestimating the total physician funding envelope, particularly for lower-billing physicians. We also do not have data on physician overhead, which is necessary to calculate "take-home" physician income. We cannot determine whether cardiac testing was ordered by the billing cardiologist, or by other physicians involved, thus limiting our ability to identify the extent of self-referral. Our analysis did not evaluate facility ownership influence on the billing patterns.

Despite these limitations, this study provides novel and important insights into the associations between physician billing, practice patterns, and outcomes in patients with cardiac disease.

CONCLUSIONS

In this population-based retrospective cohort study, patients with AF seen by the high-billing cardiologists

Table 4. Adjusted Results for Clinical Outcomes in 1 Year*

Outcome	Median billing quintile	All patients aOR (95% CI)	New consults aOR (95% CI)†	Follow-up patients aOR (95% CI)‡
AF hospitalization	1	1.04 (0.97–1.12)	…	1.05 (0.96–1.13)
	3	1.04 (0.97–1.12)	…	1.05 (0.97–1.13)
	4	1.03 (0.96–1.11)	…	1.01 (0.93–1.09)
	5	1.07 (0.99–1.15)	…	1.01 (0.93–1.10)
Stroke hospitalization	1	0.97 (0.86–1.09)	…	…
	3	1.02 (0.91–1.14)	…	…
	4	0.91 (0.80–1.02)	…	…
	5	0.95 (0.84–1.07)	…	…
CVD hospitalization	1	1.02 (0.96–1.09)	1.05 (0.96–1.14)	1.03 (0.96–1.10)
	3	1.06 (1.00–1.13)	1.05 (0.97–1.14)	1.07 (1.00–1.14)‖
	4	1.00 (0.94–1.06)	1.06 (0.97–1.15)	0.95 (0.89–1.02)
	5	1.11 (1.04–1.18)‖	1.17 (1.07–1.26)‖	1.01 (0.95–1.09)
ED visits for AF	1	0.95 (0.88–1.03)	1.01 (0.92–1.10)	0.91 (0.83–0.99)‖
	3	0.99 (0.92–1.06)	0.97 (0.89–1.06)	0.98 (0.90–1.07)
	4	0.98 (0.91–1.06)	0.97 (0.88–1.05)	0.98 (0.89–1.07)
	5	0.93 (0.86–1.00)	0.91 (0.84–1.00)‖	0.91 (0.83–1.00)
Death§	1	0.96 (0.85–1.08)	0.98 (0.85–1.15)	0.96 (0.85–1.10)
	3	0.97 (0.86–1.09)	0.96 (0.83–1.11)	0.97 (0.86–1.10)
	4	0.98 (0.87–1.11)	1.00 (0.86–1.17)	0.97 (0.86–1.11)
	5	1.00 (0.88–1.13)	1.05 (0.91–1.22)	0.88 (0.77–1.01)
Composite outcome: ED visits, hospitalizations, death	1	1.00 (0.95–1.06)	1.02 (0.96–1.10)	1.00 (0.94–1.06)
	3	1.02 (0.97–1.07)	1.00 (0.93–1.06)	1.03 (0.97–1.09)
	4	0.98 (0.93–1.04)	1.01 (0.94–1.08)	0.96 (0.90–1.02)
	5	1.04 (0.98–1.09)	1.06 (0.99–1.13)	0.98 (0.92–1.05)

AF indicates atrial fibrillation; aOR, adjusted odds ratio; CVD, cardiovascular disease; and ED, emergency department.
*Reference level is quintile 2.
†Models for AF hospitalization and stroke hospitalization did not converge.
‡Model for stroke hospitalization did not converge.
§Includes only patients who were not censored within the first year.
‖Values that are statistically significant.

had significantly higher rates of noninvasive testing compared with lower- billing cardiologists, with no differences in outcomes at 1 year. Further research into optimal testing and treatment strategies for patients with AF is warranted.

ARTICLE INFORMATION

Received January 4, 2021; accepted July 15, 2021.

Affiliations

Institute for Health Systems Solutions and Virtual Care, Women's College Hospital, Toronto, Ontario, Canada (R.S.B., C.C., Z.B., E.C.); Peter Munk Cardiac Centre, University Health Network, Toronto, Ontario, Canada (R.S.B., H.R.); St. Matthew's University School of Medicine, Cayman Islands (A.K.); ICES, Toronto, Ontario, Canada (D.T.K., B.Y., J.F., P.C.A.); Sunnybrook Health Sciences Centre (A.K., D.T.K., K.G.S., E.C.), Department of Medicine, Faculty of Medicine (K.G.S., P.D., H.R., S.G.G., E.C.); Institute of Health Policy, Management and Evaluation (P.C.A.) and Epidemiology Division, Dalla Lana School of Public Health (Z.B.), University of Toronto, Toronto, Ontario, Canada; Division of Cardiology, St. Michael's Hospital, Toronto, Ontario, Canada (P.D., S.G.G.); and Cardiology Department, Health Sciences North, Health Sciences North Research Institute, Northern Ontario School of Medicine, Sudbury, Ontario, Canada (M.S.).

Sources of Funding

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long-Term Care (MLTC). Parts of this material are based on data and information compiled and provided by the MOH and Canadian Institute for Health Information (CIHI). The authors also acknowledge that the clinical registry data used in this publication are from participating hospitals through CorHealth Ontario, which serves as an advisory body to the Minister of Health and Long-Term Care (MOHLTC), is funded by the MOHLTC, and is dedicated to improving the quality, efficiency, access, and equity in the delivery of the continuum of adult cardiac, vascular, and stroke services in Ontario, Canada. We thank IQVIA Solutions Canada Inc. for use of their Drug Information File. The analyses, conclusions, opinions, and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

Disclosures

Shaun G. Goodman reports research grant support (eg, steering committee or data and safety monitoring committee) and/or speaker/consulting honoraria (eg, advisory boards) from: Amgen, AstraZeneca, Bayer, Boehringer Ingelheim, Bristol Myers Squibb, CSL Behring, Daiichi-Sankyo/American Regent, Eli Lilly, Esperion, Ferring Pharmaceuticals, GlaxoSmithKline, HLS Therapeutics, Janssen/Johnson & Johnson, Merck, Novartis, Novo Nordisk A/C, Pfizer, Regeneron, Sanofi, Servier; and salary support/honoraria from the Heart and Stroke Foundation of Ontario/University of Toronto (Polo) Chair, Canadian Heart Research Centre and MD Primer, Canadian VIGOUR

Centre, Duke Clinical Research Institute, New York University Clinical Coordinating Centre, and PERFUSE Research Institute. Peter Austin reports the Mid-Career Investigator Award from the Heart and Stroke Foundation. Mohammed Shurrab reports the Fellowship Award from the Canadian Institutes of Health Research (CIHR). The remaining authors have no disclosures to report.

Supplementary Material

Tables S1–S4
Figure S1

REFERENCES

1. Levinson W, Kallewaard M, Bhatia RS, Wolfson D, Shortt S, Kerr EA. 'Choosing Wisely': a growing international campaign. *BMJ Qual Saf*. 2015;24:167. doi: 10.1136/bmjqs-2014-003821
2. Sirovich B, Gallagher PM, Wennberg DE, Fisher ES. Discretionary decision making by primary care physicians and the cost of U.S. health care. *Health Aff*. 2008;27:813–823. doi: 10.1377/hlthaff.27.3.813
3. Mandelblatt JS, Berg CD, Meropol NJ, Edge SB, Gold K, Hwang YT, Hadley J. Measuring and predicting surgeons' practice styles for breast cancer treatment in older women. *Med Care*. 2001;39:228–242. doi: 10.1097/00005650-200103000-00004
4. Wennberg DE, Dickens JD Jr, Biener L, Fowler FJ Jr, Soule DN, Keller RB. Do physicians do what they say? The inclination to test and its association with coronary angiography rates. *J Gen Intern Med*. 1997;12:172–176. doi: 10.1007/s11606-006-5025-5
5. Komaromy M, Lurie N, Osmond D, Vranizan K, Keane D, Bindman AB. Physician practice style and rates of hospitalization for chronic medical conditions. *Med Care*. 1996;34:594–609. doi: 10.1097/00005650-199606000-00009
6. Patel NJ, Deshmukh A, Pant S, Singh V, Patel N, Arora S, Shah N, Chothani A, Savani GT, Mehta K, et al. Contemporary trends of hospitalization for atrial fibrillation in the United States, 2000 through 2010. *Circulation*. 2014;129:2371–2379. doi: 10.1161/CIRCULATIONAHA.114.008201
7. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC Jr, Conti JB, Ellinor PT, Ezekowitz MD, Field ME, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *Circulation*. 2014;130:e199–e267. doi: 10.1161/CIR.0000000000000040
8. Kirchhof P, Camm AJ, Goette A, Brandes A, Eckardt L, Elvan A, Fetsch T, van Gelder IC, Haase D, Haegeli LM, et al. Early rhythm-control therapy in patients with atrial fibrillation. *N Engl J Med*. 2020;383:1305–1316. doi: 10.1056/NEJMoa2019422
9. Marrouche NF, Brachmann J, Andresen D, Siebels J, Boersma L, Jordaens L, Merkely B, Pokushalov E, Sanders P, Proff J, et al. Catheter ablation for atrial fibrillation with heart failure. *N Engl J Med*. 2018;378:417–427. doi: 10.1056/NEJMoa1707855
10. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, Boriani G, Castella M, Dan GA, Dilaveris PE, et al. 2020 ESC guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association of Cardio-Thoracic Surgery (EACTS): the task force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. *Eur Heart J*. 2021;42:373–498. doi: 10.1093/eurheartj/ehaa612
11. Luft HS, Arno P. Impact of increasing physician supply: a scenario for the future. *Health Aff*. 1986;5:31–46. doi: 10.1377/hlthaff.5.4.31
12. Shah BR, Cowper PA, O'Brien SM, Jensen N, Patel MR, Douglas PS, Peterson ED. Association between physician billing and cardiac stress testing patterns following coronary revascularization. *JAMA*. 2011;306:1993–2000. doi: 10.1001/jama.2011.1604
13. Tu K, Nieuwlaat R, Cheng SY, Wing L, Ivers N, Atzema CL, Healey JS, Dorian P. Identifying patients with atrial fibrillation in administrative data. *Can J Cardiol*. 2016;32:1561–1565. doi: 10.1016/j.cjca.2016.06.006
14. Hughes DR, Bhargavan M, Sunshine JH. Imaging self-referral associated with higher costs and limited impact on duration of illness. *Health Aff*. 2010;29:2244–2251. doi: 10.1377/hlthaff.2010.0413
15. Gazelle GS, Halpern EF, Ryan HS, Tramontano AC. Utilization of diagnostic medical imaging: comparison of radiologist referral versus same-specialty referral. *Radiology*. 2007;245:517–522. doi: 10.1148/radiol.2452070193
16. Hillman BJ, Joseph CA, Mabry MR, Sunshine JH, Kennedy SD, Noether M. Frequency and costs of diagnostic imaging in office practice–a comparison of self-referring and radiologist-referring physicians. *N Engl J Med*. 1990;323:1604–1608. doi: 10.1056/NEJM199012063232306
17. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ. Variations in the longitudinal efficiency of academic medical centers. *Health Aff*. 2004;23:VAR-19–VAR-32. doi: 10.1377/hlthaff.var.19
18. Nieuwlaat R, Capucci A, Camm AJ, Olsson SB, Andresen D, Davies DW, Cobbe S, Breithardt G, Le Heuzey J-Y, Prins MH, et al. Atrial fibrillation management: a prospective survey in ESC Member Countries: the euro heart survey on atrial fibrillation. *Eur Heart J*. 2005;26:2422–2434. doi: 10.1093/eurheartj/ehi505
19. Wyse DG, Waldo AL, DiMarco JP, Domanski MJ, Rosenberg Y, Schron EB, Kellen JC, Greene HL, Mickel MC, Dalquist JE, et al. A comparison of rate control and rhythm control in patients with atrial fibrillation. *New Engl J Med*. 2002;347:1825–1833. doi: 10.1056/NEJMoa021328
20. Douglas PS, Garcia MJ, Haines DE, Lai WW, Manning WJ, Patel AR, Picard MH, Polk DM, Ragosta M, Ward RP, et al. ACCF, ASE, AHA, ASNC, HFSA, HRS, SCAI, SCCM, SCCT, SCMR 2011 Appropriate use Criteria for Echocardiography. A report of the American College of Cardiology foundation appropriate use criteria task force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance American College of Chest Physicians. *J Am Soc Echocardiogr*. 2011;24:229-267. doi: 10.1016/j.echo.2010.12.008
21. Canadian Cardiovascular Society. Management of atrial fibrillation: complete ccs guidelines listing. CJC Online Supplement 2018. Available at: https://www.onlinecjc.ca/article/S0828-282X(18)31062-6/fulltext. Accessed August 1, 2020.
22. Barnett ML, Wilcock A, McWilliams JM, Epstein AM, Joynt Maddox KE, Orav EJ, Grabowski DC, Mehrotra A. Two-year evaluation of mandatory bundled payments for joint replacement. *New Engl J Med*. 2019;380:252–262. doi: 10.1056/NEJMsa1809010
23. McWilliams JM, Hatfield LA, Chernew ME, Landon BE, Schwartz AL. Early performance of accountable care organizations in medicare. *N Engl J Med*. 2016;374:2357–2366. doi: 10.1056/NEJMsa1600142
24. Yang JX, Stevenson MJ, Valsdottir L, Ho K, Spertus JA, Yeh RW, Strom JB. Association between procedure appropriateness and patient-reported outcomes after percutaneous coronary intervention. *Heart*. 2020;106:441. doi: 10.1136/heartjnl-2019-315835
25. Rajkumar CA, Suh WM, Francis DP. Upcoding of clinical information to meet appropriate use criteria for percutaneous coronary intervention. *Circ Cardiovasc Qual Outcomes*. 2019;12:e005025. doi: 10.1161/CIRCOUTCOMES.118.005025

SUPPLEMENTAL MATERIAL

Table S1. All patients - Adjusted outcomes for frequency of physician visits in one year*

Outcome	Median Billing Quintile	aOR (95% CI)
Visits with PCP or cardiologist	1	1.00 (0.98-1.03)
	3	1.01 (0.99-1.04)
	4	1.00 (0.97-1.03)
	5	1.01 (0.98-1.03)
Outpatient visits with PCP	1	1.00 (0.97-1.04)
	3	1.00 (0.97-1.03)
	4	1.00 (0.97-1.03)
	5	0.99 (0.96-1.03)
Outpatient visits with cardiologist	1	1.06 (0.99-1.14)
	3	1.06 (1.00-1.14)
	4	1.04 (0.97-1.11)
	5	0.98 (0.92-1.05)
Inpatient visits with cardiologist (non-emergency)	1	1.03 (0.91-1.15)
	3	1.08 (0.96-1.21)
	4	0.93 (0.83-1.05)
	5	1.12 (0.99-1.26)
Visits with index cardiologist*	1	**0.82 (0.68-0.99)**
	3	0.97 (0.81-1.17)
	4	0.95 (0.79-1.14)
	5	**0.61 (0.51-0.74)**
Cardiologist visits with index cardiologist or with referral made by index cardiologist†	1	**0.82 (0.68-0.98)**
	3	0.97 (0.82-1.16)
	4	0.96 (0.80-1.14)
	5	**0.62 (0.52-0.74)**

Abbreviations: PCP = primary care physician
* Reference level is quintile 2
† Index cardiologist refers to the cardiologist seen on the patient's index date
Bold numbers show those values that are statistically significant.

Table S2. All patients - Adjusted results for prescription claims in one year*

Outcome	Median Billing Quintile	aOR (95% CI)
Beta blockers	1	**0.89 (0.80-0.98)**
	3	0.97 (0.88-1.07)
	4	1.01 (0.92-1.11)
	5	1.07 (0.97-1.18)
Calcium channel blockers	1	0.95 (0.84-1.08)
	3	0.98 (0.86-1.11)
	4	0.89 (0.78-1.01)
	5	0.91 (0.80-1.04)
Digoxin	1	1.01 (0.89-1.15)
	3	1.01 (0.90-1.15)
	4	0.94 (0.83-1.06)
	5	**0.87 (0.77-0.99)**
Anti-arrhythmic	1	1.11 (0.96-1.28)
	3	1.09 (0.95-1.25)
	4	1.01 (0.88-1.16)
	5	0.99 (0.86-1.14)
Anticoagulant	1	0.99 (0.90-1.10)
	3	1.00 (0.91-1.10)
	4	1.08 (0.98-1.19)
	5	0.98 (0.89-1.08)
Warfarin	1	1.05 (0.92-1.19)
	3	1.03 (0.91-1.16)
	4	0.92 (0.81-1.04)
	5	0.94 (0.83-1.06)

* Reference level is quintile 2

Bold numbers show those values that are statistically significant.

Table S3. Adjusted results for dichotomous healthcare utilization outcomes in one year excluding EP physicians *

Outcome	Median Billing Quintile	aOR (95% CI) – All Patients	aOR (95% CI) – New Consults†	aOR (95% CI) – Follow Up Patients
Echocardiogram	1	0.87 (0.75-1.01)	0.89 (0.78-1.02)	0.88 (0.74-1.04)
	3	**1.16 (1.02-1.33)**	**1.14 (1.01-1.29)**	**1.19 (1.02-1.39)**
	4	**1.19 (1.03-1.36)**	**1.18 (1.04-1.33)**	**1.18 (1.01-1.39)**
	5	**1.25 (1.09-1.43)**	**1.26 (1.11-1.42)**	**1.29 (1.09-1.52)**
Stress test	1	0.97 (0.83-1.13)	0.97 (0.84-1.13)	0.94 (0.79-1.12)
	3	1.07 (0.93-1.23)	1.09 (0.95-1.26)	1.04 (0.88-1.22)
	4	**1.30 (1.13-1.51)**	**1.33 (1.15-1.53)**	**1.29 (1.09-1.52)**
	5	**1.30 (1.12-1.50)**	**1.32 (1.15-1.52)**	**1.22 (1.03-1.45)**
Holter monitoring	1	0.85 (0.71-1.01)	**0.83 (0.70-0.98)**	0.84 (0.69-1.03)
	3	1.04 (0.88-1.22)	1.00 (0.85-1.17)	1.07 (0.89-1.29)
	4	**1.30 (1.10-1.53)**	**1.27 (1.09-1.50)**	**1.30 (1.08-1.57)**
	5	0.91 (0.77-1.08)	0.90 (0.77-1.06)	0.91 (0.75-1.10)
Stress echocardiogram	1	0.74 (0.52-1.06)	**0.63 (0.43-0.92)**	0.78 (0.51-1.18)
	3	1.25 (0.91-1.72)	1.33 (0.95-1.85)	1.19 (0.82-1.72)
	4	1.27 (0.91-1.77)	1.28 (0.91-1.79)	1.36 (0.93-1.98)
	5	**1.74 (1.25-2.43)**	**1.74 (1.24-2.44)**	**1.69 (1.15-2.49)**
Cardioversion	1	1.00 (0.87-1.15)	1.00 (0.86-1.16)	0.96 (0.82-1.13)
	3	0.95 (0.84-1.08)	0.91 (0.79-1.04)	0.94 (0.80-1.09)
	4	1.02 (0.89-1.16)	1.02 (0.89-1.18)	1.00 (0.85-1.17)
	5	0.90 (0.79-1.03)	0.90 (0.78-1.04)	0.91 (0.78-1.08)
Ablation	1	1.04 (0.90-1.20)	1.02 (0.86-1.21)	1.05 (0.88-1.25)
	3	1.10 (0.96-1.25)	1.02 (0.88-1.19)	1.11 (0.95-1.31)
	4	1.04 (0.91-1.19)	0.97 (0.82-1.13)	1.07 (0.91-1.27)
	5	1.01 (0.88-1.16)	1.03 (0.88-1.21)	0.99 (0.82-1.18)
Electrophysiologist visit	1	1.03 (0.87-1.22)	-	0.97 (0.79-1.19)
	3	1.00 (0.86-1.16)	-	1.07 (0.90-1.28)
	4	0.95 (0.81-1.10)	-	0.92 (0.76-1.11)
	5	0.97 (0.82-1.13)	-	0.98 (0.80-1.20)

Abbreviations: aOR = adjusted odds ratio; CI = confidence interval * Reference level is quintile 2
† Model for electrophysiologist visit did not converge
Bold numbers show those values that are statistically significant.

Table S4. Logistic regression results using billing amounts as a continuous variable[*,†,‡]

Outcome	**OR (95% CI)**	**P-value**
Echocardiogram	**2.15 (1.62-2.85)**	**<.0001**
Holter monitoring	1.32 (0.94-1.86)	0.1095
Stress test	**2.48 (1.85-3.31)**	**<.0001**
Stress echocardiogram	**7.26 (3.76-14.01)**	**<.0001**
EP visit	0.71 (0.48-1.06)	0.0958
AF hospitalization	**1.18 (1.01-1.38)**	**0.0429**
Stroke hospitalization	0.85 (0.64-1.13)	0.2627
CVD hospitalization	**1.32 (1.15-1.52)**	**0.0001**
ED visits for AF	0.93 (0.79-1.10)	0.4196

Abbreviations: EP=electrophysiologist; AF= atrial fibrillation; CI = confidence interval; CVD= cardiovascular disease; ED=emergency department; OR=odds ratio

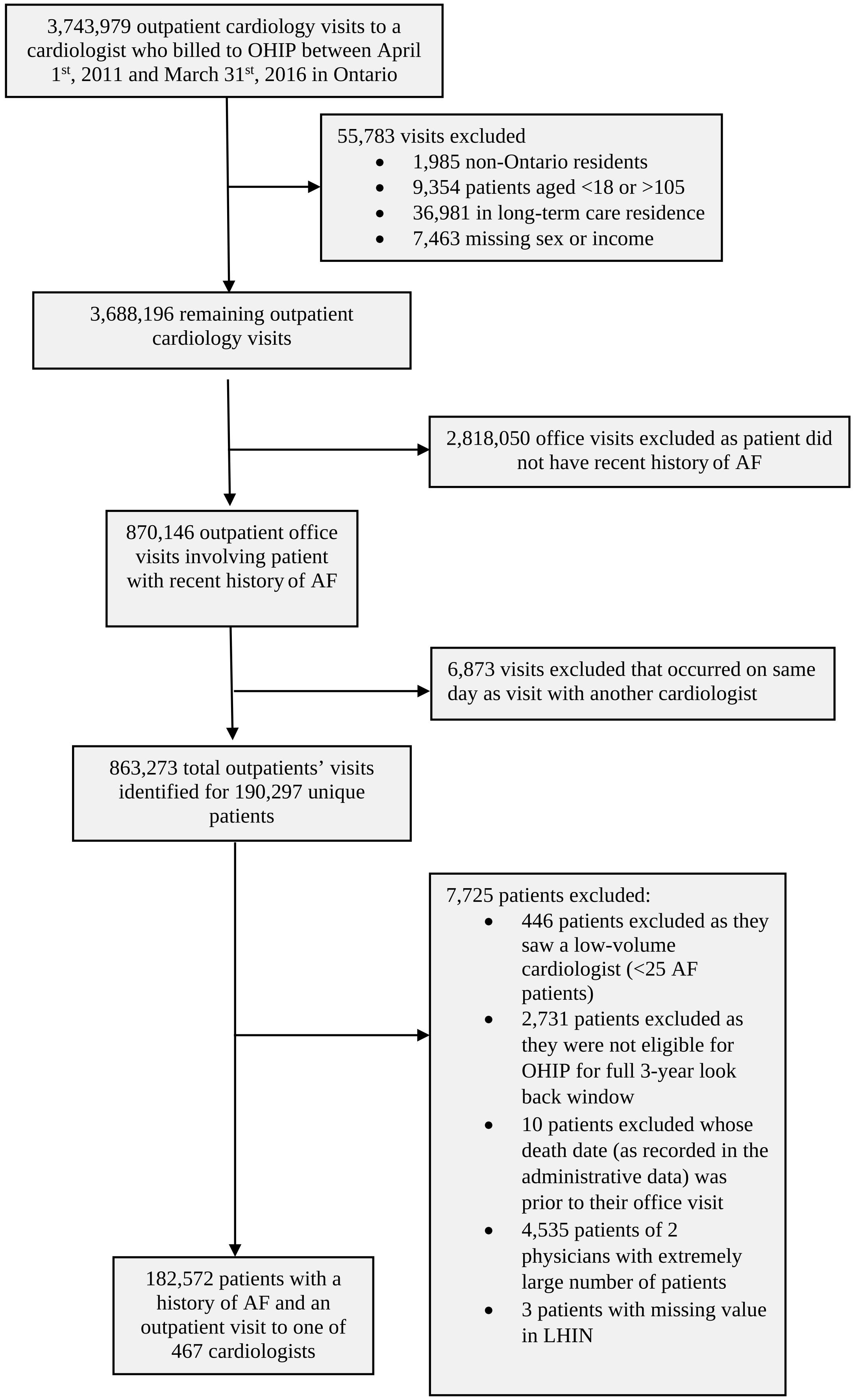
[*]ORs and P-values reported here are based on median physician billings per patient as a continuous variable. Only billings for AF patients were used.

[†]ORs are based on the change per $1000 unit increase in billings per patient

[‡]Sample includes all patients (new and follow up) and all physicians (EPs and non-EPs)

Bold numbers show those values that are statistically significant.

Figure S1. Patient cohort creation: the flow of atrial fibrillation patients into the study.



AF = atrial fibrillation; LHIN = Local Health Integration Network; OHIP= Ontario Health Insurance Plan.