Basic & Clinical Pharmacology & Toxicology

BCPT Basic & Clinical Pharmacology & Toxicology

ORIGINAL ARTICLE OPEN ACCESS

Adjustment for 'Prescriber Type' in Pharmacoepidemiological Analyses

Saad Hanif Abbasi | Jesper Hallas | Peter Bjødstrup Jensen | Hassan Al-Jasim | Anton Pottegård

Clinical Pharmacology, Pharmacy, and Environmental Medicine, Department of Public Health, University of Southern Denmark, Odense, Denmark

Correspondence: Saad Hanif Abbasi (shabbasi@health.sdu.dk)

Received: 20 March 2025 | **Revised:** 31 July 2025 | **Accepted:** 16 September 2025

Funding: This work was supported by the Danmarks Frie Forskningsfond (1052-00035B).

Keywords: confounder adjustment | confounding | pharmacoepidemiology | prescriber setting | prescriber type

ABSTRACT

The type of prescriber typically fulfils the criteria for confounding, as it is associated both with the exposure (e.g., prescriber types may differ in their choice of first-line treatment) and with the outcome (as different types of prescribers often treat patients with different disease severity). Additionally, the type of prescriber may correlate with other factors such as treatment adherence, surveillance or coding practices. Although information on the type of prescriber is often available in healthcare registries, it is very rarely employed to control for confounding in pharmacoepidemiological analyses. Here, we argue the potential value in adjusting for the prescriber type in pharmacoepidemiological studies. In an applied example, we conducted a cohort study using Danish healthcare registers of the risk of ischemic stroke associated with the use of direct oral anticoagulants (DOACs) compared to warfarin. We found a hazard ratio (HR) of 0.95 (95% CI: 0.90–1.01) for DOACs versus warfarin when adjusting only for age and sex. Further adjustment for prescriber type showed an effect of similar magnitude (HR 0.92; 95% CI: 0.87–0.98). However, interaction testing and stratified analyses confirmed prescriber type as an effect modifier. Future studies are needed to clarify the role of adjusting for prescriber type across other use cases and healthcare settings.

Plain Language Summary

Different prescribers may choose different treatments or treat patients with more severe conditions, making the type of prescriber a so-called confounder, that is, a factor that, if not controlled for, will lead to spurious results. However, information on prescriber type is only very rarely used inpharmacoepidemiology studies. We tried to illustrate the value of considering prescriber type by studying the effectiveness of two types of anticoagulants to prevent strokes. Although adjustment for prescriber type only had minimal effect on the estimates obtained, analysis conducted within hospital prescribers and general practitioners separately showed divergent results. We need more studies to fully determine when adjusting for prescriber type is important in pharmacoepidemiology studies.

1 | Introduction

In pharmacoepidemiological studies, we almost always aim to address confounding, which occurs when the effect of the exposure of interest is mixed with the effect of another variable, usually referred to as a confounder [1]. Typically, confounders are managed by including them as covariates in regression models [2], incorporating them into a propensity score model [3] or using them as criteria for stratification [2]. Some confounders are directly measurable, such as age, sex or certain comorbidities, and can be directly included in adjustment models. Others are only indirectly measurable, often

https://doi.org/10.1111/bcpt.70126

requiring the use of proxies, such as adjusting for chronic obstructive pulmonary disease as a marker of heavy smoking. The extent to which confounding can be controlled depends not only on the study question and potential confounders but also on the data available to the researcher.

One covariate that might act both as a confounder and as a proxy for other characteristics is the type of prescriber issuing a given prescription. In most cases, the majority of prescriptions are issued by generalists (e.g., general practitioners), whereas a smaller proportion are prescribed by specialists [4]. Specialist prescribers, compared to generalist prescribers, might be more likely to treat patients with greater comorbidity or more severe forms of disease. The issue is complicated, though. Some studies have shown that patients treated by specialists have lower mortality rates when using monoamine oxidase inhibitors compared to dopamine agonists [5] and reduced bleeding risk with warfarin [6], compared to patients treated by primary care physicians or general practitioners. This might be due to better adherence and continuation of therapies among patients whose initial prescriber is a specialist [7–9]. Alternatively, the type of prescriber may represent other factors, such as differences in data availability or coding practices, which could also correlate with study outcomes.

Although information on the type of prescriber is available in some healthcare registries, it is rarely used to control for confounding in pharmacoepidemiology studies. In this paper, we suggest, illustrate and discuss the value of including the prescriber type as a covariate in pharmacoepidemiological outcome studies.

1.1 | Type of Prescriber as a Confounder

The type of prescriber typically meets the criteria of a confounder as it is (1) associated with the exposure, (2) associated with the outcome and (3) not part of the causal pathway. The type of prescriber can influence whether a patient receives a first or second-line drug. Similarly, specialists might handle more complex cases compared to general practitioners, leading to different health outcomes among patients. Additionally, the type of prescriber can act as a proxy for other confounders, such as disease severity, treatment adherence and monitoring. Information on these confounders is difficult to obtain and is typically unavailable in the healthcare registries used in pharmacoepidemiological research.

Consider a standard pharmacoepidemiologic study comparing two drugs for an outcome (Figure 1). Because the choice of treatment is typically associated with disease severity (which is usually unmeasured), the type of prescriber can serve as proxy for this variable. Adjusting for the type of prescriber is expected to reduce such confounding. This reasoning can also apply to other unmeasured confounders, where adjusting for the type of prescriber may mitigate confounding. However, the underlying causal structure may also be more complex, as illustrated in Figure 2. Prescriber type may be influenced by other unmeasured variables such as socioeconomic status, and in such cases, it may function as a collider. Adjusting for prescriber type may

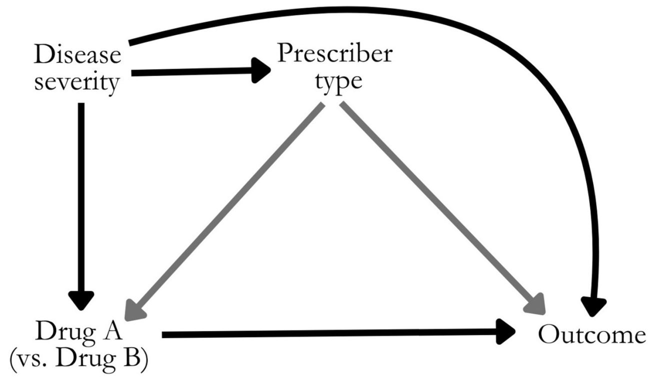

FIGURE 1 | Directed acyclic graph illustrating prescriber type as a proxy for disease severity in a standard pharmacoepidemiological study comparing Drug A with Drug B in combination with a specific health outcome.

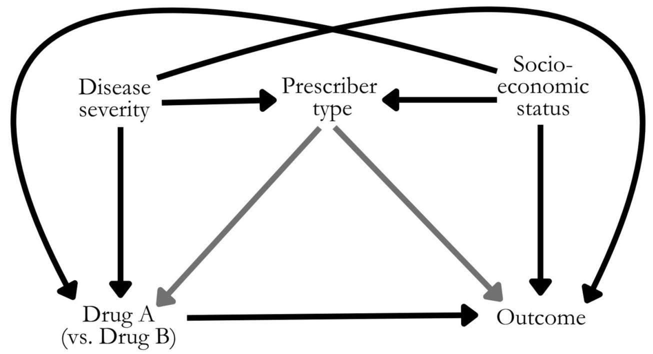

FIGURE 2 | Directed acyclic graph illustrating prescriber type as a proxy for disease severity and socioeconomic status in a pharmacoepidemiological study comparing Drug A with Drug B in combination with a specific health outcome.

block part of the backdoor path but also risks conditioning on a collider and thus introduce bias, if not properly handled.

2 | Type of Prescriber in the Danish Context

Denmark has a tax-financed healthcare system that is free for all its residents [10]. General practitioners (GPs) act as the first point of contact for patients within the healthcare system and prescribe the majority of medications in Denmark [4, 11]. A referral from a GP is required to access hospital care and the majority of the office-based specialists [11]. In the Danish context, the prescriber type is closely linked to the prescriber setting, as different prescriber types (GPs and hospital prescribers) also represent the healthcare setting where the prescription was written. Thus, the use of prescriber type as a covariate implicitly suggests the use of prescriber setting. The dichotomy in the prescriber type may not hold for healthcare systems in other countries, such as in the United States, where nurse practitioners and physician assistants are allowed to prescribe in most states. Further, unlike Denmark, the prescribing pattern in the United States may be driven by payer reimbursement decisions. Finally, certain data sources such as the Clinical Practice Research Datalink (CPRD) from the

United Kingdom, where data primarily come from the GPs, may not be able to utilize the covariate as proposed here.

BOX 1 | Validity of Prescriber Information

The validity of prescriber information is crucial for its use in pharmacoepidemiological research, although its accuracy in the healthcare registries may vary depending on the setting. In Denmark, the prescriber information in the Danish National Prescription Registry 12 has been validated [12]. The study reported high positive predictive values for prescriber type classification, ranging from 94% to 99% over the years. However, the proportion of prescriptions from a prescriber type that were correctly identified ranged between 65% and 92%, with lower values particularly for prescriptions from private-practice specialists. Overall, the results show that prescriber information in the registry is valid.

3 | Review of Literature

We conducted a literature review to support our claim that adjustment for prescriber type is rarely performed. Our goal was to identify pharmacoepidemiological outcome studies that included the type of prescriber as a covariate for confounding adjustment or that stratified analyses by the type of prescriber.

3.1 | Search Strategy

As covariates adjusted for in such studies are generally not indexed and thus difficult to systematically search, we employed three independent search strategies. First, an extensive search was conducted in PubMed, covering publications from inception to February 2024. Due to the complexity of the clinical question, the search strategy did not follow the conventional PICO model. Instead, a broad and inclusive approach was taken, focusing solely on synonyms for 'type of prescriber' identified through iterative snowball searching. No additional search terms were used to maximize the retrieval of relevant information. The actual search string used is presented in Appendix A. Second, we performed a targeted search in the journal *Pharmacoepidemiology and Drug Safety*, covering all publications from 2020 to 2022. No additional search terms or filters were applied, ensuring comprehensive retrieval of all articles published during this period. Finally, artificial intelligence (AI)–driven tools, including ChatGPT 4.0, SciSpace and ResearchRabbit, were used to enhance the identification of relevant studies by generating specific queries aligned with the review's objectives (Appendix B). Although this AI-driven approach provided valuable insights, it was not systematic, as it did not adhere to a strict search protocol.

3.2 | Study Selection

Studies were included if they met the following criteria: The study (1) investigated any type of drug, (2) assessed a patient-related outcome, (3) adjusted for the type of prescriber (or investigated the type of prescriber as a primary exposure), (4) was published in English and (5) consisted of original research. Studies were excluded if they focused solely on prescription patterns, the usage of drugs or lacked a relevant outcome of interest. Titles and abstracts for potentially relevant articles were screened using the Covidence tool. Articles meeting the inclusion criteria, or with uncertainty based on title and abstract alone, were advanced to a full-text screening. At this stage, studies were thoroughly examined to confirm their eligibility for the review. Relevant data were then extracted from the included studies.

A total of 3664 studies were identified across all three search methods. Of the 3664 studies, 166 were eligible for full-text screening. After this process, four studies were included in the final review (Appendix C). The systematic search identified 2997 hits, of which three studies were included [5, 6, 8]. Among 652 studies from *Pharmacoepidemiology and Drug Safety*, no relevant studies were identified. Finally, the AI tools identified 15 papers, two of which were relevant [6, 13], though one [6] had already been identified in the systematic search.

3.3 | Results

The studies investigated are summarized as follows: Kayser et al. [8] found no difference in hormone therapy continuation rates between those prescribed by gynaecologists and other physicians, though there was a trend towards better adherence among patients receiving prescriptions from gynaecologists. Tian et al. [13] demonstrated that adjusting for the prescriber's specialty, alongside other relevant factors, significantly reduced the hazard ratios (HR) for all-cause mortality and major adverse cardiovascular and cerebrovascular events in patients receiving antihypertensive, lipid-lowering or antidiabetic medications. Tvete and Klemp [5] reported lower mortality rates among patients who received prescriptions from specialists, as compared to those who initially received them from general practitioners, across all age groups. Zhang et al. [6] found that in comparison to those whose first prescriber was a cardiologist, patients prescribed warfarin by primary care practitioners (family practitioners, general practitioners and internal medicine) or other specialties had a higher risk of experiencing a bleeding event.

In conclusion, although our literature search identified papers where the type of prescriber was considered, the results confirm that such adjustment is rarely performed.

4 | Applied Example

We used an applied example of direct oral anticoagulants (DOACs) versus warfarin use and assessed the efficacy outcome of ischaemic stroke. Clinical studies and guidelines now recommend DOACs (including dabigatran, rivaroxaban, apixaban and edoxaban) over warfarin due to their improved safety profile and efficacy [14–16]. Using the Danish healthcare registers, we conducted a cohort study from 2010 to 2018 to identify the risk of ischaemic stroke associated with the use of DOACs compared to warfarin. The study was conducted in accordance with the Basic & Clinical Pharmacology & Toxicology policy for experimental and clinical studies [17].

We utilized the Danish National Prescription Registry [18], which contains data on all prescription drugs redeemed at community pharmacies since 1995, and the Danish National Patient Register [19], which contains data on all nonpsychiatric hospital admissions since 1977 and on all outpatient contacts since 1995. The Danish National Prescription Registry employs the Anatomical Therapeutic Chemical (ATC) classification system for identifying the pharmacological substance, whereas all diagnoses in the Danish National Patient Register are encoded using the International Classification of Diseases, Tenth Revision (ICD-10).

In our cohort study spanning from 2010 to 2018, we identified the incident users of DOACs (Level 4 ATC codes: B01AE, B01AF) or warfarin (Level 5 ATC code: B01AA03). Patients were followed for up to 2 years from treatment initiation to observe the occurrence of ischaemic stroke (ICD-10 code: I63). Patient follow-up was censored upon switching to a different drug class and in cases of migration or death. We conducted both unadjusted and adjusted Cox regression analyses to identify the impact of potential confounders, including age, sex and prescriber type, on the association between anticoagulant use and ischaemic stroke risk. We evaluated effect modification in the Cox proportional hazards model by including an interaction term between exposure and prescriber type. Finally, we conducted a stratified analysis by prescriber type to explore any potential effect modification.

We divided the type of prescribers into three categories: (1) general practitioner, (2) hospital prescribers and (3) unknown (either an unknown sector, specialty or both). Both DOACs and warfarin were mainly prescribed by hospital prescribers, with 62 840 incident prescriptions of DOACs and 47 567 incident prescriptions of warfarin (Figure 3). For general practitioners, 30 777 incident prescriptions for warfarin and 17 088 incident prescriptions for DOACs were recorded (Figure 3). The regression analysis showed that the type of prescriber was a significant risk factor for stroke, with hospital prescribers associated with a higher risk compared to general practitioners (HR 1.30, 95% CI: 1.21–1.39, $p < 0.001$).

When adjusted for age and sex, we observed a HR of 0.95 (95% CI 0.90–1.01) for DOACs versus warfarin use across all types of prescribers (Table 1). When further adjusting for prescriber type, we observed a slight protective effect of DOACs use against ischemic stroke (HR 0.92; 95% CI 0.87–0.98) compared to warfarin use (Table 1).

The interaction term was statistically significant, with a HR of 0.82 (95% CI: 0.71–0.95; $p < 0.001$), supporting effect measure modification by prescriber type. In stratified analyses, the HR for DOACs versus warfarin use with a general practitioner as the prescriber type was 1.06 (95% CI 0.94–1.2), whereas the HR in the group of hospital prescribers was 0.88 (95% CI 0.82–0.95) (Table 1).

Our findings align with those of Tvete and Klemp [5], who reported reduced mortality for patients treated by specialists, supporting our observation of potential effect modification by prescriber type. In contrast, Tian et al. [13] found adjusting for prescriber specialty (along with other covariates) led to a more considerable change in effect estimates. Although it is difficult to ascertain the extent to which the change was driven specifically by prescriber specialty, the possibility that it acted as a confounder cannot be ruled out. These differences underscore that the role of prescriber type may vary depending upon the context and outcomes under study.

In conclusion, in this example, prescriber type was associated with the outcome and was unevenly distributed between the two groups, meeting the criteria of being a confounder. We only observed a marginal effect on HR upon adjustment using regression analyses, suggesting limited confounding in this case. However, the test for interaction and stratified analysis

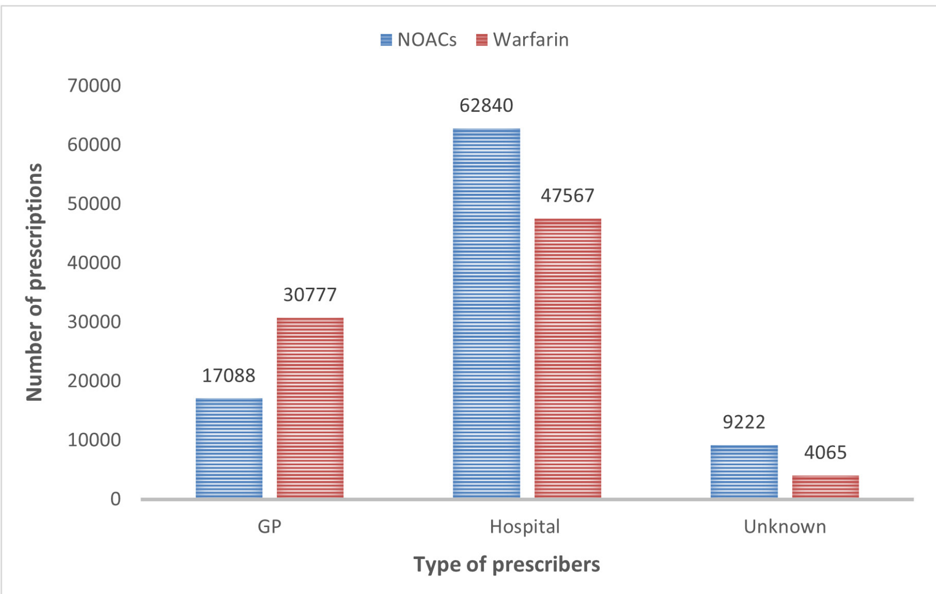

FIGURE 3 | Distribution of prescribers for incident prescriptions of DOACs and warfarin from 2010 to 2018. DOAC, direct oral anticoagulant; GP, general practitioner; unknown PC, unknown primary care.

TABLE 1 | Unadjusted, adjusted and stratified Cox regression analyses for the association between anticoagulant use and ischaemic stroke.

Prescriber type	Exposure	Population (*n*)	No. of events	Follow-up time (years)	Incidence rate (per 100 PY)	Crude HR[a] (95% CI; *p* value)	Adjusted HR[b] (95% CI; *p* value)
Any	Warfarin	82 409	2019	137 330	1.47	1.00 (ref)	1.00 (ref)
	DOAC	89 150	2227	156 301	1.42	0.95 (0.90–1.01; 0.114)	0.92 (0.87–0.98; 0.013)
Stratified analyses							
GP	Warfarin	30 777	655	51 520	1.27	1.00 (ref)	
	DOAC	17 088	423	29 327	1.44	1.06 (0.94–1.20; 0.367)	
Hospital	Warfarin	47 567	1288	79 056	1.63	1.00 (ref)	
	DOAC	62 840	1644	110 280	1.49	0.88 (0.82–0.95; 0.001)	

Abbreviations: CI, confidence interval; DOAC, direct oral anticoagulant; HR, hazard ratio; PY, person-years.
[a]Adjusted for age and sex.
[b]Adjusted for age, sex, and prescriber type.

indicated prescriber type as an effect modifier in the current example.

4.1 | Limitations

Although the information on prescriber type is available in some healthcare registries (including Danish registries), this is not the case in all datasets. This might be one reason why prescriber type adjustment is rarely used, as apparent from the literature review. Further, the findings of this study are case and context specific. Finally, although the overall missing data on prescriber type were low among all patients initiating anticoagulation (7.7% of initiators), Table 1 and Figure 3 show some evidence for differential missingness by treatment (10.3% for DOACs vs. 4.9% for warfarin). We included 'unknown' as a separate category in our models. Although this approach retains all patients in the analysis, it does not fully account for potential bias from differential missingness.

5 | Conclusion and Future Work

This paper presents the idea of adjusting for prescriber type as a confounder or relevant covariate in pharmacoepidemiological studies. Our literature review showed that the utilization of prescriber type for confounding adjustment is rare, despite its availability in some healthcare databases. In our applied example, adjusting for prescriber type had only a marginal effect on the overall estimates. However, interaction testing and stratified analyses suggested that prescriber type may act as an effect modifier. Additional examples across different use cases and healthcare settings are needed to better assess the role of adjusting for prescriber type in pharmacoepidemiological analyses.

A key focus should be on validating the accuracy of prescriber type data across various healthcare settings to ensure its consistent and reliable use. Additionally, methodological research is required to determine when prescriber type should be included in analyses and the most effective ways to utilize it for confounder adjustment. These efforts will help optimize the use of prescriber type in statistical models, ultimately enhancing the precision and validity of pharmacoepidemiological studies and ensuring more accurate assessments of drug safety and effectiveness.

Author Contributions

Saad Hanif Abbasi and Anton Pottegård were responsible for the initial conceptualization and planning of the study. Peter Bjødstrup Jensen and Saad Hanif Abbasi were responsible for managing and analysing the data. Anton Pottegård and Jesper Hallas supervised the overall project. All authors provided significant contributions in the planning and subsequent reporting of the work described in this paper. The manuscript was primarily drafted by Saad Hanif Abbasi. All authors have reviewed and edited the manuscript for important intellectual content and approved the final version.

Acknowledgements

The authors thank Marie-Catherine Schaller for her help with language editing and proofreading of the article.

Ethics Statement

In Denmark, studies based solely on register data do not require review or ethical approval.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Due to Danish data protection regulations, individual-level data cannot be shared directly by the authors. Deidentified data from Danish healthcare registries are accessible for researchers after application to the Danish Health Data Authority. The analytical source code can be made available by the authors upon request.

References

1. K. van Stralen, F. Dekker, C. Zoccali, and K. Jager, "Confounding," *Nephron. Clinical Practice* 116, no. 2 (2010): c143–c147.

2. K. Jager, C. Zoccali, A. Macleod, and F. Dekker, "Confounding: What It Is and How to Deal With It," *Kidney International* 73, no. 3 (2008): 256–260.

3. P. R. Rosenbaum and D. B. Rubin, "The Central Role of the Propensity Score in Observational Studies for Causal Effects," *Biometrika* 70, no. 1 (1983): 41–55.

4. A. Pottegård, M. Olesen, B. Christensen, M. B. Christensen, J. Hallas, and L. Rasmussen, "Who Prescribes Drugs to Patients: A Danish Register-Based Study," *British Journal of Clinical Pharmacology* 87, no. 7 (2021): 2982–2987.

5. I. F. Tvete and M. Klemp, "Parkinson's Disease, Treatment Choice and Survival Over Time," *Clinical Parkinsonism & Related Disorders* 6 (2022): 100136.

6. K. Zhang, C. Young, and J. Berger, "Administrative Claims Analysis of the Relationship Between Warfarin Use and Risk of Hemorrhage Including Drug-Drug and Drug-Disease Interactions," *Journal of Managed Care Pharmacy* 12, no. 8 (2006): 640–648.

7. K. Z. Bambauer, S. B. Soumerai, A. S. Adams, F. Zhang, and D. Ross-Degnan, "Provider and Patient Characteristics Associated With Antidepressant Nonadherence: The Impact of Provider Specialty," *Journal of Clinical Psychiatry* 68, no. 6 (2007): 867–873.

8. J. Kayser, B. Ettinger, and A. Pressman, "Postmenopausal Hormonal Support: Discontinuation of Raloxifene Versus Estrogen," *Menopause* 8, no. 5 (2001): 328–332.

9. N. Rashid, B. W. Coburn, Y. L. Wu, et al., "Modifiable Factors Associated With Allopurinol Adherence and Outcomes Among Patients With Gout in an Integrated Healthcare System," *Journal of Rheumatology* 42, no. 3 (2015): 504–512.

10. Ministry of Health, *Healthcare in Denmark: An Overview* (Ministry of Health, Published online, 2017).

11. K. M. Pedersen, J. S. Andersen, and J. Søndergaard, "General Practice and Primary Health Care in Denmark," *Journal of the American Board of Family Medicine* 25, no. Suppl 1 (2012): S34–S38.

12. L. Rasmussen, J. Valentin, K. M. Gesser, J. Hallas, and A. Pottegård, "Validity of the Prescriber Information in the Danish National Prescription Registry," *Basic & Clinical Pharmacology & Toxicology* 119, no. 4 (2016): 376–380.

13. Y. Tian, B. Reichardt, D. Dunkler, et al., "Comparative Effectiveness of Branded vs. Generic Versions of Antihypertensive, Lipid-Lowering and Hypoglycemic Substances: A Population-Wide Cohort Study," *Scientific Reports* 10, no. 1 (2020): 1–12.

14. T. Hicks, F. Stewart, and A. Eisinga, "NOACs Versus Warfarin for Stroke Prevention in Patients With AF: A Systematic Review and Meta-Analysis," *Open Heart* 3, no. 1 (2016): e000279.

15. C. T. January, L. S. Wann, H. Calkins, et al., "2019 AHA/ACC/HRS Focused Update of the 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 Clinical Practice Guidelines and the Heart Rhythm Society in Collaboration With the Society of Thoracic Surgeons," *Circulation* 140, no. 2 (2019): e125–e151.

16. I. C. van Gelder, M. Rienstra, K. V. Bunting, et al., "2024 ESC Guidelines for the Management of Atrial Fibrillation Developed in Collaboration With the European Association for Cardio-Thoracic Surgery (EACTS) Developed by the Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology (ESC), With the Special Contribution of the European Heart Rhythm Association (EHRA) of the ESC. Endorsed by the European Stroke Organisation (ESO)," *European Heart Journal* 45, no. 36 (2024): 2214–3414.

17. P. Tveden-Nyborg, T. K. Bergmann, N. Jessen, U. Simonsen, and J. Lykkesfeldt, "BCPT 2023 Policy for Experimental and Clinical Studies," *Basic & Clinical Pharmacology & Toxicology* 133, no. 4 (2023): 391–396.

18. A. Pottegård, S. A. J. Schmidt, H. Wallach-Kildemoes, H. T. Sørensen, J. Hallas, and M. Schmidt, "Data Resource Profile: The Danish National Prescription Registry," *International Journal of Epidemiology* 46, no. 3 (2017): 798–798f.

19. M. Schmidt, S. A. J. Schmidt, J. L. Sandegaard, V. Ehrenstein, L. Pedersen, and H. T. Sørensen, "The Danish National Patient Registry: A Review of Content, Data Quality, and Research Potential," *Clinical Epidemiology* 7 (2015): 449.

Appendix A

Search String

‘Prescription type’ [Title/Abstract] OR ‘prescriber type’ [Title/Abstract] OR ‘provider type’ [Title/Abstract] OR ‘provider characteristic*’ [Title/Abstract] OR ‘prescriber characteristic*’ [Title/Abstract] OR ‘prescription characteristic*’ [Title/Abstract] OR ‘provider specialty’ [Title/Abstract] OR (‘Specialty’ [Title/Abstract] AND ‘Prescriber’ [Title/Abstract]).

Appendix B

Queries for AI Searching

1. How does the specialty of the prescriber impact the clinical outcomes for their patients?
2. Provide me studies that investigate the ‘type of prescriber’ as a covariate influencing patient outcome.
3. Are there any studies available that investigate certain drug outcomes and adjust for the ‘type of prescriber’?
4. Can you find similar studies that have adjusted for the specialty of prescriber? (While referring to a study)
5. Are there any literatures that have all-cause mortality as an outcome and adjust for different confounders/covariates, including the specialty of prescriber?
6. What is the correlation between the specialty of a prescriber and the patient's overall health outcomes?

Appendix C

Summary of Studies Included in the Literature Review

First author, country, year	Aim	Study design	Study population	Type of prescriber studied	Main findings
Kayser, J., United States, 2001	To determine differences in continuation in women treated with raloxifene versus systemic oestrogens	Cohort study	Women aged 60+ years who filled a prescription raloxifene or noninjectable systemic oestrogens from 1997 through 2000.	Gynaecologists, others	When adjusting for the type of prescriber, continuation was better for those prescribed by gynaecologists compared to others (not statistically significant).
Tian, Y., Austria, 2020	To compare the effects of branded versus generic medications on all-cause mortality and major adverse cardiac and cardiovascular events (MACCE).	Cohort study	9 413 620 patients aged 18+ years who filled a prescription for hyperlipidemia, hypertension/heart failure, diabetes mellitus from 2007 to 2021.	General practitioners, Internal medicine specialist, hospital, other	The results indicated that after adjusting for set of covariates including prescriber type, the mortality HR for branded drugs compared to generics changed significantly for antihypertensive, lipid-lowering and hypoglycaemic drugs.
Tvete, I.F., Norway, 2022	To examine monoamine oxidase (MAO-B) inhibitors and dopamine agonists initiation in patients and assessing survival over time.	Cohort study	21 047 patients aged 50+ years initiating monotherapy with MAO-B inhibitors or dopamine agonists from 2006 to 2016.	General practitioners, specialists	Patients who had a specialist as their first prescriber showed a lower mortality risk compared to those whose first prescriber was a general practitioner (statistically significant impact in the younger patient group).
Zhang, K., United States, 2006	To evaluate the relative risk of haemorrhage in patients treated with warfarin alone versus warfarin along with other drugs.	Cohort study	17.895 patients < 100 years of age treated with warfarin and drawn from 1.7 million health plan members managed by Caremark Rx, a pharmacy benefits manager.	Cardiologists, primary care practitioners, others	Compared to those whose first prescriber was a cardiologist, patients prescribed warfarin by primary care practitioners or other specialties had a higher risk of haemorrhage. Warfarin users who received prescriptions from multiple prescribers were at a higher risk of haemorrhage