An association between socioeconomic deprivation and primary care antibiotic prescribing in Scotland

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Objective: To evaluate the association between socioeconomic deprivation and antibiotic prescribing in Scotland.

Patients and methods: Data for dispensed antibiotic prescriptions written by general practitioners were obtained for all Scottish National Health Service boards from 2010 to 2012. Deprivation was assessed linking dispensing events to the Scottish Index of Multiple Deprivation (SIMD) score for the patient’s datazone (neighbourhood area). The relationship between the deprivation area and antibiotic use (items per 1000 persons per day) was stratified according to the patient’s age and sex and the antibiotic class dispensed. A multivariate Poisson regression model was used to formally test the associations.

Results: Approximately 12 million prescription items during 2010–2012 were assessed. Patients in the most deprived SIMD quintile had an overall prescription rate that was 36.5% higher than those in the least deprived quintile. The effect of deprivation upon prescription rates was most pronounced for women aged 40–59 years, and for penicillins and metronidazole.

Conclusions: Deprivation was found to have a consistent association with increased rates of antibiotic prescribing in Scotland, which may have significant implications for antimicrobial stewardship and public health campaigns.

Keywords: Antimicrobial stewardship, database, public health

Introduction

Despite a nationalized delivery of healthcare, health inequalities remain a major challenge for Scotland. On average, men and women from the most socially deprived areas of the country have a life expectancy that is 10.9 and 7.4 years, respectively, less than that of their peers.¹ In 2008, the Ministerial Task Force on Health Inequalities published a report examining the effect of deprivation upon public health within Scotland. In addition to diminished life expectancy, other disparities were evident based on socioeconomic deprivation: poorer mental health, higher rates of disability and a higher incidence of problems associated with drugs, alcohol and tobacco.² Included were recommendations on how to overcome the identified problems, such as focusing on supporting young people, increasing employment, improving public spaces and developing proactive strategies to improve health and wellbeing.²

The association of deprivation with healthcare utilization is also of recent interest. Increased socioeconomic deprivation has been associated with a higher prescribing of statins,³ antipsychotics⁴ and antidepressants,⁵,⁶ although this relationship has been debated.⁷–¹⁰ While the connection between chronic disease and deprivation is logical, the relationship with more acute illness, such as infection, is unclear. A limited body of literature suggests that deprivation is positively associated with antibiotic use but has either produced weak correlations,¹¹ been in selected patient populations¹²,¹³ or assessed individual socioeconomic determinants rather than comprehensive deprivation indicators.¹⁴ With spending on antibiotics in Scotland totalling over £22 million in 2012/13,¹⁵ and with 32% of the Scottish population having at least one antibiotic dispensed in 2011,¹⁶ it is of particular importance to examine their use.

The Scottish Antimicrobial Prescribing Group (SAPG) was commissioned in 2008 by the Scottish government to coordinate the implementation of a national and comprehensive antimicrobial stewardship programme, discussed in detail elsewhere.¹⁷ With an overall goal of improving the quality of antibiotic prescribing and infection management, the SAPG has focused its initial efforts into areas of national concern, such as a reduction in the unnecessary use of broad-spectrum antibiotics associated with
Clostridium difficile infection (CDI). The effect of deprivation upon all aspects of public health makes it a central issue necessary to understanding the use of antibiotics in Scotland, and targeting resources appropriately. Furthermore, the availability of a valid measure of the multiple aspects of deprivation such as the Scottish Index of Multiple Deprivation (SIMD) makes this type of analysis timely and necessary. Accordingly, the aim of the present analysis was to evaluate the association between deprivation and antibiotic prescribing in Scotland.

Patients and methods

Data were obtained from the Prescribing Information System (PIS), an electronic database of all National Health Service (NHS) prescriptions dispensed to individuals across Scotland, which is maintained by NHS National Services Scotland (NSS). The PIS is created from information supplied by the Practitioner Services Division of the NSS, which is responsible for the processing and pricing of all NHS prescriptions dispensed in Scotland. Data on private (non-NHS) prescriptions are not routinely collected and were therefore unavailable for analysis; however, as prescription charges were abolished in Scotland in 2011 and the NHS is free at the point of use for the entire population, the relative contribution of these prescriptions is expected to be low. The PIS contains fields for a variety of metrics, including prescriber and dispenser information (e.g. location and organizational structure) and prescription details (e.g. the name, strength, formulation and cost of the medicine). Since 2009, an increasing proportion of NHS prescriptions issued in Scotland contain the patient’s Community Health Index (CHI) number, which enables linkage to demographic metrics, including the patient’s age, sex, location and relative socioeconomic deprivation.

A data extract from the PIS was created for the present analysis. The extract included data for 2010–2012 from all 14 Scottish NHS boards, covering a population of ~5.1 million people. Data fields included calendar year, the patient’s age and sex, the Information Services Division (ISD)-derived SIMD deprivation quintile, the class and name of the medicine, and the number of items. Age was categorized into 10 year bands, with a terminal band of 90 years and older. Deprivation was estimated by linking the patient’s address at the time of dispensing to the SIMD 2009 score for their neighbourhood area, which ranks small areas (datazones, containing ~500–1000 residents) of Scotland according to seven weighted domains of socioeconomic determinants: income (relative weight: 12), employment (12), health (6), education/training (6), access to services (4), and crime (2) and housing (1). After ranking, patients were categorized into quintiles, from quintile 1 (most deprived) to quintile 5 (least deprived). Medicines were categorized by both British National Formulary (BNF) subsection and approved name, and included medicines in BNF section 5.1 (antibacterial drugs), excluding 5.1.9 (antituberculosis drugs) and 5.1.10 (antileptoprax drugs, except streptomycin). The number of items referred to those items processed and paid for under NHS Scotland, excluding those from GP10A (Stock Order) forms and hospital-based prescription forms.

In order to account for differences in population over time, prescription rates were standardized to mid-year and small-area population estimates from the General Register Office for Scotland, adjusting for the patient’s age, sex and deprivation category. Population estimates for the year prior to prescription estimates were utilized (i.e. 2011 population data for 2012 prescription data). The effect of deprivation was evaluated for the entire population as well as according to age, sex and BNF subsection; figures were expressed as items per 1000 persons per day (items/1000/day).

The analysis was performed using Minitab 16 statistical software (Minitab Ltd, Coventry, UK) and IBM SPSS Statistics 21 (IBM; Armonk, NY, USA). The α-significance level for all tests was set at P = 0.05. Pearson’s coefficient was used to assess the correlation across SIMD quintiles, and linear regression was used to compare trend differences between groups. A Poisson regression model was utilized to test the association between variables; a negative binomial extension of this model was utilized to account for overdispersion in the data. The number of items was set as the outcome variable, with corresponding population counts as the offset variables. All variables were assessed independently, with significant predictors utilized in the multivariate model, and the variables additionally assessed for interactions. The final model was decided based on best fit of the regression variables; results were displayed using incident rate ratios (IRR) and 95% CIs. The dataset provided for analysis was aggregated and anonymized in accordance with ISD confidentiality rules and the Data Protection Act of 1998.

Results

Overall antibiotic items

The number of dispensed antibiotic items included ranged from 3,937,375 items in 2010 to 4,245,761 items in 2012, corresponding to a crude mean of 2.1–2.2 items/1000/day for each year. A percentage of items had no CHI number and/or SIMD quintile available and could not be used in further analysis; this was similar across 2010–2012 and ranged from 10.8% to 12.3% of the total number of items each year.

The overall prescription rate decreased as the level of deprivation decreased (Figure 1). In 2012, the rate decreased 36.5% from 2.49 items/1000/day for the most deprived quintile to 1.58 items/1000/day for the least deprived; similar decreases were found for 2010 and 2011. The overall prescription rate increased from 2010 to 2012 by a mean of 8.3%, with the greatest increase seen for the least deprived patients, at 9.1%.

Antibiotic items according to age/sex

Women were found to have higher prescription rates than men for all years assessed and across all deprivation categories (Figure 2). For 2012, the most deprived women had a prescription rate of 3.09 items/1000/day—almost three times that of the least deprived men. Deprivation had a larger trend effect on women, with the prescription rate decreasing 38.1% from the most to least deprived, compared with 34.3% for men (P < 0.001). Accordingly, the largest differential between men and women occurred for the most deprived patients at 40.7%, decreasing marginally to 37.1% for the least deprived.

Age was also an important influence upon prescription rates (Figure 3). Overall, prescription rates increased according to age, with a 3-fold difference between children aged 0–9 years and adults aged 90 years and older, at 1.6 items/1000/day and 5.2 items/1000/day, respectively. Children aged 0–9 years had higher rates than anticipated by the trend, at approximately the same rate as adults aged 20–29 years. The effect of deprivation upon prescription rates was maintained for each age group, with the exception of adults aged 90 years and older. The largest differential in prescription rates between most and least deprived occurred at adults aged 40–49 years and 50–59 years at 50.6% and 51.4%, respectively (P < 0.001).

Results of the regression are shown in Table 1. In the univariate analysis, age, sex and deprivation were identified as predictors of the number of antibiotic items dispensed; the year of dispensing failed to reach statistical significance. These predictors maintained significance in the final multivariate model (P < 0.001 for all), with the addition of interaction terms between age and sex (P < 0.001), age and deprivation (P < 0.001) and sex and deprivation...
In this adjusted analysis, the least deprived patients received antibiotics at a rate 29.0% lower than the most deprived patients (IRR 0.71, 95% CI 0.68–0.75).

Antibiotic items according to antibiotic class

Penicillins (BNF 5.1.1; 49% of total) were by far the most prescribed antibiotic class, followed by macrolides (5.1.5; 14%), tetracyclines (5.1.3; 12%) and sulphonamides and trimethoprim (5.1.8; 11%). All classes sustained increases in prescribing ranging from 3.0% to 36.7% from 2010 to 2012 with the exception of cephalosporins and quinolones, which decreased by 35.2% and 15.1%, respectively. Trends in prescribing rates between 2010 and 2012 were relatively stable with no preference for any particular deprivation category. The effect of deprivation across a single year, however, was seen across all BNF subsections ($P<0.001$) (Table 2). The degree of this effect varied, with metronidazole and penicillins having the largest absolute differentials at 12.0% and 9.4%, respectively, between the most and least deprived patients.

**Discussion**

Our analysis confirms that increasing levels of deprivation are significantly correlated with antibiotic volume in Scotland, maintaining the relationship irrespective of the patient’s age or sex, or the antibiotic dispensed. The implications of the data for identifying and resolving health inequalities are significant.

Assessing the relationship between deprivation and health can be difficult. For instance, there is a well-established relationship between unemployment and negative health outcomes. As employment and income are the most heavily weighted components of the SIMD score, their effect is likely to be a driving contributor to the correlation between deprivation and antibiotic...
Figure 3. Total antibiotic prescription rate by age, stratified by SIMD quintile (2012). Pearson’s r: 0.970 (quintile 1; \( P < 0.001 \)), 0.909 (quintile 2; \( P < 0.001 \)), 0.860 (quintile 3; \( P = 0.001 \)), 0.842 (quintile 4; \( P = 0.002 \)), 0.838 (quintile 5; \( P = 0.002 \)).

Table 1. Poisson regression model for prescription rate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Univariate</th>
<th>Multivariate&lt;sup&gt;a,b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IRR (95% CI) P value</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–9 years</td>
<td>1.0 (reference)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>10–19 years</td>
<td>0.89 (0.77 – 1.03)</td>
<td>0.99 (0.95 – 1.05)</td>
</tr>
<tr>
<td>20–29 years</td>
<td>0.93 (0.80 – 1.08)</td>
<td>1.35 (1.29 – 1.42)</td>
</tr>
<tr>
<td>30–39 years</td>
<td>1.02 (0.88 – 1.18)</td>
<td>1.58 (1.50 – 1.66)</td>
</tr>
<tr>
<td>40–49 years</td>
<td>1.09 (0.94 – 1.27)</td>
<td>1.72 (1.64 – 1.81)</td>
</tr>
<tr>
<td>50–59 years</td>
<td>1.32 (1.14 – 1.53)</td>
<td>1.98 (1.88 – 2.08)</td>
</tr>
<tr>
<td>60–69 years</td>
<td>1.64 (1.42 – 1.91)</td>
<td>2.22 (2.12 – 2.34)</td>
</tr>
<tr>
<td>70–79 years</td>
<td>2.03 (1.75 – 2.35)</td>
<td>2.35 (2.23 – 2.47)</td>
</tr>
<tr>
<td>80–89 years</td>
<td>2.45 (2.11 – 2.84)</td>
<td>2.41 (2.29 – 2.54)</td>
</tr>
<tr>
<td>90+ years</td>
<td>3.16 (2.72 – 3.67)</td>
<td>2.66 (2.53 – 2.80)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>1.0 (reference)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>male</td>
<td>0.69 (0.62 – 0.77)</td>
<td>0.95 (0.92 – 0.98)</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>1.0 (reference)</td>
<td>0.590</td>
</tr>
<tr>
<td>2011</td>
<td>1.03 (0.89 – 1.19)</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1.08 (0.93 – 1.24)</td>
<td></td>
</tr>
<tr>
<td>Deprivation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quintile 1 (most)</td>
<td>1.0 (reference)</td>
<td>0.003</td>
</tr>
<tr>
<td>quintile 2</td>
<td>0.93 (0.78 – 1.11)</td>
<td>0.94 (0.89 – 0.99)</td>
</tr>
<tr>
<td>quintile 3</td>
<td>0.85 (0.71 – 1.02)</td>
<td>0.84 (0.80 – 0.88)</td>
</tr>
<tr>
<td>quintile 4</td>
<td>0.78 (0.65 – 0.94)</td>
<td>0.75 (0.71 – 0.78)</td>
</tr>
<tr>
<td>quintile 5 (least)</td>
<td>0.72 (0.60 – 0.86)</td>
<td>0.71 (0.68 – 0.75)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Interactions between age and sex (\( P < 0.001 \)), age and deprivation (\( P < 0.001 \)) and sex and deprivation (\( P = 0.006 \)) were also included in the model.

<sup>b</sup>Overall model fit tested by the omnibus test (\( P < 0.001 \)).
dispensing in the current analysis, although the direction of causation is unclear, particularly at the neighbourhood level of deprivation.

There are many known drivers of antibiotic use, from both the patient’s and the clinician’s perspective, that are particularly important within areas of increased socioeconomic deprivation. Poor and/or overcrowded living conditions, a sustained incidence of smoking, reduced vaccination uptake and poor diet contribute to a person’s susceptibility to infection, thereby increasing the need for antibiotics. Such associations have been realized across a large spectrum of (widely preventable) infectious diseases, including measles, tuberculosis and Haemophilus influenzae type b. The prevalence of chronic illness among those living in deprived areas is also higher, necessitating the use of antibiotics for secondary complications from conditions such as diabetes and chronic obstructive pulmonary disease, or resulting from adverse health behaviours such as heavy alcohol use. The burden of such chronic diseases is commonly manifested in middle age, with 68%–84% of disability-adjusted life years occurring before 60 years of age. Notably, this coincides with the peak effect of deprivation upon antibiotic prescribing in this analysis, at 40–59 years of age.

Patients’ involvement in healthcare decisions exerts some influence on antibiotic use. Patients from more deprived areas have been shown to be less knowledgeable concerning the use of antibiotics, such as believing that they are effective for treating minor coughs and colds. A perceived patient desire for antibiotics during a consultation has been shown to drive clinicians’ decisions, which may account for some of the increases in prescribing in deprived areas. The absolute influence of deprivation ranged from 3.3% to 12.0% depending on the BNF subsection, providing some direction for where to focus future efforts in evaluating the appropriateness of antibiotic prescribing. Equally important are the public health implications stemming from this analysis, such as for women, who received more antibiotics and felt deeper effects of deprivation than their male counterparts. Women in general are more prone to the overall influence of deprivation due to an increased prevalence of common infectious diseases and chronic illnesses, and may be more vulnerable to the associated health effects. Public health campaigns to increase the use of and access to services may be ideal, but previous analyses have shown difficulties in instituting disease screening and prevention in deprived areas. Accordingly, it may be more logical for governmental policy to concentrate on preventing the causes of the deprivation itself.

This analysis does have some limitations. A total of 11.7% of antibiotic prescriptions were excluded from the analysis, either because no CHI number was listed on the issued prescription, or because of an inability to link the CHI number on the prescription with an address to estimate the SIMD quintile. In addition, the analysis was unable to capture any prescriptions issued privately. Prescription charges were abolished in Scotland during the time frame of the present data, but a significant proportion of patients were receiving prescriptions without charge prior to 2011 on the basis of age and/or chronic illness; the relative contribution of this change to the data would be expected to be low. The resultant prescription rates in our analysis are likely to be an underestimate of true prescribing, as they are based upon total population figures in Scotland. We also cannot estimate whether these excluded prescriptions were distributed evenly across deprivation categories. Furthermore, prescribing estimates cannot determine

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**Table 2. Antibiotic items [n (%)] by selected BNF subsection, stratified by SIMD quintile (2012)**

<table>
<thead>
<tr>
<th>Antibiotics</th>
<th>Quintile 1</th>
<th>Quintile 2</th>
<th>Quintile 3</th>
<th>Quintile 4</th>
<th>Quintile 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cephalosporins and other β-lactams</td>
<td>21822 (22.3)</td>
<td>22742 (23.2)</td>
<td>19611 (20.0)</td>
<td>17948 (18.3)</td>
<td>15877 (16.2)</td>
</tr>
<tr>
<td>Macrolides</td>
<td>123884 (24.2)</td>
<td>112386 (22.0)</td>
<td>100015 (19.6)</td>
<td>90517 (17.7)</td>
<td>84535 (16.5)</td>
</tr>
<tr>
<td>Metronidazole</td>
<td>21830 (26.2)</td>
<td>18871 (26.2)</td>
<td>16421 (19.7)</td>
<td>14420 (17.3)</td>
<td>11827 (14.2)</td>
</tr>
<tr>
<td>Penicillins</td>
<td>469658 (25.1)</td>
<td>408747 (21.9)</td>
<td>362766 (19.4)</td>
<td>334555 (17.9)</td>
<td>294142 (15.7)</td>
</tr>
<tr>
<td>Quinolones</td>
<td>26735 (22.9)</td>
<td>24989 (21.4)</td>
<td>23318 (20.0)</td>
<td>21087 (18.1)</td>
<td>20526 (17.6)</td>
</tr>
<tr>
<td>Sulphonamides and trimethoprim</td>
<td>97703 (22.5)</td>
<td>92846 (21.3)</td>
<td>87503 (19.1)</td>
<td>83099 (19.1)</td>
<td>79388 (17.0)</td>
</tr>
<tr>
<td>Tetracyclines</td>
<td>97530 (21.5)</td>
<td>94882 (20.9)</td>
<td>90154 (19.8)</td>
<td>89452 (19.7)</td>
<td>82732 (18.2)</td>
</tr>
<tr>
<td>UTI antibiotics</td>
<td>45018 (21.8)</td>
<td>43922 (21.3)</td>
<td>40859 (19.8)</td>
<td>39913 (19.3)</td>
<td>36908 (17.9)</td>
</tr>
</tbody>
</table>

UTI, urinary tract infection.

*aQuintile 1 is the most deprived; quintile 5 is the least deprived.

bClass includes co-trimoxazole, sulfadiazine and trimethoprim.

CClass includes nitrofurantoin and methenamine.

Although we cannot draw any conclusions regarding the appropriateness of antibiotic prescribing in the present analysis, identifying pockets of possible antibiotic overuse is an important target for antimicrobial stewardship and controlling the development of bacterial resistance. The prescribing of antibiotics in primary care is associated closely with development of resistance, which can persist for up to 12 months post-treatment, although reductions in prescribing can decrease such resistance and do so with without resulting in adverse consequences. In the present analysis, the absolute influence of deprivation ranged from 3.3% to 12.0% depending on the BNF subsection, providing some direction for where to focus future efforts in evaluating the appropriateness of antibiotic prescribing.
whether patients take the dispensed medicine or ‘stockpile’ it. It is also important to note that this analysis utilizes ‘items/1000/day’ as its volume metric, which does not take into account differences in prescription quantities, such as the defined daily dose. However, this metric is endorsed and commonly employed by the SAPG, allowing this analysis to be compared with previous and future data from the group. Lastly, SIMD is a measure of geographical, and not individual, deprivation. As it represents a measure of deprivation for the area in which the patient lives (in relation to the rest of Scotland), there are patients within the area who individually may be considered more or less deprived than their area average.

In conclusion, there is a clear relationship between antibiotic use and a validated measure of multiple aspects of socioeconomic depression in a large, nationalized analysis of pharmacy dispensing. This finding may be important for shedding light on continued health inequalities, and within a policy context for focusing future efforts in antimicrobial stewardship and public health.

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**Transparency declarations**

None to declare.

**References**