Variation of GP antibiotic prescribing tendency for contacts with out-of-hours primary care in Denmark – a cross-sectional register-based study

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ABSTRACT

Objective: To study variation in antibiotic prescribing rates among general practitioners (GP) in out-of-hours (OOH) primary care and to explore GP characteristics associated with these rates.

Design: Population-based observational registry study using routine data from the OOH primary care registration system on patient contacts and antibiotic prescriptions combined with national register data.

Setting: OOH primary care of the Central Denmark Region.

Subjects: All patient contacts in 2014–2017.

Main outcome measures: GPs’ tendency to prescribe antibiotics. Excess variation (not attributable to chance).

Results: We included 794,220 clinic consultations (16.1% with antibiotics prescription), 281,141 home visits (11.6% antibiotics), and 1,583,919 telephone consultations (5.8% antibiotics). The excess variation in the tendency to prescribe antibiotics was 1.56 for clinic consultations, 1.64 for telephone consultations, and 1.58 for home visits. Some GP characteristics were significantly correlated with a higher tendency to prescribe antibiotics, including ‘activity level’ (i.e. number of patients seen in the past hour) for clinic and telephone consultations, ‘familiarity with OOH care’ (i.e. number of OOH shifts in the past 180 days), male sex, and younger age for home visits. Overall, GP characteristics explained little of the antibiotic prescribing variation seen among GPs (Pseudo r²: 0.008–0.025).

Conclusion: Some variation in the GPs’ tendency to prescribe antibiotics was found for OOH primary care contacts. Available GP characteristics, such as GPs’ activity level and familiarity with OOH care, explained only small parts of this variation. Future research should focus on identifying factors that can explain this variation, as this knowledge could be used for designing interventions.

KEY POINTS

Current awareness:
- Antibiotic prescribing rates seem to be higher in out-of-hours than in daytime primary care.

Most important results:
- Antibiotic prescribing rates varied significantly among general practitioners after adjustment for contact- and patient-characteristics.
- This variation remained even after accounting for variation attributable to chance.
- General practitioners’ activity level and familiarity with out-of-hours care were positively associated with their tendency to prescribe antibiotics.

Introduction

High exposure to antibiotics and inappropriate antibiotic prescribing are major causes of antibiotic resistance [1]. Antibiotic resistance may delay or reduce effective treatment, resulting in higher morbidity and mortality rates, more complications, and longer hospital stays in addition to higher healthcare costs [1,2]. Therefore, increased focus is warranted on ensuring prudent use of antibiotics, including narrow-spectrum antibiotics, and avoiding unnecessary treatment.

In Denmark, most prescriptions are issued to patients in the primary care setting [3]. GPs have
varying antibiotic prescribing rates [4,5]. Gjelstad et al. found a three times difference between the lowest and highest prescribers for respiratory tract infections in the daytime [6]. A range of factors was associated with GP variation in antibiotic prescribing rates in the daytime, such as GP gender and age, years of practice experience, the volume of practice, perceived time available per patient, the general attitude towards prescribing, geographical location, consultation rates for infections, and workload [7–11].

Antibiotic prescribing is a challenge to GPs in the daytime, but even more so in the out-of-hours (OOH) services [12,13]. In 2011–2012, 15% of all contacts to Danish OOH primary care ended with an antibiotic prescription [14]. The average antibiotic prescribing rate in OOH primary care varies across Europe, ranging from 15% in Norway and England to 23.7% in Belgium and 33% in Iceland [5,15–17].

Variation in prescription rates and decisive influential factors may differ between daytime and out-of-hours care. Antibiotic prescribing rates seem to be higher in OOH than in daytime care [12,13] due to contact characteristics (e.g. overrepresentation of respiratory tract infections, more vulnerable or foreign-language patients, and more young children in OOH care) and organisational factors (e.g. high workload, limited access to patient records and to diagnostics, including point-of-care (POC) tests) [12,18–20]. In the OOH setting, GPs do not always feel sufficiently confident to use the ‘wait and see’ approach [21], and many have lower thresholds for prescribing antibiotics than during office hours as such prescriptions may provide a safety net [19,22].

Knowledge about the variation in antibiotic prescribing among GPs and associated factors can inform future intervention development. Therefore, we aimed to study GP variation in antibiotic prescribing rates and explore GP characteristics associated with antibiotic prescribing in OOH primary care. We hypothesised that the antibiotic prescribing rates varied significantly among GPs in OOH primary care.

Material and methods
Design and population
We conducted a population-based observational registry study using routine registry data from the OOH registration system on antibiotic prescriptions for patient contacts with the OOH primary care service (GP cooperative) in the Central Denmark Region from 1 January 2014 to 31 December 2017.

Setting
OOH primary care provides primary healthcare outside the GPs’ office hours for all citizens in the region (1.3 million citizens on 1 January 2014) [23]. At the OOH primary care service, GPs answer the telephone and perform triage. This GP can decide to give telephone advice (telephone consultation) or refer to a face-to-face consultation with a GP (clinic consultation or home visit). The OOH primary care service is open on weekdays between 4pm and 8am, on weekends, and on holidays.

The above model exists in four out of five Danish regions. In 2014, the Capital Region of Denmark implemented a different model called medical helpline 1813, where nurses with computerised decision support and physicians answer the telephone and perform triage. Patients referred to a clinic consultation are seen at the hospital.

In Denmark, primary care is tax-funded and freely available for residents. General practice is responsible for providing healthcare to all patients 24/7. In the Central Denmark Region, all GPs (excluding GPs aged 60+ years) are assigned at least six shifts at the OOH primary care service over a 4-month period. Furthermore, GPs are allowed to swap or sell shifts.

Data collection
We retrieved data on contacts and antibiotic prescribing from the OOH primary care registration system in the Central Denmark Region. For each contact, we included the date and time of the contact, contact type, patients’ age, and sex, GPs’ age and sex, GPs’ authorisation ID, and antibiotic prescription (Anatomical Therapeutic Chemical (ATC) code).

From Danish national registries, we collected additional data, which were used as covariates. The Civil Registration System was used to collect additional data on patient characteristics from Statistics Denmark (i.e. ethnicity, living status, urbanisation, income, and education level). The Danish National Health Service Register provided information on the number of contacts with OOH primary care. The National Patient Register provided data for calculating the Charlson Comorbidity Index, and the Register of Authorised Health Personnel provided information on the year of registration and specialization of the GPs.

Data handling
We excluded telephone contacts resulting in referral to face-to-face consultation in OOH primary care, as
these were seen as triage contacts to further care (without the option of an antibiotic prescription). In addition, we excluded GPs with less than two shifts on average per year for each type of contact. Therefore, a GP could be excluded from the analysis for one type of contact while contributing to the two other sets of analysis. ATC codes level 4 (chemical subgroup) and level 5 (chemical substance) were used to identify antibiotics, including J01 (antibacterial agents for systemic use).

We constructed a range of variables for case mix adjustment and stratifications (Supplementary Table 1). Two contact characteristics were defined: (1) ‘time to next in-hours period’, which measured the amount of time until daytime GP opening hours, and (2) ‘regional patient load, past hour’, which measured the overall workload at the entire regional OOH primary care service at the time of the contact. In addition, the patient characteristic ‘patients seen in the past hour’ as a proxy for the activity of the individual GP at the time of the contact. We could not calculate ‘OOH shifts in the past 180 days’ as a proxy of familiarity with working in OOH primary care and ‘patients seen in the past hour’ as a proxy for the activity of the individual GP at the time of the contact. We could not calculate ‘OOH shifts in the past 180 days’ if the contact took place within the first 180 days of the study period or ‘patients seen in the past hour’ if the contact took place during the first hour of the shift. These contacts were analysed as a separate category for completeness, but they were not presented in the final results. When calculating the complete workload for telephone shifts, we included telephone consultations and telephone triage contacts ending with a referral to a face-to-face consultation. If necessary, a missing category was introduced for each covariate.

**Analyses**

To study GP variation in antibiotic prescribing (aim 1), we calculated the GPs’ unadjusted antibiotic prescribing rate, that is, the number of prescriptions per 100 contacts, and a prescribing tendency measure for each individual GP. This allowed us to adjust for case-mix variation between GPs, making the GP’s antibiotic prescribing tendency independent of his/her patient population. Therefore, we aggregated the data by covariate combinations and GP authorisation ID, and constructed a model for predicting prescription rates based on all before-mentioned patient- and contact-related characteristics using a Poisson regression model for each contact type separately [24]. This allowed us to estimate the number of expected antibiotic prescriptions for each GP given their particular case-mix. Second, we counted the number of observed prescriptions for each individual GP. Dividing the number of observed prescriptions by the number of expected prescriptions for each individual GP resulted in the antibiotic prescribing tendency (APT). The APT reflects the individual GP’s likelihood of prescribing antibiotics compared to the average GP. Thus, an APT >1 means that the GP is more likely to prescribe antibiotics than the average GP, and an APT <1 means that the GP is less likely to prescribe antibiotics than the average GP (adjusted for all before-mentioned patient- and contact-related characteristics). In other words, a GP with an APT of 1.2 prescribed antibiotics 20% more frequently than the average GP (adjusted for the above patient- and contact-related characteristics).

To obtain an objective measure of the APT variation among GPs, we sorted GPs according to APT and calculated the ratio between the 90th and 10th percentile. If a lot of variation is seen in APT among GPs, the distance between the 90th and 10th percentile will be wide, and the p90/p10 will be large. However, some variation among GPs will occur due to unobservable factors and random variation. To account for this, we estimated the amount of variation to be expected if all GPs acted exactly the same, that is if all GPs behaved as predicted by the Poisson model. For this, we used the estimated likelihood of antibiotic prescription for each consultation (from the Poisson model) as the mean in a binomial distribution and drew from that 100 random samples. This left us with 100 simulated datasets, which were each analysed in the same way as the real-world data, that is, for each of the 100 random samples, we calculated p90 and p10. Next, we calculated the median p90 and median p10 of these 100 random samples. Finally, we calculated the ratio between these median simulated p90 and p10, and compared this ratio to the observed p90/p10. The ratio between the observed p90/p10-ratio and the simulated p90/p10-ratio provided a measure of the excess variation in APT, that is, the amount of variation left after subtracting the expected variation from the observed variation. We refer to this as the expected variation, and it may be interpreted as the amount of observed variation that we would expect even if all GPs acted the same (i.e. if no true GP variation existed). We plotted these simulated APTs with the actual APTs alongside histograms of the unadjusted prescription rates. An alternative tool for studying excess variation, so-called funnel plots, were also constructed and showed similar results as the main analysis (Supplementary File).
To explore GP characteristics associated with antibiotic prescribing in OOH primary care (aim 2), we investigated GP-specific predictors of the APT by studying associations between GP and context characteristics and the observed APTs through the use of a multivariable Poisson model. Due to collinearity between GP age and experience, only age was included in the multivariable model. All regression models included cluster-robust variance estimation at the GP level to account for repeated measurements. All analyses were conducted in Stata 16 (StataCorp LP, College Station, TX, USA).

Results

OOH contacts, patient- and GP-related characteristics and antibiotic prescription rate

From 2014 to 2017, the OOH primary care service in the Central Denmark Region provided 794,220 clinic consultations, 281,141 home visits, and 1,583,919 telephone consultations (Tables 1 and 2). We excluded 39% of 954 GPs for clinic consultations (5.5% of contacts), 15% of 974 GPs for home visits (1.7% of visits), and 35% of 987 GPs for telephone consultations (2.0% of contacts). Table 2 presents the distribution of contact- and patient-related characteristics by contact type. The antibiotic prescription rate varied between contact types: 5.8% for telephone consultations, 11.6% for home visits, and 16.1% for clinic consultations. The range of quintiles for contact and GP characteristics is presented in Supplementary Table 2. GP characteristics on GP level can be found in Supplementary Table 3.

GP variation in prescription rate and APT

The histograms of the raw prescription rates show an approximately normal distribution of prescription rates for each contact type, with the range being the smallest for telephone consultations (Figure 1). The S-curves present the APTs adjusted for patient characteristics. The observed variation (p90/p10 ratio) was 1.90 for clinic consultations, 2.15 for telephone consultations, and 2.52 for home visits (Figure 2). The excess variation (i.e. not attributable to chance) in APT was 1.56 for clinic consultations, 1.64 for telephone consultations, and 1.58 for home visits.

Discussion

Statement of principal findings

GPs have varying antibiotic prescribing rates in OOH primary care in Denmark; this was seen for each type of contact. The APTs adjusted for patient characteristics. The observed variation (p90/p10 ratio) was 1.90 for clinic consultations, 2.15 for telephone consultations, and 2.52 for home visits (Figure 2). The excess variation (i.e. not attributable to chance) in APT was 1.56 for clinic consultations, 1.64 for telephone consultations, and 1.58 for home visits.
Table 2. Contact-, patient- and GP-related characteristics, proportion by contact type (in %).

|                        | Clinic consultation | Home visit | Telephone consultation |
|------------------------|---------------------|------------|------------------------|
|                        | N                   | %          | N                      | %          | N                      | %          |
| Number of contacts     | 794,220             | 29.9       | 281,141                | 10.6       | 1,583,919              | 59.6       |
| Antibiotic prescriptions| 127,539             | 16.1       | 32,496                 | 11.6       | 91,244                 | 5.8        |
| Contact characteristics|                     |            |                        |            |                        |            |
| Time to next in-hours period (hours) |                     |            |                        |            |                        |            |
| 0–16                   | 350,484             | 44.1       | 143,651                | 51.1       | 745,349                | 47.1       |
| >16                    | 443,736             | 55.9       | 137,490                | 48.9       | 838,570                | 52.9       |
| Regional patient load, past hour |                     |            |                        |            |                        |            |
| First hour of shift    | 65,316              | 8.2        | 3263                   | 1.2        | 136,866                | 8.6        |
| 1st quintile           | 150,601             | 19.0       | 60,708                 | 21.6       | 292,980                | 18.5       |
| 2nd                    | 146,371             | 18.4       | 55,138                 | 19.6       | 296,210                | 18.7       |
| 3rd                    | 148,032             | 18.6       | 59,323                 | 21.1       | 280,398                | 17.7       |
| 4th                    | 140,562             | 17.7       | 51,981                 | 18.5       | 288,534                | 18.2       |
| 5th quintile           | 143,338             | 18.0       | 50,728                 | 18.0       | 288,931                | 18.2       |
| Patient characteristics|                     |            |                        |            |                        |            |
| Age in groups (years)  |                     |            |                        |            |                        |            |
| 0–3                    | 123,626             | 15.6       | 11,142                 | 4.0        | 237,778                | 15.0       |
| 4–17                   | 163,130             | 20.5       | 13,032                 | 4.6        | 231,450                | 14.6       |
| 18–39                  | 230,679             | 29.0       | 85,933                 | 30.6       | 453,365                | 28.6       |
| 40–64                  | 183,704             | 23.1       | 66,315                 | 23.6       | 351,052                | 22.2       |
| ≥65                    | 70,480              | 9.0        | 151,454                | 53.9       | 264,185                | 16.7       |
| Sex                    | 409,657             | 51.6       | 147,611                | 52.5       | 893,919                | 56.4       |
| Highest educational level (years) |                     |            |                        |            |                        |            |
| <10                    | 207,886             | 26.2       | 123,117                | 43.8       | 467,248                | 29.5       |
| 10–15                  | 230,679             | 29.0       | 85,933                 | 30.6       | 453,365                | 28.6       |
| ≥15                    | 86,627              | 10.9       | 26,187                 | 9.3        | 188,087                | 11.9       |
| Children               | 250,065             | 31.5       | 19,769                 | 7.0        | 418,478                | 26.4       |
| Missing values         | 18,963              | 2.4        | 26,135                 | 9.3        | 56,741                 | 3.6        |
| Income* (deciles)      |                     |            |                        |            |                        |            |
| 1st–3rd                | 249,452             | 31.4       | 109,575                | 39.0       | 542,473                | 34.2       |
| 4th–7th                | 329,701             | 41.5       | 129,774                | 46.2       | 675,526                | 42.6       |
| 8th–10th               | 215,067             | 27.1       | 41,792                 | 14.9       | 365,020                | 23.1       |
| Living status          | 543,295             | 68.4       | 127,988                | 45.5       | 954,064                | 60.2       |
| Married/cohabitating  | 250,925             | 31.6       | 153,153                | 54.5       | 629,855                | 39.8       |
| Unmarried/widow(er)/divorced | 699,824             | 88.1       | 262,125                | 92.2       | 1,425,728              | 90.0%      |
| Ethnicity              | 57,638              | 7.3        | 15,458                 | 5.5        | 97,344                 | 6.1        |
| 2nd generation immigrants| 57,638              | 7.3        | 15,458                 | 5.5        | 97,344                 | 6.1        |
| No comorbidities       | 681,020             | 85.7       | 140,675                | 50.0       | 1,253,337              | 79.1%      |
| 1                      | 87,498              | 11.0       | 73,295                 | 26.1       | 211,581                | 13.4       |
| 2                      | 18,577              | 2.3        | 39,465                 | 14.0       | 73,689                 | 4.7        |
| 3                      | 5072                | 0.6        | 17,584                 | 6.3        | 28,376                 | 1.8        |
| ≥4                     | 2053                | 0.3        | 10,122                 | 3.6        | 16,736                 | 1.1        |
| Charlson Co-morbidity Index |                     |            |                        |            |                        |            |
| No comorbidities       | 196,013             | 24.7       | 62,579                 | 22.3       | 385,635                | 24.3       |
| 1                      | 170,531             | 21.5       | 52,170                 | 18.6       | 266,394                | 16.8       |
| 2                      | 123,772             | 15.6       | 54,829                 | 19.5       | 316,520                | 20.0       |
| 3                      | 147,121             | 18.5       | 58,111                 | 20.7       | 317,791                | 20.1       |
| 4                      | 156,783             | 19.7       | 53,452                 | 19.0       | 297,579                | 18.8       |
| GP characteristics     | 584                 | 29.2       | 829                    | 41.5%      | 585                    | 29.3       |
| Number of GPs          | 305,467             | 38.5       | 118,443                | 42.1       | 587,378                | 37.1       |
| Sex                    | 488,753             | 61.5       | 162,698                | 57.9       | 996,541                | 62.9       |
| Age in groups (years)  |                     |            |                        |            |                        |            |
| 31–40                  | 154,484             | 19.5       | 59,987                 | 21.3       | 277,527                | 17.5       |
| 41–50                  | 303,572             | 38.2       | 103,873                | 36.9       | 548,966                | 34.7       |
| 51–60                  | 221,466             | 27.9       | 75,254                 | 26.8       | 497,531                | 31.4       |
| ≥60                    | 114,698             | 14.4       | 42,027                 | 14.9       | 259,895                | 16.4       |

(continued)
of investigated contact. The variation is 56–64% larger than would be expected if every GP acted the same. The included GP characteristics explained little of the variation among GPs, but some were significantly related to higher relative APT; activity level of the individual GP (for clinic consultations and home visits), familiarity with working at the OOH primary care, male sex, and younger age (all for home visits). Average familiarity with working at the OOH primary care correlated with lower antibiotic prescribing rates for clinic consultations.

**Strengths and weaknesses of the study**

The large dataset with unique data on individual GPs enabled us to study GP variation in antibiotic prescribing in OOH primary care. We developed our own measure of excess variation, adjusting for patient- and contact-related characteristics and taking into account that some variation will exist even when GPs act the same. The use of retrospective routine care data implied that the GPs were not aware of the analyses of their prescribing behaviour, which removed the risk of bias from socially desirable prescribing behaviour. Furthermore, the linking of data across national registers allowed us to adjust for many patient- and contact-related characteristics, thereby limiting confounding.

The quality of our data is unknown, but we assume that the data has high validity. We used billing data from GPs, who are paid on a fee-for-service basis in OOH primary care. In addition, antibiotic prescriptions are made directly in the OOH primary care registration system, which limits the risk of incorrect prescription data. Data on prescriptions and contacts came in two

### Table 2. Continued.

| GP experience (years) | Clinic consultation | Home visit | Telephone consultation |
|-----------------------|---------------------|------------|------------------------|
| 6–10                  | 118,123             | 49,537     | 204,233                |
| 11–20                 | 346,430             | 115,259    | 633,477                |
| >20                   | 329,667             | 116,345    | 746,209                |
| Primary care specialist |                     |            |                        |
| No                    | 132,270             | 46,339     | 256,698                |
| Yes                   | 404,080             | 141,992    | 698,033                |
| Missing               | 237,870             | 92,810     | 629,188                |
| OOH shifts in the past 180 days, quintiles | | | |
| First 180 days of follow-up | 100,772 | 37,160 | 203,848 |
| 1st quintile | 159,487 | 53,781 | 286,159 |
| 2nd                  | 136,566             | 48,390     | 282,160                |
| 3rd                  | 124,699             | 50,214     | 272,232                |
| 4th                  | 141,608             | 44,278     | 271,064                |
| 5th quintile         | 131,148             | 47,318     | 268,456                |
| Patients seen in the past hour, quintiles | | | |
| First hour of shift  | 129,878             | 89,847     | 246,562                |
| 1st quintile         | 202,711             | 106,350    | 309,319                |
| 2nd                  | 106,885             | 0          | 275,376                |
| 3rd                  | 112,784             | 68,429     | 271,272                |
| 4th                  | 161,247             | 0          | 246,581                |
| 5th quintile         | 80,715              | 16,515     | 234,809                |

*aWe used parental characteristics to categorise children.*

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![Figure 1. Histogram presenting raw antibiotic prescription rates, per contact type.](image-url)
essentially independent datasets, which we merged by the personal identification number and timestamp. Few prescriptions (3.8%) could not be linked to a contact and were excluded. As we collected the data directly from the OOH primary care system, we obtained data from only one of the five Danish regions, which could have influenced the generalisability. However, since the organisation of the OOH primary care services in the Central Denmark Region is largely similar to the organisation in the other three regions served by a GP cooperative, we expect the results to be representative for Danish OOH primary care. Only the Capital Region of Denmark has a different organisation (i.e. medical helpline 1813) without clinic consultations by GPs. Furthermore, the results can be generalised to settings with similar OOH primary care services in other countries with low antibiotic prescribing rates. We assume that GP characteristics associated with APT are largely similar to those in other countries with a GP gatekeeping system. Only limited information was available on GP characteristics in the Danish registers, and GP characteristics explained only little of the variation seen. Consequently, a range of other characteristics could be relevant, such as communication skills and personality characteristics [10]. We cannot rule out additional confounding from unobserved covariates or residual confounding. Finally, our contact data lacked information on diagnoses and reason for the encounter. This information could have improved the precision of the prediction model. However, in consideration of the vast amount of data, this is unlikely to have influenced our findings.

Findings in relation to other studies

We are not aware of other studies that have investigated GP variation in antibiotic prescribing in OOH primary care. However, many studies have investigated variation in daytime GP practices, mostly at the practice level, and have reported great variation in antibiotic prescribing rates between diagnoses and practices [6,7,9]. Besides different settings, comparison of these studies is difficult due to differences in the measures used. The percentage of contacts ending with an antibiotic prescription was commonly used while correcting for case mix and/or standardising between practices. By calculating excess variation, we took into account that some variation would be observed between GPs, even if no true variation was present (if all GPs acted exactly the same). This method described variation more accurately, but it complicated comparison with existing literature that did not take this random variation into account.

In the daytime, GP activity level (i.e. practice activity, consultation rates, feeling of busyness) was associated with antibiotic prescriptions [25,26]. In line with other studies in OOH primary care, we found that GP activity level was related to antibiotic prescribing. Lindberg et al. found that antibiotic prescribing for acute respiratory tract infections increased during busy sessions [5]. In a qualitative study by Williams et al., the GPs indicated that prescribing antibiotics is sometimes easier than starting a discussion with a patient during a busy OOH shift [18].
Meaning of the study

The GPs in OOH primary care had varying antibiotic prescribing rates, which suggests room for improvement, but further research is needed to move towards clinical recommendations. In our study, the activity level of the individual GP and the GP’s familiarity with working at the OOH primary care had the strongest associations with antibiotic prescribing among the investigated GP characteristics. Activity can be seen as a GP-related and/or context-related characteristic. On the one hand, the GPs can influence the number of patients they handle, for example by speeding up and taking fewer or shorter breaks. On the other hand, the number of patients seen per hour is, at least partly, an indicator of the overall busyness in the clinic; if the patient load is high, a GP could see more patients per hour. When many patients are seen (high activity), the GPs may feel the pressure of time constraints; the GP may not be able to discuss alternative approaches or the nature of the illness with the patient, and the GP may ultimately prescribe antibiotics as a time-saving strategy [27]. The GPs could also be less motivated to discuss the necessity of an antibiotic prescription with a patient during busy OOH shifts [20] as they do not see their own patients, for whom such time investment may seem more relevant. Furthermore, the fee-for-service payment might affect the activity level because the GPs get paid more when handling more patients, which holds an incentive to work faster.

As the GP characteristics included in our study explained only a limited part of GP variation, future studies could focus on identifying other relevant characteristics that may affect the OOH antibiotics prescribing behaviour of GPs, such as interest in antibiotic prescribing, emotional state [22], personal habits [28], ideas about overuse of antibiotics [26], limited access to patient records [20], and the clinician’s perception that a patient expected an antibiotic prescription [10]. It is also relevant to consider the GPs’ antibiotic prescribing rate in the daytime. Furthermore, organisational characteristics might explain some of the variation. Access to and use of POC tests could be a relevant factor [7]. These tests have been introduced to support the GPs’ decision-
making to reduce the number of unnecessary antibiotic prescriptions [29].

Studying variation in prescribing helps to pinpoint both low and high antibiotic prescribers, which can be used to tailor interventions [30]. We could learn from the low prescribers when developing interventions that focus on the large middle group and from high prescribers when aiming to reduce the antibiotics prescribing rate across all GPs. Qualitative research is warranted to get more insight into the decision-making process and to explore the considerations of low prescribers. Identified modifiable factors could be operationalised and measured quantitatively to estimate their relative importance in explaining variation. Finally, possible negative consequences of reducing antibiotic prescribing should be considered. When aiming at reducing antibiotic prescriptions where possible (increasing specificity), one might miss patients who actually need antibiotics (decreasing sensitivity). Both errors come at different costs, and the cut-off point for accepting the risk of an error (and subsequent costs) may be different for GPs in OOH care than for GPs in daytime care.

**Ethical approval**

We received approval from the Danish Patient Safety Authority (no. 3-3013-2692/1) for using data from the regional OOH primary care system. Furthermore, the project is listed in the project of processing activities at the Research Unit for General Practice in Aarhus in accordance with the provisions of the General Data Protection Regulation (GDPR).

**Disclosure statement**

No potential conflict of interest was reported by the author(s).

**Funding**

We received funding from the Foundation for Primary Health Care Research (Praksisforskningsfonden) in the Central Denmark Region [1-30-72-112-16] and the Foundation for General Practice (Fonden for Almen Praksis) [EMN-2017-00265].

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