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Antibiotic prescribing patterns in general medical practices in England: Does area matter?

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ABSTRACT

Antimicrobial resistance is an important public health concern. As most antibiotics are prescribed in primary care, understanding prescribing patterns in General Medical (GP) practices is vital. The aim of this study was a spatial pattern analysis of antibiotic prescribing rates in GP practices in England and to examine the association of potential clusters with area level socio-economic deprivation.

The pattern analysis identified a number of hot and cold spots of antibiotic prescribing, with hot spots predominantly in the North of England. Spatial regression showed that patient catchments of hot spot practices were significantly more deprived than patient catchments of cold spot practices, especially in the domains of income, employment, education and health.

This study suggests the presence of area level drivers resulting in clusters of high and low prescribing. Consequently, area level strategies may be needed for antimicrobial stewardship rather than national level strategies.

1. Introduction

Antimicrobial resistance is a global public health problem, with potentially severe consequences for routine medical procedures, as well as general morbidity and mortality (Ridge et al., 2011; The Review on Antimicrobial Resistance, 2016). In the UK, the majority of human antibiotic prescriptions are issued in primary care (Rooney et al., 2017). At an individual patient level, antibiotic susceptibility patterns of subsequent infections are linked to previous prescribing (Costelloe et al., 2010). Antibiotic prescribing is determined by multiple factors, including those that are clearly appropriate, such as medical diagnosis or medical history of the patient, and those that may be less appropriate, such as patient expectations or the doctor-patient relationship (Gill and Roalfe, 2001).

The majority of previous research has focused on antibiotic prescribing in individual patients or individual general medical (GP) practices (Steinke et al., 2000; Ashworth et al., 2016; Butler et al., 1998) and few studies have analysed prescribing patterns over larger areas or geographic regions (Di Martino et al., 2017; Zhang et al., 2012). Since patient catchment areas of English GP practices are often relatively large and not geographically exclusive (Sofianopoulou et al., 2012), it is reasonable to assume that some/ many neighbouring practices will treat patients living in the same area. Therefore, area level pressures affecting patients living in the same area or clinicians practicing in those areas could affect prescribing rates in multiple neighbouring practices, resulting in spatial clusters of practices with high or low prescribing rates. Spatial cluster analysis is routinely used in many fields, ranging from disease surveillance and ecology to crime analysis and market analysis (Jacquez, 2008). However, to date few studies have applied this technique in the analysis of drug prescribing rates (Cartabia et al., 2012; Cheng et al., 2011; Hutka and Bernard, 2014; Beuscart et al., 2017) and only one of these studies analysed the association between high and low prescribing clusters and area level drivers, such as socio-economic deprivation (Beuscart et al., 2017). This study analysed potentially inappropriate prescribing of all medications in elderly patients in France and was not antibiotic specific. The authors identified several spatial clusters of high prescribing and low prescribing. High prescribing clusters had significantly higher unemployment rates, lower incomes and lower socioeconomic status compared to low prescribing clusters.

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The aim of this study was to analyse antibiotic prescribing rates in GP practices in England to identify spatial clusters of high (hot spots) and low (cold spots) prescribers. If clusters were identified, a secondary aim was to compare GP practices located in high antibiotic prescribing clusters with GP practices in low antibiotic prescribing clusters in terms of area level socio-economic deprivation, using the index of multiple deprivation (IMD). The reasons for analysing socio-economic deprivation were two-fold: firstly, associations with area-level drivers were of interest, rather than GP or patient specific (i.e. individual) drivers. Secondly, data for the IMD is provided for the overall score, as well as for its seven domains and eight sub-domains. By analysing these domains and sub-domains it was hoped to identify a specific component of deprivation, which may warrant further investigation and which may offer a potential target for an intervention to reduce antibiotic prescribing.

2. Methods

2.1. Datasets

2.1.1. GP practice information

The National Health Service (NHS) Prescription Services provides a list of all General Medical Practices in England (https://digital.nhs.uk/organisation-data-service/data-downloads/gp-data). This list contains the practice codes, practice names and address information, as well as the status code ("active", "closed", "dormant", "proposed"), open and close dates, and the prescribing setting. Only practices with a "GP practice" prescribing setting were included in the analysis. Practices were geocoded based on their postcode, using the Ordnance Survey (OS) Code-Point Open layer. Postcode locations in the OS Code-Point layer are based on the nearest postal delivery point to the calculated mean location of all delivery points within the postcode area (Ordnance Survey, 2015). On average a UK postcode contains 15 delivery points.

The number of patients registered with GP practices is published every three months via NHS digital (http://www.content.digital.nhs.uk/gppatientsregistered). Data for each practice is available by gender, by age or by Lower-layer Super Output Area (LSOA, average population = 1500)(Wang et al., 2009). Datasets for 2016 were downloaded. Datasets were included if they had been collected at least 12 months after the practice had been opened, if the practice was not marked as closed and if 12 months of data for 2016 were available. Practices with < 750 registered patients were excluded, as these practices were assumed to be newly opened or about to be closed (Wang et al., 2009). It was assumed that the number of patients registered with a practice was relatively stable over time, therefore months without data were assumed to be equivalent to the previous month with data (e.g. the number of registered patients in February and March was assumed to be equivalent to the number of patients in January).

2.1.2. Prescribing data

NHS Prescription Services records all prescriptions issued by general practices in England and publishes this data as "GP Practice Prescribing Presentation-level Data" on a monthly basis (https://digital.nhs.uk/). These monthly datasets provide the number of items prescribed, the net ingredient cost, actual cost and quantity by 15 digit British National Formulary (BNF) code for each practice. Datasets from January to December 2016 were downloaded and BNF codes belonging to chapter 5.1 - antibacterial drugs were extracted. Only antibiotic drugs that are administered orally or intravenously were included. The total number of items of antibiotic drug was calculated per practice per month. Using the GP practice information monthly sex and age standardised prescribing rates (Item based Specific Therapeutic group Age-sex weightings-Related Prescribing Unit (STAR-PU), http://content.digital.nhs.uk/prescribing/measures) were calculated. For each included practice, the standardised mean antibiotic prescribing rate was calculated. Practices with prescribing rates below the first centile and above the 99th centile were excluded, as these were assumed to be either apparent outliers, due to reporting errors, or genuine outliers, resulting in an undue influence on the analysis (Wang et al., 2009).

2.1.3. Socio-economic deprivation

The English Index of Multiple Deprivation (IMD) measures socio-economic deprivation at the LSOA level (Smith et al., 2015). IMD scores are based on census statistics and secondary sources, such as income and revenue records and police statistics, with higher scores indicating a higher level of deprivation. The IMD consists of seven domains (Income, Employment, Education, Health, Crime, Barriers to Housing and Services, Living Environment, see Online Supplement, Fig. 1) and each domain score is based on multiple indicators. For the income, education, barriers to housing and services and living environment domains further information is provided at the sub-domain level: income deprivation affecting children, income deprivation affecting older people, education of children and young people, adult skills, geographic barriers, wider barriers, indoor and outdoor environments. Weighted deprivation scores for the GP patient catchment area (from all LSOAs in which patients of a practice live) were calculated based on the proportion of patients living in each LSOA:

$$DS^{(i)} = \sum_{j=1}^{N_{LSOA}^{(i)}} \frac{n_j^{(i)} \times DS_j^{(i)}}{N^{(i)}}, \quad i = 1 \dots N \tag{1}$$

where (i) is the index for the practices in England in 2016, j is the index for the LSOA within each practice catchment, $DS^{(i)}$ is the weighted deprivation score for practice (i), N is the total number of patients in practice (i), n is the number of patients in practice (i) who live in LSOA j, $DS_j^{(i)}$ is the deprivation score for LSOA j in practice (i).

2.2. Spatial analysis

Hot spot analysis was used to identify statistically significant spatial clusters of high and low prescribing practices. In this analysis the prescribing rate of each practice is analysed in the context of the prescribing rates of neighbouring practices using the Getis-Ord Gi* statistic, which results in a z-score for each practice (Getis and Ord, 1992). The scale of analysis determines which neighbouring practices are included in the analysis of each practice. The two most common methods to set the scale of analysis are fixed distance bands or a set number of nearest neighbours. Since GP practices are not spread evenly across England, i.e. more practices are located in densely populated urban areas and fewer practices in sparsely populated rural areas, both of these methods have disadvantages. For example, in rural areas a set number of neighbours may include practices that are unrealistically far away, while a fixed distance band may include no other practice. To compromise between these two methodologies the following process was used to determine the scale of analysis: (1) all GP practices in England belong to clinical commissioning groups (CCGs). CCGs are clinically led statutory NHS bodies, which are responsible for the planning and commissioning of health services in defined geographic areas. In this first step the minimum (k_{min}) and median (k_{median}) number of practices per CCG was calculated. (2) The median Euclidean distance ($d_{median,}$ in metres) of all practices to the k_{median} nearest neighbours was calculated. (3) A spatial weights matrix was created assigning all neighbouring practices within d_{median} a weight of 1, and all other practices a weight of 0. (4) If no neighbouring practices existed within d_{median}, the k_{min} nearest neighbours were assigned a weight of 1. The resulting spatial weights matrix was entered into the hot spot analysis with the geocoded practices and their standardised annual prescribing rates. The analysis assigns practices to seven categories ranging from − 3 (cold spot, p < 0.01) through 0 (no pattern) to + 3 (hot spot, p < 0.01). To account for multiple testing a false discovery rate correction was applied (Caldas de Castro and Singer, 2006), which results in a decrease in the critical p-value used to assign practices to