BCPT Basic & Clinical Pharmacology & Toxicology

Basic & Clinical Pharmacology & Toxicology Doi: 10.1111/bcpt.12610

Validity of the Prescriber Information in the Danish National Prescription Registry

Lotte Rasmussen[1], Julie Valentin[1], Katarina Margareta Gesser[2], Jesper Hallas[1] and Anton Pottegård[1]

[1]Clinical Pharmacology and Pharmacy, Department of Public Health, University of Southern Denmark, Odense, Denmark and [2]Department of Data Delivery & Medicinal Product Statistics, The Danish Health Data Authority, Copenhagen, Denmark

(Received 23 December 2015; Accepted 5 April 2016)

Abstract: The aim of this study was to measure the validity of the prescriber information recorded in the Danish National Prescription Registry (DNPR). The prescriber information recorded in the pharmacies' electronic dispensing system was considered to represent the prescriber information recorded in the DNPR. Further, the problem of validity of the prescriber information pertains only to non-electronic prescriptions, as these are manually entered into the dispensing system. The recorded prescriber information was thus validated against information from a total of 2000 non-electronic prescriptions at five Danish community pharmacies. The validity of the recorded prescriber information was measured at the level of the individual prescriber and the prescriber type, respectively. The proportion of non-electronic prescriptions with incorrect registrations was 22.4% (95% confidence interval (CI): 20.6–24.3) when considering individual prescriber identifiers and 17.8% (95% CI: 16.1–19.5) when considering prescriber type. When excluding prescriptions specifically registered as 'missing prescriber identifier', the proportions decreased to 9.5% (95% CI: 8.2–11.0) and 4.1% (95% CI: 3.2–5.1), respectively. The positive predictive values for the classification of prescriber types were in the range of 94.0–99.2%, while the sensitivity ranged between 64.6% and 91.8%. With a maximum of 14% non-electronic prescriptions of all prescriptions in the DNPR in 2015, this corresponds to correct classification of prescriber types in the DNPR of at least 97.5%. In conclusion, the prescriber information in the DNPR was found to be valid, especially in recent years. Researchers should be aware of the low sensitivity towards prescriptions from private practicing specialists.

The Danish National Prescription Registry (DNPR) constitutes a unique data source that has been widely used in Danish pharmacoepidemiological research ever since it was made accessible to researchers in 2003 [1]. The DNPR contains several variables describing the single drug purchase since 1995, including the person-identifier, the date of purchase, the substance and the amount of drug dispensed [1].

One of the variables included in the DNPR is a prescriber variable that designates the prescriber via a unique prescriber identifier [2], also referred to as the 'provider number' (in Danish: ydernummer). Information from this variable can, for example, be used to differentiate prescriptions issued by specialists from those issued by general practitioners. This is useful when assessing the extent to which clinical treatment guidelines are followed [3] or when analysing patterns indicative of doctor shopping or misuse [4].

While the application of this variable holds great potential in drug utilization studies, the validity has been questioned by those responsible for the registry [2]. The potential issue of the validity of the prescriber variable pertains only to non-electronic prescriptions, as electronic prescriptions automatically transfer the correct prescriber identifier to the electronic dispensing systems (EDSs) at the pharmacies. In a Danish, non-peer-reviewed assessment from 2008, it was reported that the prescriber variable was incorrectly recorded in 11% of non-electronic prescriptions [2].

We undertook this study to validate the prescriber information recorded in the DNPR.

The Danish Setting

The prescriber variable.

The Register of Medicinal Product Statistics (RMPS) [1], currently maintained by the Danish Health Data Authority, contains data on sale of medicinal products in Denmark since 1994 [5]. The DNPR is a subregister within the RMPS, which holds complete and nationwide data on all prescriptions filled by Danish citizens at community pharmacies since 1995 [1]. Via linkage with the CPR number – a unique identifier assigned to all Danish residents [6] – it is possible to outline a person's prescription history over time. Prescription data in the DNPR include information on the dispensed drug, date of dispensing, dispensed quantity and a prescriber variable [1].

The prescriber variable has been recorded in the DNPR since 1995 [1,7] and is a unique identifier designating the prescriber practice by use of the 'provider number' or designating the hospital department by use of the hospital department number. The provider number and the hospital department number are in our study collectively referred to as the prescriber identifier as these are both covered by the same variable in the DNPR. Importantly, the prescriber identifier does not necessarily refer to a single prescriber; it refers to a single-practice unit, for example a general practitioner practice or

Author for correspondence: Lotte Rasmussen, Clinical Pharmacology, Department of Public Health, University of Southern Denmark, J.B. Winsløws Vej 19, 2., 5000 Odense C, Denmark (e-mail lorasmussen@health.sdu.dk).

a private practicing specialist practice, with either one or with multiple physicians or a hospital department. Importantly, a prescriber identifier can only cover identical prescriber types. The variable does not in itself contain information on the type of prescriber, i.e. general practitioners, hospital doctors or private practicing specialists. However, via linkage with data on prescriber identifiers from other sources, it is possible to identify the prescriber type. Via linkage to the Registry of Health Providers [8], it is possible to classify the prescriber identifiers into those belonging to general practitioners and private practicing specialists. Likewise, by linking the prescriber variable with a list of hospital identifiers currently available from the SHAK classification [9], it is possible to identify the prescriber identifiers belonging to hospital departments. When identifying hospital prescribers, only the four initial digits of the identifier (identifying the individual hospital) should be used, as the last three digits (designating the specific hospital department) are rarely recorded at the pharmacy as it is often not stated on the prescription [10]. When classifying prescriber types, researchers should take care to identify those prescriptions recorded with 'missing prescriber identifier' in the DNPR (further described below). In a given project, the Research Services unit from either Statistics Denmark or the Danish Health Data Authority can assist in this process. For a schematic overview of the linkage, see table 1.

Registration of prescriptions at Danish pharmacies. All pharmacies are required by law to report data every month on filled prescriptions on the level of the individual patient to the RMPS [1,5]. Transfer of data is automated, based on the information recorded in the pharmacies' EDSs.

In Denmark, prescriptions can be either electronic or non-electronic. At the pharmacies, the EDS receive electronic prescriptions directly from the prescribing physicians' computer. For electronic prescriptions, the prescriber identifier is thus expected to be almost perfectly registered in the EDS and thereby in the RMPS.

For non-electronic prescriptions, the prescriber identifiers must be manually registered into the EDS by the pharmacy staff, potentially resulting in incorrect registrations of prescriber identifiers. Furthermore, the prescriber identifier may not be included or legible on the prescription or the prescriber may not have an assigned prescriber identifier, in which case the pharmacy staff may choose to register it as 'missing prescriber' by typing in a pre-specified identifier in the EDS indicating missing prescriber identifier (table 1). The pharmacies are not obliged to validate their own registrations reported to the RMPS and do not have access to validation via files on prescriber identifiers.

In the DNPR, it is not possible to differentiate between non-electronic and electronic prescriptions, and while no systematic data are available on the proportion of prescriptions filled at Danish pharmacies that are electronic *versus* non-electronic, it is generally accepted that the share of non-electronic prescriptions is decreasing. In 2009, the proportion of non-electronic prescriptions out of all prescriptions was approximately 50% [11], while in 2014 this was approximately 20% [unpublished data from the National eHealth Authority].

Materials and Methods

To validate the prescriber information in the DNPR, we manually reviewed the prescriber information from a total of 2000 non-electronic prescriptions. This information was compared to the information recorded in pharmacies' EDS, which represents the information that would appear in the DNPR. Based on the validity for non-electronic prescriptions, we estimated the overall validity of the prescriber information in the DNPR.

Data collection and validation. The study was conducted in March 2015 at five community pharmacies, one in each of the five Danish regions. At each pharmacy, we collected the 400 most recently filled non-electronic prescriptions. From the prescriptions, we extracted (i) the prescriber identifier, (ii) the type of prescriber and (iii) the anatomical therapeutic chemical (ATC) classification code [12] of the first appearing drug. We classified the type of prescriber into six categories: general practitioners (including on-call general practitioners), practicing specialists, hospital doctors, dentists, others and unidentifiable prescribers. Prescribers were classified as others when the type of prescriber could not be determined based on the prescriber identifier but the identifier was valid. Prescribers were classified as unidentifiable when the prescriber identifier on the prescription could not be verified.

Table 1.
Schematic overview of the linkage between prescriber identifiers and the Registry of Health Providers/the SHAK classification. Obtained from [2].

Prescriber identifier	Healthcare sector	Prescriber type	Linkage
0000010–0989999*	Primary sector	General practitioners, private practicing specialists.	Linking the prescriber identifier with the Registry of health providers will provide information on medical specialty (e.g. general practitioners *versus* private practicing specialists).
0990027 4600000 4700000	Primary sector	Missing prescriber identifiers	
1301011–9999999*	Secondary sector	Hospital prescribers	Linking the first four digits (e.g. 1301) with the SHAK classification will identify the specific hospital to which the prescriber belongs.
0990027 0994057 0990019	Secondary sector	Missing prescriber identifiers	

*Here reported as a range.

Finally, the prescriber identifier and the prescriber type identified through the manual review were compared to the information recorded in the EDS. In the EDS, prescribers were classified as missing prescribers when the pharmacy staff had entered a pre-specified identifier indicating missing prescriber identifier.

Outcome. Our main outcome was the proportion of prescriptions with incorrect registration of the prescriber information in the EDS. This was assessed both regarding the correctness of the specific prescriber identifier and the prescriber type, as the type of prescriber could still be correct despite an incorrectly specified prescriber identifier. The proportion of prescriptions with incorrectly registered prescriber information was calculated both overall and when excluding prescriptions recorded with a missing prescriber identifier in the EDS.

To assess the distribution of incorrectly registered prescriber information according to prescriber type and to assess the positive predictive value (PPV) and sensitivity among non-electronic prescriptions, we stratified the number of prescriptions with incorrectly registered prescriber information by prescriber types (as registered in the EDS).

Lastly, to assess whether some drug classes were associated with a higher or lower degree of accuracy in recording of the prescriber information, we also stratified our results by the first level of the ATC code (i.e. organ system affected by the drug) [13].

Narcotic substances. We hypothesized that the prescriber information in non-electronic prescriptions for narcotic substances would be registered with a higher degree of accuracy as such prescriptions include substances that are under control by the Danish authorities. Therefore, as a supplementary analysis, we collected the most recently filled non-electronic prescriptions for narcotic substances dispensed within 6 months before the date of data collection but with an upper limit of 50 prescriptions. Narcotic substances included drugs listed as 'substances under control' in Denmark [14].

Statistical analysis. Results were presented with 95% confidence intervals (95% CI) under the assumption of a binomial distribution. All calculations were performed using STATA Release 13.0 (StataCorp, College Station, TX, USA).

Approvals and ethics. Ethics committee approval was not required. The study was approved by the Danish Data Protection Agency.

Results

From a total of 2000 non-electronic prescriptions (table 2), we identified 448 prescriptions with incorrectly registered prescriber identifier in EDS and 355 prescriptions with incorrectly registered prescriber type. This corresponded to 22.4% (95% CI: 20.6–24.3) of prescriptions having an incorrectly registered prescriber identifier and 17.8% (95% CI: 16.1–19.5) prescriptions with an incorrectly registered prescriber type. When disregarding prescriptions registered in the EDS with missing prescriber identifier (n = 285; 14.3%), these proportions decreased to 9.5% (95% CI: 8.2–11.0) and 4.1% (95% CI: 3.2–5.1), respectively.

The distribution of incorrectly registered prescriber types and prescriber identifiers according to prescriber types, based on registrations in EDS, is displayed in table 3. Based on registrations in EDS, registration of a prescription as being prescribed by a general practitioner had a PPV of 94.0% and a sensitivity of 91.8%. For hospital doctors, we found a PPV of 95.0% and a sensitivity of 87.7%, and for practicing specialists, we found a PPV of 99.2% and a sensitivity of 64.6% (table 3).

Table 2.
Distribution of prescriber types.

Type of prescriber	Non-electronic prescriptions N = 2000
Type of prescriber	
General practitioner	706 (35.3%)
Practicing specialist	181 (9.0%)
Hospital doctor	431 (21.6%)
Dentists	542 (27.1%)
Other	117 (5.9%)
Unidentifiable prescriber type	23 (1.1%)
No prescriber identifier at the prescription	335 (16.8%)
Missing prescriber identifier in EDS	285 (14.3%)

EDS, electronic dispensing system.

The supplementary analysis for narcotic substances was based on 236 non-electronic prescriptions. Overall, the prescriber validity was slightly lower for these prescriptions, but with higher sensitivity for private practicing specialists (93.3% compared to 64.6% in the main analysis) (Table S1 and S2).

Categorization by prescribed drug, i.e. first level of the ATC code, showed a slightly higher rate of incorrect registration for prescriptions for drugs within the respiratory system, the nervous system, antiparasitic products, insecticides and repellents and drugs within the sensory organs. When we excluded prescriptions with missing prescriber identifier, this mainly concerned drugs related to blood and blood-forming organs and antineoplastic and immunomodulating agents (Table S3).

To estimate the overall validity of the prescriber information in the DNPR, we performed an exploratory analysis based on the estimated validity for non-electronic prescriptions and assuming perfect validity for electronic prescriptions. We conservatively assumed a linear increase in the proportion of electronic prescriptions, starting at 50% in year 2009 and rising to 80% in year 2014. From fig. 1, it is observed that a validity of >90% of the prescriber type would be achieved around year 2009 and a >95% validity achieved during year 2013. Assuming 14% non-electronic prescriptions in 2015, this corresponds to correct classification of prescriber types in at least 97.5% of prescriptions. For individual prescriber practice identifiers, the corresponding estimates of validity would be >88% in year 2009 and >94% in year 2013. In 2015, this corresponds to correct classification of prescriber identifiers in at least 96.9% of all prescriptions.

Discussion

To our knowledge, this is the first comprehensive study assessing the validity of the prescriber information in the DNPR. Based on the validity of non-electronic prescriptions, we achieved an overall validity of 97.5% for registration of prescriber types and 96.9% for registration of the prescriber

Table 3.
Registrations of prescriber information stratified by prescriber type as recorded in the electronic dispensing system (EDS).

	EDS				
Manual review	GP N = 689	HP N = 398	SP N = 118	Missing prescriber N = 285	Other N = 510
GP N = 706	94.0% (n = 648)	1.5% (n = 6)	0.0% (n = 0)	18.2% (n = 52)	0.0% (n = 0)
HP N = 431	1.7% (n = 12)	95.0% (n = 378)	0.8% (n = 1)	13.3% (n = 38)	0.4% (n = 2)
SP N = 181	1.2% (n = 8)	0.5% (n = 2)	99.2% (n = 117)	18.6% (n = 53)	0.2% (n = 1)
Other N = 682	3.0% (n = 21)	3.1% (n = 12)	0.0% (n = 0)	49.8% (n = 142)	99.4% (n = 507)*
Incorrect registration					
Prescriber identifier N = 448	21.4% (n = 96)	10.3% (n = 46)	0.2% (n = 1)	63.6% (n = 285)	4.5% (n = 20)
Prescriber type N = 355	11.5% (n = 41)	5.6% (n = 20)	0.3% (n = 1)	80.3% (n = 285)	2.3% (n = 8)

GP, general practitioner; HP, hospital doctor; SP, practicing specialist.
'Missing prescriber' includes prescriptions with missing prescriber identifier.
'Other' includes dentists, unidentifiable prescribers and other (from table 1).
*Five of 507 prescriptions were categorized incorrectly within this aggregated category (e.g. dentist being misclassified as other, etc.)

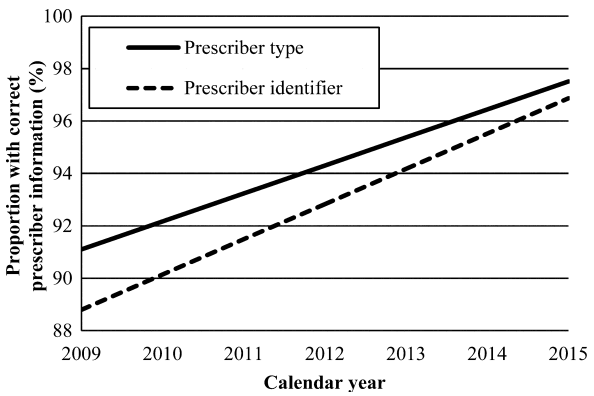

Fig. 1. Overall validity of the prescriber information in the Danish National Prescription Registry. The validity is shown as a function of the calendar time under the assumption of a linear increase in electronic prescriptions starting at 50% in year 2009 [11] and reaching 80% in year 2014 [unpublished data from the National eHealth Authority].

identifier. We found high PPVs for the classification of prescriber types but with lower values of sensitivity, especially for private practicing specialists.

Our study has several strengths. Firstly, we collected a large sample of non-electronic prescriptions at five different pharmacies. Thus, we are confident that our sample is representative and that our results are generalizable to other Danish pharmacies and thereby to the general validity of the prescriber information in the DNPR. Secondly, we collected the prescriptions retrospectively, and awareness of data collection at each pharmacy did therefore not lead to bias, that is by increasing awareness of correct registration of the prescriber information.

We observed that approximately 22% of non-electronic prescriptions were registered with an incorrect prescriber identifier. A Danish, non-peer-reviewed assessment from 2008, based on 3248 non-electronic prescriptions collected at 33 pharmacies, reported that the pharmacy staff incorrectly registered the prescriber identifier in 11% (n = 363) of non-electronic prescriptions, while the physician did not list the prescriber identifier in 7% (n = 240) of prescriptions [unpublished data from the Danish Health Authority]. The total estimate of incorrectly registered prescriber identifier (19%) is therefore slightly lower than what we observed in our study. While the methodology applied in this assessment is insufficiently accounted for, several factors may explain the difference. Firstly, the prescribers might more often omit their identifier, as we observed that 17% of the prescriptions did not contain a prescriber identifier compared to 7% in the previous assessment. Secondly, the proportion of non-electronic prescriptions has decreased markedly since 2008, raising the possibility that the most error-prone prescriptions now remain (e.g. prescriptions issued by telephone).

Contrary to our hypothesis, we observed that prescriptions for narcotic substances were registered with a slightly lower degree of accuracy than other prescriptions. We generally observed only minor variations in the accuracy of registration of prescriber information when stratifying by type of prescribed drug. Prescriptions for acute conditions, for example antibiotics or analgesics, or drugs mainly used in specialized care, for example psychotropics, may more often be prescribed by a prescriber different from the general physician. As a result, the pharmacy staff may forget to change the prescriber identifier in EDS, thus resulting in incorrect registration of the prescriber information. This might explain the minor variations observed.

Based on the validity of non-electronic prescriptions, we were able to estimate the overall validity of the prescriber information in the DNPR, not only limiting this to non-electronic prescriptions. We based our estimated validity on the assumption of a linear decrease in the proportion of non-electronic prescriptions starting at 50% in 2009 and reaching 20% in 2014. While the assumption of a linear decrease cannot be validated, our assumptions are generally conservative with an assumed proportion of 14% non-electronic prescriptions in 2015. We therefore believe that our results reflect a high validity of the prescriber information in the DNPR (fig. 1). However, the validity is highly dependent on calendar time, and in studies using prescription data prior to 2009, the validity estimates for non-electronic prescriptions only (see results)

might be used as a conservative estimate of the overall validity.

Our study revealed high PPVs, for the classification of each prescriber type. As such, when a prescription is classified as a specific prescriber type in the DNPR, the researcher can be confident that this is correct. However, our study also revealed somewhat lower sensitivities, especially for the classification of prescriptions prescribed by private practicing specialists. Among the non-electronic prescriptions, only 65% of prescriptions from private practicing specialists are registered as such in the DNPR. Importantly, this is an underestimate of the true sensitivity, as the electronic prescriptions, which are increasingly common, can be assumed correctly recorded. Unfortunately, the distribution of electronic *versus* non-electronic prescriptions among different prescriber types is unknown. Assuming that the proportion of non-electronic prescriptions among private practicing specialists is relatively high, one may need to consider the potential lack of sensitivity for this prescriber type.

Approximately 14% of the non-electronic prescriptions had 'missing prescriber identifier' registered by the pharmacy staff in EDS. While nearly one-third of prescriptions from private practicing specialists were registered as 'missing prescriber identifier', this proportion was substantially lower for prescriptions prescribed by general practitioners (one in seven) and hospital doctors (one in nine). This largely explains the variation in sensitivity comparing the different prescriber types.

In conclusion, the prescriber information in the DNPR can be considered valid, especially when considering prescriber type instead of single prescriber identifiers. Researchers should be aware that the validity is dependent on calendar time, with higher validity in recent years. Further, researchers should be aware of the low sensitivity towards prescriptions issued by private practicing specialists.

Acknowledgements

The authors wish to thank Copenhagen Sønderbro Pharmacy, Ringsted pharmacy, Albani Pharmacy, Horsens Søndergades Pharmacy and Budolfi Pharmacy Aalborg for their participation in this study. The authors also wish to thank Sct. Nicolai Pharmacy in Svendborg for letting us conduct a small pilot study prior to the final study.

Disclosure statement

The authors declare that there is no conflict of interest.

References

1 Wallach Kildemoes H, Toft Sorensen H, Hallas J. The Danish national prescription registry. Scand J Public Health 2011;**39**:38–41.

2 Statistics Denmark. [Handbook for data in the Register of Medicinal Product Statistics] (in Danish) [Internet]. http://www.dst.dk/~/media/Kontorer/13-Forskning-og-Metode/LMDB%20H%C3%A5ndbog%202014.pdf (last accessed on 24 September 2014).

3 Pottegård A, Bjerregaard BK, Glintborg D, Hallas J, Moreno SI. The use of medication against attention deficit hyperactivity disorder in Denmark: a drug use study from a national perspective. Eur J Clin Pharmacol 2012;**68**:1443–50.

4 Rasmussen L, Zoëga H, Hallas J, Pottegård A. Deviant patterns of methylphenidate use in adults: a Danish nationwide registry-based drug utilization study: deviant use of methylphenidate in Denmark. Pharmacoepidemiol Drug Saf 2015; **24**:1189–96.

5 The Danish State Serum Institute. Register of Medicinal Product Statistics [Internet]. http://www.ssi.dk/English/HealthdataandICT/Health%20data/Registries/Register%20of%20Medicinal%20Products%20Statistics.aspx (last accessed on 1 July 2015).

6 Pedersen CB, Gøtzsche H, Møller JØ, Mortensen PB. The Danish civil registration system. Dan Med Bull 2006;**53**:441–9.

7 The Legal Information Division. [The act on reporting of information to the Register of Medicinal Product Statistics] (in Danish) [Internet]. https://www.retsinformation.dk/Forms/R0710.aspx?id=46522 (last accessed on 1 December 2015).

8 The Danish State Serum Institute. [The Provider Registry] (in Danish). [Internet]. [cited 2015 Jul 14]; http://www.ssi.dk/pdf.ashx?title=Yderregisteret&url=http%3A%2F%2Fwww.ssi.dk%2FSundhedsdataogit%2FRegistre+og+kliniske+databaser%2FDe+nationale+sundhedsregistre%2FPersonoplysninger+sundhedsfaglig+beskeaftigelse%2FYderregisteret.aspx%3Fpdf%3D1 (last accessed on 14 July 2015).

9 The Danish State Serum Insitute. [Classification of hospital departments SHAK] (in Danish) [Internet]. http://www.ssi.dk/~/media/Indhold/DK%20-%20dansk/Sundhedsdata%20og%20it/NationalSundhedsIt/Klassifikationer/SygehusAfdelingsKlassifikationen/2015-01-01_SghAfd.ashx (last accessed on 9 June 2015).

10 Association of Danish pharmacies. [Errors and flaws on prescriptions prescribed by hospital doctors in the Capital Region of Denmark] (in Danish) [Internet]. http://www.apotekerforeningen.dk/~/media/Apotekerforeningen/stoerre_publikationer/2011_fejl_mangler_recepter_regionhovedstaden_hosplaeger.ashx (last accessed on 16 December 2015).

11 The Danish Medicines Agency. [Do You Prescribe Electronically?] (in Danish). The Danish Medicines Agency, Copenhagen, 2009.

12 WHOCC. ATC/DDD Index [Internet]. http://www.whocc.no/atc_ddd_index/?code=N06BA04&showdescription=yes (last accessed on 19 May 2014).

13 WHO collaborating Centre for Drug Statistics Methodology, Guidelines for ATC classification and DDD assignment, 2015. Oslo, 2014.

14 The Legal Information Division. [The act on euphorizing drugs] (in Danish) [Internet]. https://www.retsinformation.dk/forms/R0710.aspx?id=120356 (last accessed on 17 July 2014).

Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Incorrect registrations of the prescriber identifier and the prescriber type for narcotic substances.

Table S2. Incorrect registrations of prescriber information stratified by prescriber type as recorded in the EDS for narcotic substances.

Table S3. Incorrect registration of the prescriber identifier and prescriber type specified according to first ATC level with and without prescriptions with missing prescriber identifier.