HHS Public Access

Author manuscript

Am J Med Open. Author manuscript; available in PMC 2024 January 11.

Published in final edited form as:

Am J Med Open. 2023 December ; 10: . doi:10.1016/j.ajmo.2023.100048.

Patterns of Digoxin Prescribing for Medicare Beneficiaries in the United States 2013–2019

Claudia See[a], **Kevin M. Wheelock**[b], **César Caraballo**[c], **Rohan Khera**[a,c], **Amarnath Annapureddy**[a], **Shiwani Mahajan**[b,c], **Yuan Lu**[a,c], **Harlan M. Krumholz**[a,c,d], **Karthik Murugiah**[a,c,*]

[a]Section of Cardiovascular Medicine, Department of Internal Medicine, Yale School of Medicine, New Haven, Conn

[b]Department of Internal Medicine, Yale School of Medicine, New Haven, Conn

[c]Center for Outcomes Research and Evaluation, Yale-New Haven Hospital, New Haven, Conn

[d]Department of Health Policy and Management, Yale School of Public Health, New Haven, Conn

Abstract

Background: Studies show that digoxin use is declining but is still prevalent. Recent data on digoxin prescription and characteristics of digoxin prescribers are unknown, which can help understand its contemporary use.

Methods: Using Medicare Part D data from 2013 to 2019, we studied the change in number and proportion of digoxin prescriptions and digoxin prescribers, overall and by specialty. Using logistic regression, we identified prescriber characteristics associated with digoxin prescription.

*Correspondence author: Karthik Murugiah, 195 Church St, 6th Floor, New Haven, Conn, 06510, 203-487-1239, 203-764-5653. karthik.murugiah@yale.edu (K. Murugiah).

Disclosure Statement

Dr. Khera reported receiving honorarium from the *New England Journal of Medicine* Journal Watch; being the coinventor of the US Provisional Patent Application No. 63/177,177; and being the founder of Evidence2Health.

Dr. Krumholz received expenses and/or personal fees in the past 3 years from UnitedHealth, Element Science, Eyedentifeye, and F-Prime. He is a cofounder of Refactor Health and HugoHealth and is associated with contracts, through Yale New Haven Hospital from the Centers for Medicare & Medicaid Services and through Yale University from the Food and Drug Administration, Johnson & Johnson, Google, and Pfizer.

Dr. Lu reported receiving grants from the National Heart, Lung, and Blood Institute and the Yale Center for Implementation Science outside the submitted work.

Dr. Murugiah received support from the National Heart, Lung, and Blood Institute of the National Institutes of Health (under award K08HL157727).

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Rohan Khera reports a relationship with *NEJM* Journal Watch that includes: consulting or advisory. Rohan Khera reports a relationship with Evidence2Health that includes: employment. Rohan Khera has pending Provisional Patent Application No. 63/177,177. Harlan Krumholz reports a relationship with UnitedHealth, Element Science, Aetna, Reality Labs, Tesseract/4Catalyst, F-Prime, the Siegfried and Jensen Law Firm, Arnold and Porter Law Firm, and Martin/Baughman Law Firm that includes: consulting or advisory. Harlan Krumholz reports a relationship with Refactor Health and HugoHealth that includes: employment. Harlan Krumholz reports a relationship with the Centers for Medicare & Medicaid Services and Johnson & Johnson that includes: employment. Yuan Lu reports a relationship with National Heart Lung and Blood Institute that includes: funding grants. Karthik Murugiah reports a relationship with National Heart Lung and Blood Institute that includes: funding grants.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ajmo.2023.100048.

Results: From 2013 to 2019, total digoxin prescriptions (4.6 to 1.8 million) and proportion of digoxin prescribers decreased (9.1% to 4.3% overall; 26.6% to 11.8% among General Medicine prescribers and 65.4% to 48.9% among Cardiology). Of digoxin prescribers from 2013 practicing in 2019 (91.2% remained active), 59.1% did not prescribe digoxin at all, 31.7% reduced, and 9.2% maintained or increased prescriptions. The proportion of all digoxin prescriptions that were prescribed by General Medicine prescribers declined from 59.7% to 48.2% and increased for Cardiology (29% to 38.5%). Among new prescribers in 2019 (N = 85,508), only 1.9% prescribed digoxin. Digoxin prescribers when compared to non–digoxin prescribers were more likely male, graduated from medical school earlier, were located in the Midwest or South, and belonged to Cardiology (all P < .001).

Conclusions: Digoxin prescriptions continue to decline with over half of 2013 prescribers no longer prescribing digoxin in 2019. This may be a result of the increasing availability of newer heart failure therapies. The decline in digoxin prescription was greater among general medicine physicians than cardiologists, suggesting a change in digoxin use to a medication prescribed increasingly by specialists.

Keywords

Digoxin; Practice variation; Prescription patterns

1. Introduction

Digoxin is often prescribed to treat heart failure (HF) or atrial fibrillation (AF). The landmark Digitalis Investigation Group (DIG) trial[1] published in 1997 showed a reduction in hospitalizations with digoxin in patients with HF with reduced ejection fraction (HFrEF), but no effect on survival. In the DIG ancillary trial, where digoxin was studied in an HF with preserved ejection fraction (HFpEF) population, there was no effect on mortality or hospitalization.[2] The use of digoxin as a rate control agent in AF, on the other hand, has not been studied in a randomized trial and some observational data suggest increased mortality,[3–5] while others do not.[6,7]

Despite digoxin showing a benefit in reducing hospitalizations, especially in advanced HF patients,[8] over time, the enthusiasm for digoxin has declined. The reasons digoxin fell out of favor are unclear and could be related to concerns raised about its safety in subgroups such as older patients and women,[9,10] the narrow therapeutic window of digoxin necessitating close monitoring,[11] and the increasing use of other HF therapies showing clear mortality benefits without a need for cumbersome monitoring. These alternate HF therapies have become the mainstay of HFrEF treatment and include beta-blockers,[12,13] aldosterone receptor antagonists,[14] angiotensin-converting enzyme inhibitors,[15] and now additionally SGLT2-inhibitors.[16] In parallel, guideline societies downgraded digoxin for HFrEF over time from a Class Ia recommendation by the ACC/AHA/HFSA in 2001 to Class IIa in 2009,[17] with the ESC further downgrading it to Class IIb in 2016 which may have also accelerated the decline in digoxin use.[18]

Digoxin use has thus been declining in the United States,[19,20] with outpatient prescriptions decreasing by 50% from 2007 to 2014 among Medicare beneficiaries.[20] This precipitous

decline occurred despite some data suggesting harm with digoxin discontinuation in stable patients.[21,22] Nevertheless, despite this reduction, digoxin continued to be frequently prescribed with 4.3 million prescriptions made to Medicare beneficiaries in 2014[20]; for context, 14 million prescriptions of carvedilol were made in the same year.[23]

Whether this declining trend in digoxin use has continued in more recent years is unknown. In addition, it is unknown how this reduction in prescriptions is occurring—have prescribers just reduced digoxin prescription or have some stopped prescribing it altogether? Further, are new prescribers prescribing digoxin? Lastly, in contemporary practice, what kind of prescribers are prescribing digoxin—is it still prescribed routinely by general medicine doctors like in the past or is it limited to specialists? Accordingly, we used Medicare Part D prescriber data from 2013 to 2019 to characterize more recent trends in digoxin prescriptions among older adults, overall and at a prescriber level, and describe characteristics of current digoxin prescribers.

2. Methods

2.1. Study Outline

From 2013 to 2019, we reported the overall number of digoxin prescriptions, overall number of prescribers, proportion of digoxin prescribers overall and by specialty (General Medicine, Cardiology, and Advanced Practice Clinicians), and proportion of all digoxin prescriptions by specialty.

The change in digoxin usage of digoxin prescribers in the year 2013 who remained in active practice in the year 2019 was described by reporting prescription proportions of 3 categories of prescribers. First, prescribers who stopped prescribing digoxin in 2019 but continued prescribing other medications. Second, prescribers who continued digoxin prescription but at reduced number of prescriptions. Third, prescribers who continued digoxin prescription but at the same or greater number of prescriptions.

We also reported digoxin prescriptions among new prescribers in 2019, defined as no prescriptions for any drug in 2013–2018.

We then described characteristics of current digoxin prescribers in 2019 such as gender, medical school graduation year, and practice region—overall and by the two top prescribing specialties (Cardiology and General Medicine). We also described characteristics of digoxin prescribers by volume of individual digoxin prescriptions (<25th percentile, 25-75th percentile, and >75th percentile).

A logistic regression model was then used to identify independent prescriber characteristics associated with digoxin prescription using 2019 data.

2.2. Data Sources

We used the annual Medicare Part D Prescribers by Provider dataset for the years 2013 through 2019, which contains prescription data for beneficiaries enrolled in the Medicare Part D prescription drug program (roughly 70% of all Medicare beneficiaries). The provider-

level dataset includes all prescribers, including physicians and advanced practice providers, with a valid National Provider Index (NPI) and at least 10 prescriptions for one or more medications, the reporting threshold for data privacy under the Centers for Medicare & Medicaid Services (CMS).

2.3. Study Population

All prescribers in the Medicare Part D Prescribers by Provider dataset were included in the retrospective cohort analysis. Digoxin prescribers were identified by ≥10 prescriptions of any generic and brand name formulation of digoxin available in the United States. For each year, information on prescriptions, geographic location, and provider specialty descriptions was obtained using the CMS database. The Doctors and Clinicians (DAC) national downloadable file and the National Plan and Provider Enumeration System (NPPES) database, updated monthly by CMS, were used by linking National Provider Identifiers (NPI) to identify graduation year and gender. Practice region was categorized into the four census regions—Northeast, Midwest, South, and West—using Federal Information Processing Series (FIPS) state codes. Prescribers with FIPS codes that could not be attributed to these four practice regions, namely FIPS codes above 56, were categorized as "Other"—eg, US territories. Provider specialties of Cardiology, Cardiovascular Disease (Cardiology), Cardiac Surgery, Advanced Heart Failure and Transplant Cardiology, Clinical Cardiac Electrophysiology, and Interventional Cardiology were combined as "Cardiology." Internal Medicine, Family Medicine, Family Practice, Preventive Medicine, Hospitalist, and Geriatric Medicine were combined into "General Medicine." Physician Assistants (PAs) and Nurse Practitioners (NPs) were combined into "Advanced Practice Clinicians (APCs)." The remaining specialties were categorized as "Other."

2.4. Statistical Analysis

Categorical variables were reported with counts and proportions and compared using Chi-squared tests. Continuous variables were reported with medians and interquartile range (IQR) and compared using MannWhitney U and Kruskal-Wallis tests. To identify individual associations of prescriber characteristics with digoxin prescription, we developed a generalized linear model with logit link using digoxin prescription as a dependent variable and with provider specialty, year of medical school graduation quartile, gender, and practice region as covariates. The parameter estimates were represented with odds ratios and 95% confidence intervals (CI). All P values shown are 2-sided, and statistical significance was set at $P < .05$ for all tests. As the Medicare Part D Prescribers by Provider and Drug dataset, NPPES database, and DAC national downloadable file are publicly available datasets without patient identifiers, this study is exempt from the review of the Yale Institutional Review Board. Data were accessed between December 2021 and March 2022, and analyses were conducted between December 2021 and August 2022. All statistical analyses were conducted in R version 4.0.4 (R Project for Statistical Computing).

3. Results

From 2013 to 2019, total digoxin prescriptions declined from 4,573,542 to 1,833,188, a relative decline of 59.9%. The total number of digoxin prescribers reduced by 44.5% from

95,576 to 53,015. The proportion of digoxin prescribers among all prescribers declined from 9.1% to 4.3% (decreased from 26.6% to 11.8% among all General Medicine prescribers and from 65.4% to 48.9% among all Cardiology prescribers; Table 1 and Figure 1). The median and IQR of digoxin prescriptions among digoxin prescribers declined from 30 (16–58) to 21 (14–39) (all $P < .001$).

In 2019, Cardiology and General Medicine combined constituted 82.2% of all digoxin prescribers and prescribed 86.7% of all digoxin prescriptions (Table 1). From 2013 to 2019, the proportion of all digoxin prescriptions that were made by General Medicine prescribers declined from 59.7% to 48.2% and increased for Cardiology prescribers (29% to 38.5%). The proportions of prescribers prescribing digoxin in 2019 by specialty subgroups of Cardiology and General Medicine are shown in Appendix Figure 1 (available online).

Overall, among digoxin prescribers from 2013 who prescribed any medication in 2019 (91.2% remained active clinicians, $N = 87,168$), 59.1% did not prescribe digoxin at all in 2019. These physicians had accounted for 36.0% of all digoxin prescriptions in 2013. Another 31.7% reduced the number of digoxin prescriptions, and 9.2% maintained or increased the number of digoxin prescriptions. A relatively higher proportion of prescribers in General Medicine (63.4%) entirely stopped digoxin compared to Cardiology (27.4%) (Table 2). Among prescribers newly beginning practice during 2019 ($N = 85,508$), 1597 (1.9%) prescribed digoxin.

Among digoxin prescribers in 2019, higher-volume prescribers compared to lower-volume prescribers had an earlier year of graduation (1990 [1982–1998] vs 1995 [1986–2005]), higher proportion of cardiologists (45.7% vs 12.3%), and higher proportion of male gender (82.8% vs 61.7%) (all $P < .001$; Table 3).

In the logistic regression model, digoxin prescribers when compared to non–digoxin prescribers were more likely to be male, to have graduated from medical school earlier, to be located in the Midwest or South, and to belong to the Cardiology specialty (all $P < .001$; Figure 2).

4. Discussion

Digoxin prescriptions continued to decline from 2013 to 2019, with a 60% decrease in total prescriptions and with over half of digoxin prescribers stopping digoxin prescribing entirely. A greater decline in digoxin prescribers occurred among General Medicine prescribers than among Cardiologists. Currently, 1 in 10 General Medicine prescribers and 1 in 2 Cardiology prescribers continue to prescribe digoxin. Current digoxin prescribers are more likely to be Cardiologists and have graduated from medical school earlier.

Our study builds on earlier analyses to capture more recent digoxin prescription trends[20] and is the first to describe characteristics of contemporary digoxin prescribers. Digoxin prescriptions have been on the decline over the past 2 decades.[20] We observed a continuation of this trend in our study period of 2013–2019, with a further reduction in digoxin prescription prescriptions from 4.6 to 1.8 million, suggesting that interest in digoxin has continued to decline. These declines have come during a period when newer therapies for

HF became available such as angiotensin receptor–neprilysin inhibitors[24] and digoxin was further downgraded from IIa to IIb in the guidelines. Of note, while a majority (67%) of patients took digoxin at baseline in the 1991 SOLVD trial on angiotensin-converting–enzyme inhibition,[25] only 30% took digoxin in the 2014 PARADIGM-HF trial,[24,26] suggesting that baseline digoxin therapy may not be necessary for renin-angiotensin system inhibitors to lower mortality in HFrEF and further reducing support for digoxin. Now another pharmacological therapy in HF is available—SGLT2 inhibitors.[16] As newer HF therapies continue to grow in the future, digoxin could decline further.

The decrease in digoxin use was driven by the fact that over half of physicians entirely stopped digoxin prescription. However, 1 in 3 digoxin prescribers from 2013 continued prescribing digoxin in 2019, albeit at a lower number of prescriptions, and 1 in 10 providers, in fact, prescribed digoxin at the same or higher number of prescriptions, suggesting a degree of practice variation and reflecting the divergent opinions regarding digoxin.[27]

Cardiologists are more likely to prescribe digoxin than General Medicine physicians as they are more likely to encounter patients that have HFrEF or AF. However, over time, an even larger proportion of prescriptions were by cardiologists and a large proportion of prescribers who continued or increased digoxin prescription from 2013 to 2019 were in Cardiology. This shift in digoxin prescriptions from General Medicine physicians to Cardiology may reflect a shift in the general opinion of digoxin from being a mainstay treatment to a selective medication, and primary care physicians may be referring patients to their cardiologists for continued use. Alternatively, this may be a part of a larger trend of specialization in medicine where cardiac medications are increasingly only prescribed by specialists. However, it may also be that opinions and perceptions regarding digoxin may differ between these specialties. For instance, the American Geriatrics Society categorizes the use of digoxin in older adults as a first-line agent for HFrEF and AF as being potentially inappropriate.[28]

Notably, one of the characteristics of digoxin prescribers was an earlier year of medical school graduation. It is possible that prescribers who have been in practice for a longer time are more likely to be taking care of patients on this legacy medication. Alternatively, given their experience and comfort in administering digoxin, they may be more reluctant to discontinue digoxin and may also interpret emerging evidence regarding risks with digoxin with a different lens. Further, very few new prescribers (1.9% of new 2019 prescribers) prescribed digoxin. It is possible that new prescribers, who are likely newer graduates, are less enthusiastic about prescribing digoxin and more wary of risks. Further, these prescribers may have encountered fewer or no patients on chronic digoxin therapy in training and thus may not be comfortable with its use. However, it may be that these new prescribers are also more likely to see new patients with HF and less faced with decisions of discontinuing digoxin in previous patients.

Similarly, another characteristic of digoxin prescribers was male gender. It is unclear why this may be. It is possible that there may be differences in the types of patients male and female physicians treat. For instance, female physicians are more likely to see female

patients,[29] a group in whom observational data have suggested possible harm with digoxin, and thus may be less likely to prescribe it overall.

Although digoxin is probably not appropriate for routine use in chronic HF or AF, it continues to have a role in select situations, such as reduction of recurrent hospitalizations in advanced HF despite optimal medical therapy and inadequate rate control in AF despite the use of other less toxic rate control agents. Thus, although its use is declining, there remains a need to ensure that the risks with this medication are minimized. Clinical decision support (CDS) tools have been beneficial in optimizing HF therapies[30] and may have a role in ensuring digoxin is prescribed in appropriate circumstances and monitored safely.

There are limitations to our study worthy of consideration. First, we used the CMS database which is an administrative claims database without individual clinical patient characteristics. Thus, we are unable to determine reasons for the prescription or discontinuation of digoxin. However, as digoxin use at discharge has been decreasing for both HFrEF and HFpEF,[19] the lack of data on indication for digoxin should not necessarily compromise our results. Second, providers were included in the CMS database as prescribing a particular drug only if the prescription count was 10 or over. Thus, providers prescribing <10 prescriptions of digoxin cannot be differentiated from those not prescribing digoxin at all. Third, although we attribute prescriptions entirely to individual providers, in reality, various providers in a treatment team will often refill a patient's chronic medication. For example, a primary care physician may refill digoxin prescribed by the patient's cardiologist. Thus, a decision for starting a medication may not be entirely of the prescriber. We are unable to discern this in our data. Fourth, individual specialty information was unavailable for advanced practice providers (NPs and PAs). Fifth, our study is limited to prescriptions for Medicare beneficiaries and the results may be different in the <65-year-old population. Lastly, our study aims to comprehensively describe current prescription trends for digoxin and is not an evaluation of the efficacy or safety of digoxin.

5. Conclusion

Digoxin prescriptions among older adults continued to reduce from 2013 to 2019, and over half of digoxin prescribers have entirely stopped using digoxin. This trend is occurring against the backdrop of the development and availability of newer HF therapies. There is a shift in digoxin prescription occurring from general medicine physicians to cardiologists.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

No organizations directly funded this research. However, two coauthors report funding outside of this work:

–Dr. Lu reported receiving grants from the National Heart, Lung, and Blood Institute and the Yale Center for Implementation Science outside the submitted work.

–Dr. Murugiah received support from the National Heart, Lung, and Blood Institute of the National Institutes of Health (under award K08HL157727).

References

1. Digitalis Investigation Group. The effect of digoxin on mortality and morbidity in patients with heart failure. N Engl J Med 1997;336:525–533. [PubMed: 9036306]
2. Ahmed A, Rich MW, Fleg JL, et al. Effects of digoxin on morbidity and mortality in diastolic heart failure: the ancillary digitalis investigation group trial. Circulation 2006;114:397–403. [PubMed: 16864724]
3. Lopes RD, Rordorf R, De Ferrari GM, et al. Digoxin and mortality in patients with atrial fibrillation. J Am Coll Cardiol 2018;71:1063–1074. [PubMed: 29519345]
4. Whitbeck MG, Charnigo RJ, Khairy P, et al. Increased mortality among patients taking digoxin—analysis from the AFFIRM study. Eur Heart J 2013;34:1481–1488. [PubMed: 23186806]
5. Vamos M, Erath JW, Hohnloser SH. Digoxin-associated mortality: a systematic review and meta-analysis of the literature. Eur Heart J 2015;36:1831–1838. [PubMed: 25939649]
6. Gheorghiade M, Fonarow GC, van Veldhuisen DJ, et al. Lack of evidence of increased mortality among patients with atrial fibrillation taking digoxin: findings from post hoc propensity-matched analysis of the AFFIRM trial. Eur Heart J 2013;34:1489–1497. [PubMed: 23592708]
7. Singh S, Moore H, Karasik PE, et al. Digoxin initiation and outcomes in patients with heart failure (HFrEF and HFpEF) and atrial fibrillation. Am J Med 2020;133:1460–1470. [PubMed: 32603789]
8. Gheorghiade M, Patel K, Filippatos G, et al. Effect of oral digoxin in high-risk heart failure patients: a pre-specified subgroup analysis of the DIG trial. Eur J Heart Fail 2013;15:551–559. [PubMed: 23355060]
9. Rathore SS, Wang Y, Krumholz HM. Sex-based differences in the effect of digoxin for the treatment of heart failure. N Engl J Med 2002;347:1403–1411. [PubMed: 12409542]
10. Ather S, Peterson LE, Divakaran VG, et al. Digoxin treatment in heart failure—Unveiling risk by cluster analysis of DIG data. Int J Cardiol 2011;150:264–269. [PubMed: 20471706]
11. Rathore SS, Curtis JP, Wang Y, Bristow MR, Krumholz HM. Association of serum digoxin concentration and outcomes in patients with heart failure. JAMA 2003;289:871–878. [PubMed: 12588271]
12. Packer M, Bristow MR, Cohn JN, et al. The effect of carvedilol on morbidity and mortality in patients with chronic heart failure. N Engl J Med 1996;334:1349–1355. [PubMed: 8614419]
13. Goldstein S, Hjalmarson A. The mortality effect of metoprolol CR/XL in patients with heart failure: results of the MERIT-HF Trial. Clin Cardiol 1999;22:V30–V35. [PubMed: 10526701]
14. Pitt B, Zannad F, Remme WJ, et al. The effect of spironolactone on morbidity and mortality in patients with severe heart failure. Randomized Aldactone Evaluation Study Investigators. N Engl J Med 1999;341:709–717. [PubMed: 10471456]
15. Shah A, Gandhi D, Srivastava S, Shah KJ, Mansukhani R. Heart failure: a class review of pharmacotherapy. P T 2017;42:464–472. [PubMed: 28674474]
16. McMurray JJV, Solomon SD, Inzucchi SE, et al. Dapagliflozin in patients with heart failure and reduced ejection fraction. N Engl J Med 2019;381:1995–2008. [PubMed: 31535829]
17. Jessup M, Abraham WT, Casey DE, et al. 2009 Focused Update: ACCF/AHA guidelines for the diagnosis and management of heart failure in adults. Circulation 2009;119:1977–2016. [PubMed: 19324967]
18. Ponikowski P, Voors AA, Anker SD, et al. 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC). Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. Eur J Heart Fail 2016;18:891–975. [PubMed: 27207191]
19. Patel N, Ju C, Macon C, et al. Temporal trends of digoxin use in patients hospitalized with heart failure: analysis from the American Heart Association get with the guidelines-Heart Failure Registry. JACC Heart Fail 2016;4:348–356. [PubMed: 26874392]
20. Angraal S, Nuti SV, Masoudi FA, et al. Digoxin use and associated adverse events among older adults. Am J Med 2019;132:1191–1198. [PubMed: 31077654]

21. Packer M, Gheorghiade M, Young JB, et al. Withdrawal of Digoxin from Patients with Chronic Heart Failure Treated with Angiotensin-Converting-Enzyme Inhibitors. N Engl J Med 1993;329:1–7. [PubMed: 8505940]

22. Uretsky BF, Young JB, Shahidi FE, Yellen LG, Harrison MC, Jolly MK. Randomized study assessing the effect of digoxin withdrawal in patients with mild to moderate chronic congestive heart failure: results of the PROVED trial. J Am Coll Cardiol 1993;22:955–962. [PubMed: 8409069]

23. Services CfMM. Medicare Part D Prescribers - by Geography and Drug. Information on prescription drugs provided to Medicare beneficiaries enrolled in Part D (Prescription Drug Coverage), by physicians and other health care providers, aggregated by geography and drug 2022. Retrieved from https://data.cms.gov/provider-summary-by-type-of-service/medicare-part-d-prescribers/medicare-part-d-prescribers-by-geography-and-drug.

24. McMurray JJ, Packer M, Desai AS, et al. Angiotensin-neprilysin inhibition versus enalapril in heart failure. N Engl J Med 2014;371:993–1004. [PubMed: 25176015]

25. Yusuf S, Pitt B, Davis CE, Hood WB, Cohn JN. Effect of enalapril on survival in patients with reduced left ventricular ejection fractions and congestive heart failure. N Engl J Med 1991;325:293–302. [PubMed: 2057034]

26. Okumura N, Jhund PS, Gong J, et al. PARADIGM-HF Investigators and Committees∗ .Effects of Sacubitril/Valsartan in the PARADIGM-HF Trial (Prospective Comparison of ARNI with ACEI to Determine Impact on Global Mortality and Morbidity in Heart Failure) According to Background Therapy. Circ Heart Fail 2016;9(9):e003212. [PubMed: 27618854]

27. Packer M, Zannad F. Do the favorable effects of digoxin and SGLT2 inhibitors really differ in patients with heart failure and a reduced ejection fraction? A provocative side-by-side examination of trial outcomes. J Card Fail 2022;28:682–683. [PubMed: 35038597]

28. By the 2019 American Geriatrics Society Beers Criteria® Update Expert Panel. American Geriatrics Society 2019 Updated AGS Beers Criteria® for Potentially Inappropriate Medication Use in Older Adults. J Am Geriatr Soc. 2019;67:674–694. [PubMed: 30693946]

29. Linzer M, Harwood E. Gendered expectations: do they contribute to high burnout among female physicians? J Gen Intern Med 2018;33:963–965. [PubMed: 29435727]

30. Ghazi L, Yamamoto Y, Riello RJ, et al. Electronic alerts to improve heart failure therapy in outpatient practice. J Am Coll Cardiol 2022;79:2203–2213. [PubMed: 35385798]

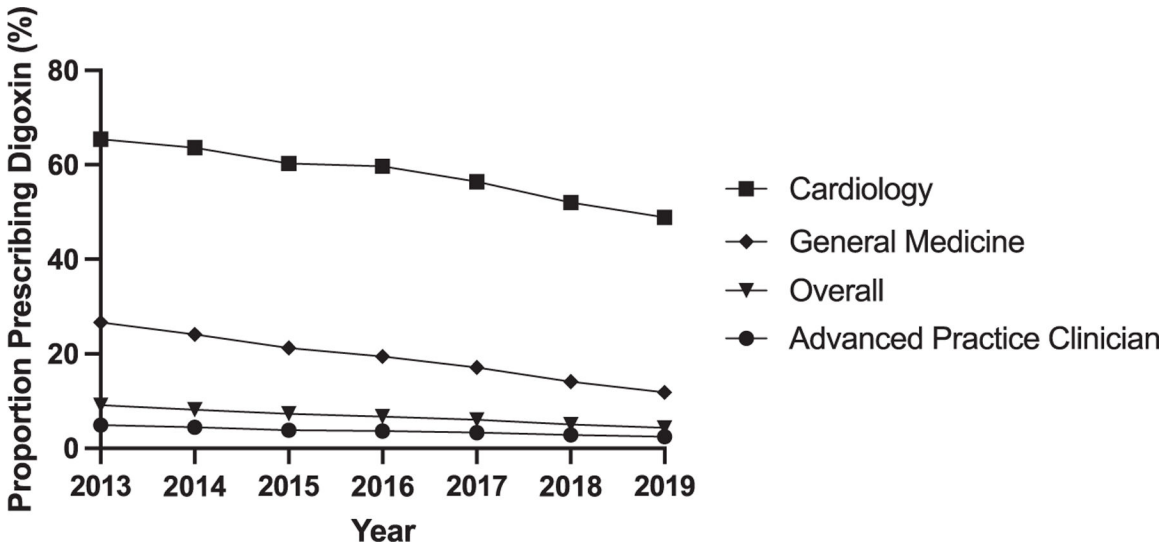

Figure 1.

Proportion of Digoxin Prescribers from 2013 to 2019 Overall and by Specialty. Line graph showing proportion of digoxin prescription of overall prescribers and in three specialty subgroups over time.

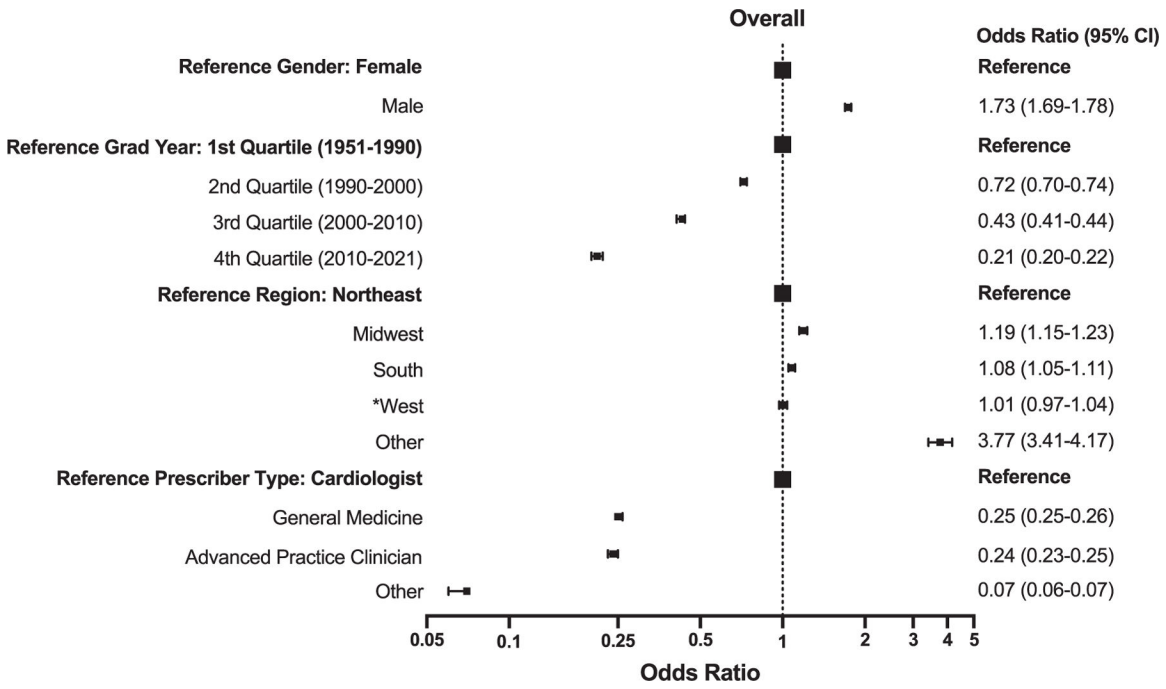

Figure 2.

Forest Plot of 2019 Prescriber Characteristics Associated with Digoxin Prescription. Forest plot showing prescriber characteristics associated with digoxin prescription in a logistic regression model with odds ratios and 95% CI. ∗ All $P < .001$ except West $P = .739$.

Table 1

Annual Digoxin Prescriptions and Digoxin Prescriber Characteristics from 2013 to 2019.

		2013	2014	2015	2016	2017	2018	2019
Overall	Total Clinicians	1,049,299	1,072,978	1,102,253	1,131,550	1,162,898	1,204,935	1,240,595
	Digoxin Prescribers	95,576 (9.1%)	88,113 (8.2%)	79,978 (7.3%)	75,721 (6.7%)	69,374 (6.0%)	60,107 (5.0%)	53,015 (4.3%)
	Total Digoxin Prescriptions	4,573,542	4,207,804	3,569,641	3,223,339	2,816,371	2,260,750	1,833,188
	Digoxin Prescriptions per Provider (Median [IQR])	30 (16–58)	30 (16–58)	27 (15–53)	26 (15–50)	24 (14–47)	23 (14–44)	21 (14–39)
	Female	24,738 (26.8%)	22,925 (26.8%)	21,240 (27.2%)	20,646 (27.8%)	19,358 (28.3%)	16,870 (28.4%)	15,088 (28.7%)
	Practice Region							
	Northeast	18,909 (21.1%)	17,677 (20.5%)	15,999 (20.4%)	15,143 (20.4%)	13,944 (20.5%)	12,189 (20.7%)	10,765 (20.8%)
	Midwest	22,397 (23.9%)	20,847 (24.1%)	18,653 (23.8%)	18,017 (24.2%)	16,466 (24.2%)	14,353 (24.4%)	12,565 (24.2%)
	South	33,212 (35.4%)	30,946 (35.8%)	28,329 (36.1%)	26,576 (35.7%)	24,113 (35.5%)	20,877 (35.5%)	18,504 (35.7%)
	West	18,313 (19.5%)	16,959 (19.6%)	15,494 (19.7%)	14,618 (19.7%)	13,484 (19.8%)	11,425 (19.4%)	10,023 (19.3%)
	Other	1714 (1.8%)	1634 (1.9%)	1464 (1.9%)	1317 (1.8%)	1330 (2.0%)	1223 (2.1%)	1130 (2.2%)
	Prescriber Group							
	Cardiology	15,831 (16.6%)	15,423 (17.5%)	14,583 (18.2%)	14,506 (19.2%)	14,981 (21.6%)	14,027 (23.3%)	13,331 (25.1%)
	General Medicine	63,990 (67.0%)	58,254 (66.1%)	51,927 (64.9%)	47,906 (63.3%)	42,607 (61.4%)	35,574 (59.2%)	30,242 (57.0%)
	Advanced Practice Clinicians	8202 (8.6%)	8020 (9.1%)	7830 (9.8%)	8096 (10.7%)	8066 (11.6%)	7487 (12.5%)	7001 (13.2%)
	Other	7553 (7.9%)	6416 (7.3%)	5638 (7.0%)	5213 (6.9%)	3720 (5.4%)	3019 (5.0%)	2441 (4.6%)
Cardiology	Total Clinicians	24,195	24,241	24,196	24,305	26,574	26,965	27,265
	Digoxin Prescribers	15,831 (65.4%)	15,423 (63.6%)	14,583 (60.3%)	14,506 (59.7%)	14,981 (56.4%)	14,027 (52.0%)	13,331 (48.9%)
	Total Digoxin Prescriptions	1,327,968	1,294,133	1,131,883	1,037,564	976,756	832,168	705,350
	Digoxin Prescriptions per Provider (Median [IQR])	58 (29–108)	60 (30–107)	54 (26–100)	49 (24–92)	44 (23–83)	41 (21–75)	35 (19–66)
	Female	1351 (8.8%)	1344 (8.9%)	1281 (9.0%)	1349 (9.4%)	1458 (9.8%)	1370 (9.9%)	1334 (10.1%)
	Practice Region *							
	Northeast	3715 (23.8%)	3551 (23.3%)	3279 (22.8%)	3252 (22.7%)	3226 (21.8%)	3042 (22.0%)	2945 (22.4%)
	Midwest	3247 (20.8%)	3168 (20.8%)	2962 (20.6%)	3014 (21.0%)	3200 (21.6%)	2960 (21.4%)	2757 (20.9%)
	South	5831 (37.3%)	5717 (37.6%)	5535 (38.5%)	5446 (38.0%)	5636 (38.1%)	5265 (38.0%)	5010 (38.1%)
	West	2819 (18.1%)	2775 (18.2%)	2609 (18.1%)	2608 (18.2%)	2737 (18.5%)	2580 (18.6%)	2452 (18.6%)
	Other	206 (1.3%)	205 (1.3%)	191 (1.3%)	180 (1.3%)	176 (1.2%)	176 (1.3%)	163 (1.2%)

		2013	2014	2015	2016	2017	2018	2019
General Medicine	Total Clinicians	240,280	241,572	244,953	247,180	249,883	252,845	255,479
	Digoxin Prescribers	63,990 (26.6%)	58,254 (24.1%)	51,927 (21.2%)	47,906 (19.4%)	42,607 (17.1%)	35,574 (14.1%)	30,242 (11.8%)
	Total Digoxin Prescriptions	2,732,379	2,429,784	2,001,164	1,768,448	1,510,244	1,148,825	884,008
	Digoxin Prescriptions per Provider (Median [IQR])	29 (16–53)	28 (16–52)	25 (15–47)	24 (15–44)	23 (14–41)	21 (14–37)	19 (14–33)
	Female**	15,707 (25.4%)	14,190 (25.1%)	12,7807 (25.3%)	11,924 (25.4%)	10,628 (25.4%)	8792 (25.0%)	7507 (25.0%)
	Practice Region							
	Northeast	13,192 (20.9%)	11,577 (20.1%)	10,301 (20.1%)	9483 (20.0%)	8518 (20.3%)	7147 (20.4%)	6051 (20.3%)
	Midwest	15,780 (25.0%)	14,472 (25.1%)	12,722 (24.8%)	12,012 (25.4%)	10,629 (25.3%)	8932 (25.5%)	7556 (25.4%)
	South	21,662 (34.3%)	19,908 (34.6%)	17,806 (34.7%)	16,254 (34.3%)	14,289 (34.0%)	11,935 (34.0%)	10,152 (34.1%)
	West	12,604 (19.9%)	11,608 (20.2%)	10,481 (20.4%)	9594 (20.3%)	8611 (20.5%)	7042 (20.1%)	6003 (20.2%)
	Other	676 (1.1%)	660 (1.1%)	597 (1.2%)	535 (1.1%)	538 (1.3%)	493 (1.4%)	462 (1.6%)

All *P* values compare 2013–2019 data (Chi-squared test for categorical data and Mann-Whitney U test for continuous data) and are <.001 except for

*$P = .063$

**$P = .361$.

Table 2

Change in Prescriber Status of Digoxin Prescribers from 2013 to 2019.

	Stopped digoxin prescribing	Continued prescribing digoxin with reduced digoxin prescriptions	Continued prescribing digoxin with same or greater digoxin prescriptions
Total Clinicians (%)	51,483 (59.1)	27,646 (31.7)	8039 (9.2)
Female (%)	16,202 (70.8)	4697 (20.5)	1989 (8.7)
Practice Location			
Northeast (%)	10,461 (58.5)	5726 (32.0)	1704 (9.5)
Midwest (%)	11,621 (58.4)	6264 (31.5)	2001 (10.1)
South (%)	18,047 (58.4)	10,291 (33.3)	2554 (8.3)
West (%)	10,554 (62.8)	4704 (28.0)	1559 (9.3)
Other (%)	773 (47.0)	653 (39.7)	218 (13.3)
Prescriber Group			
Cardiology (%)	4023 (27.4)	8053 (54.9)	2584 (17.6)
General Medicine (%)	37,841 (63.4)	17,443 (29.2)	4394 (7.4)
Advanced Practice Clinician (%)	5549 (76.3)	1045 (14.4)	677 (9.3)
Other (%)	4070 (73.2)	1,05 (19.9)	384 (6.9)

All $P < .001$.

Table 3

Digoxin Prescriber Characteristics in 2019 by Volume of Digoxin Prescriptions.

	Low digoxin prescribers: <25th percentile	Medium digoxin prescribers: 25-75th percentile	High digoxin prescribers: >75th percentile
Total Clinicians (*N*)	13,254	26,508	13,253
Total Digoxin Prescriptions	160,616	609,948	1,062,624
Digoxin Prescriptions per Provider (Median [IQR])	12 (11–13)	21 (17–28)	62 (48–91)
Graduation Year (Median [IQR])	1995 (1986–2005)	1994 (1984–2002)	1990 (1982–1998)
Female	5034 (38.3%)	7788 (29.6%)	2266 (17.2%)
Practice Region			
Northeast	2694 (20.7%)	5347 (20.6%)	2724 (21.1%)
Midwest	3195 (24.5%)	6298 (24.3%)	3072 (23.8%)
South	4356 (33.5%)	9114 (35.2%)	5034 (38.9%)
West	2777 (21.3%)	5146 (19.9%)	2100 (16.2%)
Other	225 (1.7%)	586 (2.3%)	319 (2.5%)
Prescriber Group			
Cardiology	1627 (12.3%)	5649 (21.3%)	6055 (45.7%)
General Medicine	8373 (63.2%)	16,039 (60.5%)	5830 (44.0%)
Advanced Practice Clinician	2480 (18.7%)	3586 (13.5%)	935 (7.1%)
Other	774 (5.8%)	1234 (4.7%)	433 (3.3%)

All $P < .001$.