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PHARMACOEPIDEMIOLOGY AND PRESCRIPTION

Physicians' and pharmacies' overview of patients' medication. An analysis of fidelity coefficients

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Abstract
Background It is essential that pharmacies and prescribers have an overview of each patient's medication in order to prevent drug interactions, unintentional co-prescribing, unnecessary polypharmacy and underprescribing. We have assessed this overview by measuring the 'fidelity coefficient', a measure of the extent to which a drug user has a preference for one prescriber or one pharmacy.
Methods and setting Data for all prescriptions issued for the population in Southern Denmark (population 1.2 million) in 2009 was extracted from the Odense University Pharmacoepidemiological Database (OPED). Analysis of the extracted data was then limited to persons with at least ten prescriptions within the year, resulting in 8,246,064 prescriptions issued to 283,388 individuals. For each individual, we identified the most used prescriber and calculated the proportion of all prescriptions accounted for by that prescriber (FC_{presc}). The individual user's most frequented pharmacy was also identified and the FC_{pharm} calculated in a similar fashion.
Results The average FC_{Presc} and average FC_{Pharm} were 0.883 (standard deviation 0.158) and 0.927 (0.139), respectively. The estimated difference was 0.0446 (95% confidence interval 0.0439–0.0453). Among the factors associated with a high FC_{presc} and high FC_{pharm} were older age, male gender and a high volume of prescriptions. The major drug classes that were most often prescribed by a non-main prescriber were beta-lactams, antidepressants and opioids. Similarly, the major drug classes associated with use of non-main pharmacy were beta-lactams, antidepressants and inhaled beta-agonists.
Conclusion Based on this analysis, both prescribers and pharmacies generally have an equal potential for maintaining an excellent overview of their patients' medication, but the pharmacies account for a slightly higher proportion of patients.

Keywords Pharmacy · Prescriber · Fidelity coefficient · Patient's medication · Overview

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Introduction

The risk of adverse drug reactions, polypharmacy, drug interactions and unintentional co-prescribing has become an increasingly problem as the intake of medicine also increases [1, 2]. The aim of many interventions is to decrease these adverse events, but to do so it is necessary to have an overview of the individual patient's medicine intake. However, several studies have revealed enormous discrepancies between the records of the general practitioner (GP), hospital admission papers, pharmacy records and the patient's own medicine cabinet [3–10].

Among elderly patients, the number of prescribing physicians is an independent risk factor for experiencing an adverse drug event [7, 11, 12]. A study by Gilchrist et al. in 1987 already revealed that up to two thirds of the medical records pertaining to a patient's drug history obtained from the GP were inaccurate [10]. It has since been repeatedly demonstrated that GP records [3, 5–7, 9] as well as hospital records [4, 5] and even patient reporting [4–6, 8] show major discrepancies when compared to more thorough medication reviews, with up to 25% of prescribed drugs being used without the GP's knowledge [3]. The

results of a Danish study suggest that the use of a nationwide database may prove to be the most accurate measure of actual drug use [4].

The two central players in this field are the prescriber and the pharmacy. We have attempted to assess their overview using the 'fidelity coefficient' (FC), a measure of which proportion of an individual patient's medication is accounted for by their most frequently used prescriber and pharmacy.

Materials and methods

Materials and setting

The data for this study was drawn from the Odense University Pharmacoepidemiological Database (OPED), which is a research database with full coverage of all reimbursed prescriptions in the Region of Southern Denmark (1.2 million inhabitants). The data included in each prescription record comprises the names of prescription holder, the prescriber and the pharmacy, the date of dispensing and a full account of the dispensed product, including substance, brand name, route of administration, Anatomical Therapeutic Chemical (ATC) classification code and defined daily dose (DDD) [13].

Some drugs are completely exempt from reimbursement and thus not covered by the database, including benzodiazepines, oral contraceptives, laxatives and certain antibiotics. Drugs with any degree of co-payment are covered by the database.

All prescriptions redeemed by citizens of the Region of Southern Denmark during 2009 were eligible for inclusion in the analysis.

Analysis

The analysis was restricted to individuals who had redeemed ten or more prescriptions during 2009. For each individual, we identified the prescriber who occurred most frequently on that individual's prescription list. We defined the prescriber fidelity coefficient, FC_{Presc}, as the proportion of an individual's redeemed prescriptions that were issued by the most frequent prescriber to that individual. Similarly, we defined the pharmacy fidelity coefficient, FC_{Pharm}, as the proportion of an individual's prescriptions that were redeemed at the most frequently used pharmacy. Unless otherwise stated, the FC_{Pharm} and FC_{Presc} are interpreted as a characteristic of a specific person; for example, when calculating the average FC_{Pharm}, we calculated the average value for FC_{Pharm} for all individual subjects in the study.

The FC_{Presc} and FC_{Pharm} are presented using standard descriptive statistics. We also explored the dependency of FC_{Presc} and FC_{Pharm} on such variables as age, gender, number of prescriptions, whether the most frequent prescriber was a GP, whether the main pharmacy had more than one dispensing site and whether the most used pharmacy was urban. Urban pharmacies were defined as those located in the Odense or Esbjerg municipalities (186,000 and 115,000 inhabitants, respectively) or those which had the same zip-code as another pharmacy. These associations were analysed using two linear regression models, one with FC_{Presc} as the dependant variable and one with FC_{Pharm} as the dependant variable. Data from the following individuals were excluded from this part of the analysis: (1) all individuals who had two or more pharmacies sharing the 'preferred' position where at least one was near a competitor and at least one was not (n=2246); (2) all individuals who showed equal preference for both a GP and a non-GP among the preferred prescribers (n=1,779).

The proportion of prescriptions either issued by a non-main prescriber or redeemed at a non-main pharmacy was categorised according to the major drug classes. We grouped the drug classes according to the third level of the ATC code (e.g. M01A = nonsteroidal anti-inflammatory drugs (NSAIDs)). Only groups with more than 50,000 prescriptions (covering 88.7% of the data) were reported. Finally, the proportion of prescriptions issued by a non-main prescriber or redeemed at a non-main pharmacy as a function of the month was determined, which enabled the construction of a seasonality curve for FC_{Presc} and FC_{Pharm}.

Results

A total of 10,067,798 prescriptions issued to 853,217 different individuals were extracted from the OPED in 2009. After restricting the data selection to individuals with ten or more prescriptions during 2009, we obtained 8,246,064 prescriptions issued to 283,388 individuals (121,734 (42.8%) men). The median age of the study cohort was 64 years (interquartile range 52–75 years).

The average FC_{Presc} and average FC_{Pharm} were 0.882 (standard deviation 0.158) and 0.927 (0.139), respectively. The average difference was 0.0446 (95% confidence interval 0.0439–0.0453). There were 116,918 persons (41.2%) with an FC_{Presc} of 1.00 and 182,030 (64.2%) individuals with an FC_{Pharm} of 1.00. Of those, 91,665 (32.3%) had a value of 1.00 for both parameters. The FC_{Pharm} was higher than the FC_{Presc} for 126,585 persons (44.7%), while the reverse pattern was observed for 50,640 persons (17.7%). There were 1,683 unique main prescribers and 242 unique main pharmacies.

Among the variables that were found to be significantly associated with high FC_{Pharm} were an older age, male gender, high volume of prescriptions, main pharmacy

Table 1 The dependency of the pharmacy fidelity coefficient on explanatory variables

Base FC_{Pharm}	0.838 [0.836–0.839]
Age[a]	0.018 [0.017–0.018]
Male gender	0.011 [0.010–0.012]
Number of prescriptions[b]	0.003 [0.003–0.003]
Main pharmacy near competing pharmacy[c]	−0.053 [−0.053 to −0.052]
Main pharmacy having more than one dispensing site	0.006 [0.005–0.007]

FC_{Pharm}, Pharmacy fidelity coefficient: proportion of an individual's prescriptions that were redeemed at the most frequently used pharmacy

Data are given as the FC_{Pharm}, with the 95% confidence interval (CI) given in parenthesis

[a] The influence of age over FC_{Pharm} is given as the change per 10 years

[b] The influence of number of prescriptions over FC_{Pharm} is given as the change per 10 prescriptions

[c] The classification of 'nearby pharmacies' is given in the Materials and methods section

having more than one dispensing site and the use of a pharmacy with no competing pharmacies nearby (Table 1). The use of a pharmacy near a competitor was associated with a 0.053 lower FC_{Pharm} than the use of other pharmacies. When the analysis was restricted to only pharmacies near a competitor, the crude FC_{Pharm} was 0.894. The variables associated with high FC_{Presc} was older age, male gender, high number of prescriptions and use of a GP as the main prescriber (Table 2). The dependency of FC_{Pharm} and FC_{Presc} on age and sex is shown in Fig. 1. Figure 2 shows the seasonality of both measures.

The major drug classes that were most often prescribed by a non-main prescriber were beta-lactams, antidepressants and opioids. Similarly, the major drug classes associated with use of non-main pharmacy were beta-lactams, antidepressants and adrenergics (inhalants) (Table 3).

Table 2 The dependency of the prescriber fidelity coefficient on explanatory variables

Base FC_{Presc}	0.627 [0.625–0.630]
Main prescriber being a general practitioner	0.200 [0.198–0.202]
Age[a]	0.012 [0.011–0.012]
Male gender	0.002 [0.001–0.003]
Number of prescriptions[b]	0.002 [0.002–0.002]

FC_{Presc}, Prescriber fidelity coefficient: proportion of an individual's redeemed prescriptions that were issued by the most frequent prescriber to that individual

Data are given as the FC_{Presc}, with the 95% confidence interval (CI) given in parenthesis

[a] The influence of age over FC_{Pharm} is given as the change per 10 years

[b] The influence of number of prescriptions over FC_{Pharm} is given as the change per 10 prescriptions.

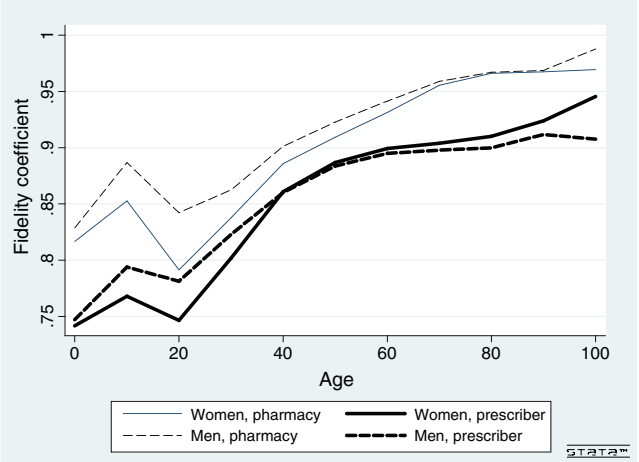

Fig. 1 The dependency of the fidelity coefficient on age and sex

Discussion

The average FC_{Pharm} and average FC_{Presc} were 0.927 and 0.882, respectively. Thus, there is a slightly higher fidelity towards the pharmacy than towards the main prescriber. However, both have the possibility to have an excellent overview of their clients' medication. The actual overview also depends on factors such as the structure and the interface of the IT-solutions used by the prescriber and the pharmacies and the training of the prescribers and pharmacist. Also, our analysis is based on the actual dispensing of drugs; therefore, we have no means of assessing to which

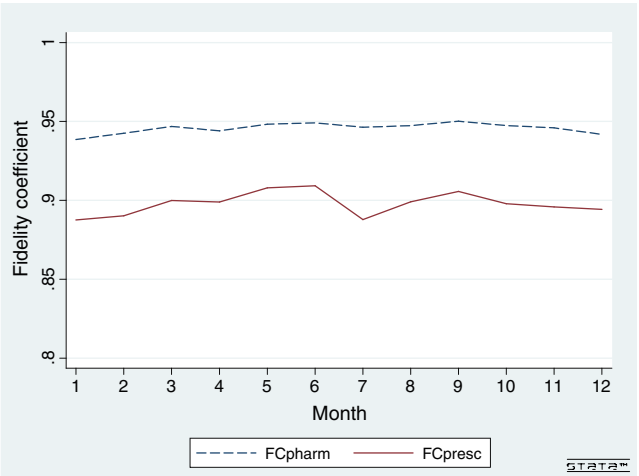

Fig. 2 Season variability of the fidelity coefficient (FC). FC_{Presc} proportion of an individual's redeemed prescriptions that were issued by the most frequent prescriber to that individual, FC_{Pharm}proportion of an individual's prescriptions that were redeemed at the most frequently used pharmacy

Table 3 The major drug classes to be prescribed by other than main prescriber and redeemed at other than main pharmacies

ATC	ATC-text	Total number of prescriptions	Prescriptions redeemed at a pharmacy other than the main pharmacy[a]	Prescriptions issued by a prescriber other than the main prescriber[a]
B01A	Antithrombotic agents	545,541	6.42 (35,021)	3.26 (17,784)
N06A	Antidepressants	531,388	8.68 (46,126)	5.57 (29,622)
N02A	Opioids	449,645	8.87 (39,888)	5.42 (24,353)
C10A	Cholesterol and triglyceride reducers	409,749	6.31 (25,851)	3.78 (15,503)
N02B	Non-opioid analgesics and antipyretics	392,559	4.82 (18,923)	3.51 (13,774)
R03A	Adrenergics, inhalants	355,135	7.96 (28,282)	7.03 (24,957)
A02B	Drugs for peptic ulcer and gastro-oesophageal reflux disease	343,252	8.27 (28,381)	4.98 (17,077)
M01A	Anti-inflammatory and antirheumatic products, non-steroids	327,479	8.86 (29,016)	6.55 (21,465)
C07A	Beta blocking agents	319,839	6.83 (21,839)	3.68 (11,775)
C09A	ACE inhibitors, plain	272,042	6.32 (17,187)	4.00 (10,887)
C08C	Selective calcium channel blockers with mainly vascular effect	250,901	6.39 (16,031)	3.90 (9,795)
A10B	Oral blood glucose lowering drugs	247,964	6.25 (15,500)	4.33 (10,735)
N05A	Antipsychotics	232,120	13.18 (30,586)	4.42 (10,265)
C03C	High-ceiling diuretics	213,882	6.01 (12,846)	2.54 (5,423)
J01C	Beta-lactam antibacterials, penicillins	210,077	31.28 (65,710)	15.29 (32,127)
C03A	Low-ceiling diuretics, thiazides	207,753	4.93 (10,241)	3.63 (7,547)
N03A	Antiepileptics	199,453	10.69 (21,322)	5.25 (10,467)
A12B	Potassium	170,159	5.45 (9,271)	2.68 (4,568)
R03B	Other drugs for obstructive airway diseases, inhalants	157,373	8.04 (12,654)	6.46 (10,162)
A10A	Insulins and analogues	144,746	15.68 (22,693)	6.23 (9,024)
C09C	Angiotensin II antagonists, plain	114,579	6.85 (7,848)	4.38 (5,017)
G03C	Oestrogens	100,345	11.68 (11,721)	6.67 (6,688)
H03A	Thyroid preparations	87,781	6.39 (5,611)	4.84 (4,249)
S01E	Antiglaucoma preparations and miotics	84,547	43.24 (36,562)	6.56 (5,547)
R06A	Antihistamines for systemic use	81,832	10.7 (28,773)	8.02 (6,560)
D07A	Topical corticosteroidss, plain	81,743	21.03 (17,189)	9.17 (7,495)
C09D	Angiotensin II antagonists, combinations	80,269	5.45 (4,376)	4.35 (3,489)
H02A	Corticosteroids for systemic use, plain	77,459	16.56 (12,828)	7.95 (6,156)
C09B	ACE inhibitors, combinations	73,710	5.57 (4,107)	4.43 (3,262)
R01A	Decongestants and other nasal preparations for topical use	72,413	21.84 (15,818)	10.33 (7,483)
M05B	Drugs affecting bone structure and mineralisation	68,863	6.66 (4,585)	3.16 (2,173)
N02C	Antimigraine preparations	68,245	8.08 (5,512)	11.15 (7,612)
C01A	Cardiac glycosides	64,522	5.75 (3,711)	2.75 (1,774)
C01D	Vasodilators used in cardiac diseases	59,812	7.22 (4,319)	2.97 (1,776)
N04B	Dopaminergic agents	57,270	12.26 (7,024)	3.81 (2,184)
G04B	Other urologicals, incl. antispasmodics	52,594	11.40 (5,997)	5.15 (2,708)
J01F	Macrolides, lincosamides and streptogramins	52,457	23.26 (12,202)	14.43 (7,571)
G04C	Drugs used in benign prostatic hypertrophy	52,377	9.87 (5,169)	3.74 (1,957)

ATC, Anatomical Therapeutic Chemical (ATC) classification code

The data have been sorted by number of prescriptions. Only groups with more than 50,000 prescriptions are included (covering 88.7% of our data)

[a] Data on prescriptions are given as the percentage with the number of prescriptions given in parenthesis

extent the main prescriber is made aware of the prescriptions issued by specialists or other doctors to his patients.

The primary strength of the study is the high internal validity due to a high quality of the prescription data [13]. In addition, there is little selection bias since all residents of Region of Southern Denmark were included in the analysis. The primary weakness of the study is that the FC_{Pharm} and FC_{Presc} are to a large extent determined by the underlying healthcare structure. Our results may thus not necessarily be equally applicable to another setting.

There are several factors in our setting that would favour a high FC_{Pharm} over the FC_{Presc}. First, pharmacies in Denmark are large units, often covering a substantial area, especially in comparison with the average pharmacy found, for example, in southern Europe. There are 56 community pharmacies in the region covered in this analysis, corresponding to a density of one pharmacy per 21,400 citizens. It is noteworthy, however, that the FC_{Pharm} only shows a minor dependency on having multiple pharmacies nearby (Table 1). Furthermore, many doctors are specialists and thus only responsible for prescribing a minor part of a patient's total medication. Other factors favour the FC_{Presc} over the FC_{Pharm}. Pharmacies are completely liberalised in Denmark and patients are therefore free to choose between pharmacies. In contrast, each citizen is assigned a regular GP who serves as a gate keeper, which means that all medical contacts, excluding emergencies, should go through the assigned GP. Although it is possible to change GP, this happens relatively rarely. There is also a tendency in Denmark among GPs to form larger units consisting of several GPs under the same roof and using the same prescriber identifier. As such, the single prescriber ID in our analysis can cover more than one individual prescriber. As these prescribers can see each other's prescribing to the individual patient within the group practice , they have the opportunity to avoid such problems that relate to multiple prescribers. Also, repeat prescriptions were registered as multiple single prescriptions in our analyses, even though they only represent a single prescription decision. By definition, repeat prescriptions are issued by the same prescriber, but not necessarily redeemed at the same pharmacy, which is also a factor that would favour a high FC_{Presc} relative to the FC_{Pharm}. Finally, GPs frequently take over the prescribing of specialised drug regimes as soon as the medication is stable. Consequently, the fidelity coefficient is highly dependent on the healthcare structure. Most of the factors in our setting point towards a higher FC_{Presc} than FC_{pharm}. It is therefore surprising that the results of our analysis reveal a FC_{Pharm} greater than the FC_{Presc}.

Our analysis in Table 3 shows that antibiotics account for most of the infidel prescriptions, a result which is hardly surprise. It is more interesting to note that the groups of 'antidepressants', 'antipsychotics' and 'antithrombotic agents' were so highly represented. These three groups are known to often represent long-term treatments and also show a wide range of possibly dangerous drug–drug interactions, especially with respect to antithrombotic agents [14]. Combining the numbers for these three groups revealed that while 111,733 of these prescriptions were prescribed by others than the most used prescriber, only 57,671 were redeemed at a pharmacy other than the most frequently used pharmacy. While both numbers are higher than desired, this results emphasises the central role of the pharmacy in identifying and preventing drug–drug interactions.

The importance of the fidelity coefficient for monitoring medication profiles with the aim of avoiding doubling of prescriptions or adverse drug interactions is most obvious in a setting where data on the medication of an individual are not readily available for the healthcare practitioner. This is still the case in most countries. In Denmark, each redemption of a prescription is registered, but no complete list of 'current treatment' is produced for routine care. This will probably change in the coming years ash new IT-solutions appear [15].

Several questions arise from this study. First, it would be interesting to explore how the 'fidelity coefficient' differs across different populations and different healthcare models. It might even be possible, through subsequent studies, to link the 'fidelity coefficient' to other parameters, such as adverse drug event rates, on a population scale. Lastly, the 'fidelity coefficient' could be used as a tool to refine future population-based analyses, for example, by having a high fidelity as an exclusion or inclusion criteria.

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