Antibiotic Prescribing and Sociodemographic Deprivation – From General Index to Specific Domains

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Abstract

Objectives: Analyse the variance associated with the domains of the English Index of Multiple Deprivation (2015) as predictors of antibiotic prescribing.

Methods: Deprivation and prescribing data for Clinical Commissioning Groups in England were collected, tabulated and used to build regression models characterising the relationship between antibiotic prescribing and indices of deprivation in the domains of education, health, employment, income, services and living environment.

Results: The Index and 6 out of the 7 deprivation domains predicted antibiotic prescribing as reported (<0.001) and explained 21-38% of the variance. The domain of Education, Training and Skills emerged as a key factor (R^2=0.38266) whereas employment explained as much variance in prescribing as health (R^2=0.23408 and 0.23549 respectively).

Conclusions: Individual indices of deprivation such as education and employment can account for the variance in antibiotic prescribing to a similar or a greater extent than health or the Index as a whole. Predictive indices provide new insights into the ways in which socio-demographic deprivation affects prescribing and can serve in the design of future more targeted interventions, such as those to lower unwarranted antibiotic prescribing.

Introduction

Since the early 1990s, studies on variations in the prescribing of antibiotics have identified deprivation in the area of practice as a contributing factor.[1,2,3] The association between higher prescribing rates and deprivation has been reported in England,[4] Scotland,[5] Germany[6] and other countries but the findings tend to differ in terms of the strength of the effects and the attribution of these effects to deprivation as compared to other factors. Some studies have reported nearly twice the number of antibiotic prescriptions delivered per capita in the most deprived populations,[4] whereas in others it fluctuated around 40%.[5] Studies considering other potential factors impacting antibiotic prescribing have found that area or practice deprivation accounted for 20%-25% of the variation in antibiotic prescribing[6,7] whereas others found only 0.1% of the variance explained[2] or no association at all.[8]

To better understand the relationship between antibiotic prescribing and sociodemographic deprivation, this study compared the ability of the general deprivation measure to explain antibiotic prescribing against individual indices (such as education or employment). To do so, it implemented the most recent English Index of Multiple Deprivation (IMD[9]), an area-level weighed sum of measures of income (22.5%), employment (22.5%), education, skills and training (13.5%), health and disability (13.5%), crime (9.3%), barriers to housing and services (9.3%) and the living environment (9.3%). Although the IMD or similar measures have been used in previous studies[2,5,6] this study differs by comparing the association between prescribing and the general index to the association with each of its components.

Data and methods

Prescribing counts were obtained from the Fingertips dataset maintained by Public Health England to monitor the UK 5 Year Antimicrobial Resistance Strategy.[10] Counts were obtained for the Clinical Commissioning Group (CCG) in England. The CCGs are regional organisations of the National Health Service set up (2012) to supervise the delivery of health services. Whereas deprivation is documented for 209 CCGs (see below), 6 were not represented in the dataset due to reorganisations or changes in CCG boundaries. Therefore, these 6 CCGs were omitted from this study.

To reduce seasonal and demographic variability, the indicator selected (ID=92377) was the twelve-month rolling total number of prescribed antibiotic items weighted by the Specific Therapeutic Group Age-Sex Weighting Related Prescribing Unit (STAR-PU). The STAR-PU weighting takes the age and gender composition in each practice into consideration and the highest levels of prescription for women, children and the elderly.[2,5,11] Prescribing is reported as the average of the rolling total prescriptions (primary care, secondary care, dentistry etc.) for each region and was tabulated monthly from July 2014 to December 2017, thus eliminating the seasonal variability from the overall score. This average was then tested for correlations with each of the deprivation indices published in 2015.

The fifth and most recent release of The English Indices of Deprivation produced by the Department of Communities and Local Government (DCLG) in Britain was used to identify the area deprivation.[9] The index and composite indices were calculated for each of the 32,844 Lower-Layer Super Output Areas in England (LSOAs, roughly neighbourhood sized;

~1500 residents) although summary measures are available for higher-level geographies including local authority districts and CCGs. The measures selected for each indicator were the rank of the average score; i.e, the weighted average of the combined scores for the areas covered by the CCG. A rank of 1 is assigned to the CCG with the highest deprivation score.

Prescribing data were extracted using the Fingertips library in R (Public Health England). A Python code was written by the author to average the prescribing measures, tabulate these measures with the deprivation indicators, and chart the correlations between deprivation and prescribing. Regression models (ordinary least squares) were established with StatsModels (a statistical package in Python) for each of the component domains.[12] Indices found to have a statistically significant relationship to prescribing were examined for their joint predictive power in a multivariable regression model. Because this study explored the variance in prescribing as explained by the indices rather than their causal relationship to prescribing, the key statistic is the coefficient of determination (R^2) which represents the proportion of the variance in the per capita antibiotic prescriptions explained by the variables in each model.

Results

The IMD and most of the indices emerged as regional predictors of antibiotic prescribing. The low values for the slope coefficients do not imply weak correlations but the scales used for the deprivation and prescribing measures (Table 1). Their signs indicate that increases in the indices for health and disability, for education, training and skills, for employment and for income predicted higher levels of prescribing, whereas living area deprivation and limited access to services and housing exhibited the opposite trend. The effect demonstrated for the IMD the, reflects the aggregate effects of factors that shape prescribing in various ways.

Domain (s)	**β**	**Sig.**	**R^2**
IMD	-0.00066	<0.001	0.08047
Education	-0.00143	<0.001	0.38266
Health	-0.00113	<0.001	0.23549
Employment	-0.00111	<0.001	0.23408
Services & Housing	0.00107	<0.001	0.21482
Income	-0.00064	<0.001	0.0761
Living Environment	0.0006	<0.001	0.06795
Crime	0.00011	>0.1	0.00208
Income & Employment		<0.001	0.454
Health & Education		<0.001	0.386
Health & Employment		<0.001	0.243
Education & Employment		<0.001	0.377
Health, Education & Employment		<0.001	0.382
Health, Education, Employment & Income		<0.001	0.544
Health, Education, Employment, Income & Environment		<0.001	0.596

Table 1: Regression (β) and Determination (R2) coefficients for the univariable and multivariable models of deprivation domains.

Specifically, there was a noticeable difference in the explanatory values for most predictors in terms of the prescribing variance (Table 1). The IMD explained less than 10% of the variation observed. However, health and disability deprivation, when examined in isolation, explained nearly twice the variance as the IMD as a whole (R^2=0.23549; Figure 1a). This result is not surprising since higher prescribing rates can be expected in areas of poor health.[11] Strikingly, however, social factors that tend not to be assumed to reflect medical issues accounted for the variance in prescribing to a similar or even greater extent. Deprivation in education, skills, and training emerged as the most significant domain that accounted for the variance in prescribing (R^2=0.38266; Figure 1b). Although income deprivation only explained 7% of the variance in prescribing, employment was as explanatory as health and disability (R^2=0.23408). When combined, income and employment explained nearly 50% of the variance (R^2=0.454) and hence should be seen as substantially more pertinent in accounting for the variation in prescribing than deprivation associated with health or disability.

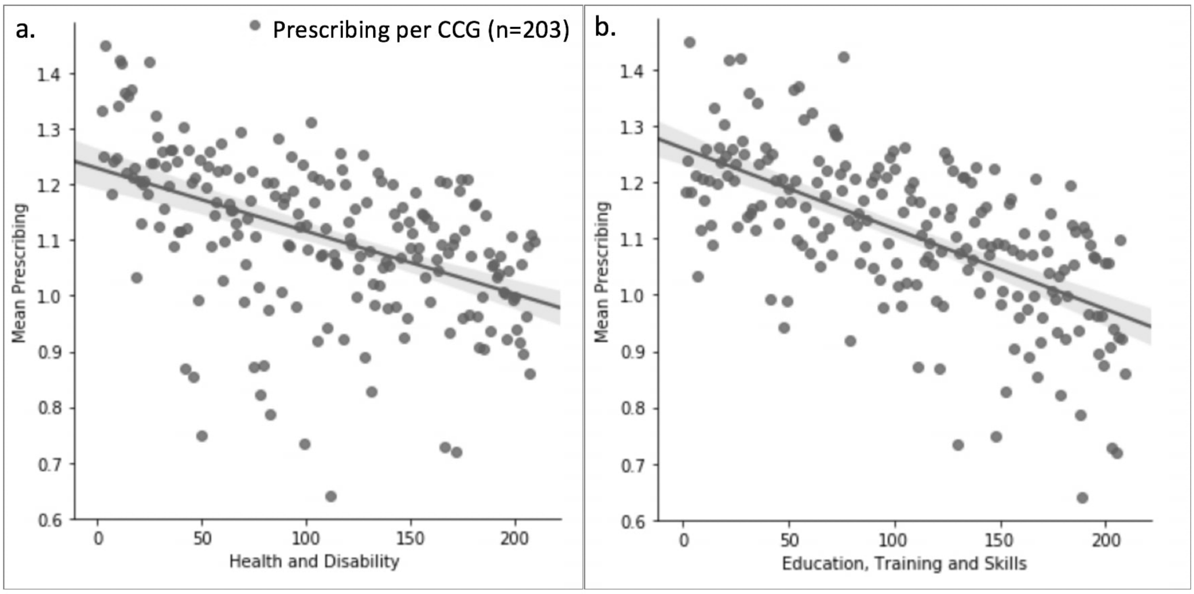

Figure 1. Mean prescribing (July 2014-December 2017) for Clinical Commissioning Groups (CCGs) in England (n=203) charted against deprivation measures for Health and Disability (a) and for Education, Training and Skills (b). Each point represents a single CCG. Deprivation is scaled from 1 (highest deprivation) to 203. For charts against other deprivation measures see Armon, 2018.

Discussion

These findings support the argument that sociodemographic deprivation plays a key role in accounting for antibiotic prescribing and may explain why the effects of deprivation are both controversial and inconsistent. One key factor is that previous studies have used the IMD or analogue measures as a cluster, thus overlooking the ways in which component indices predict prescribing, both negatively and positively.

Take for example the negative correlation between antibiotic prescribing and access to housing and services. Conceivably, restricted access to health services should limit access to the antibiotic treatments they offer. Therefore, in the specific case of prescribing, this measure may mask the impact of deprivation reflected in the IMD as a whole. In fact, when housing and services were excluded from the IMD, the remaining factors explained nearly 60% of the variation in prescribing (R^2=0.597). The IMD clusters factors that predict prescribing in opposite ways and need to be explored individually to better link antibiotic prescribing with social and/or economic determinants.

Overall, the IMD seems to reflect a host of lifestyle factors and choices in addition to health or socio-economic inequalities. It has long been recognized that individuals with lower socioeconomic status are disproportionately affected by infectious diseases in ways that are better explained by deprivation than by health care exposures.[6,13,14] However, if deprivation mainly reflects economic inequalities between regions in the UK this effect should be mediated by the income index. The finding that employment accounted for more of the variance in prescribing suggests that the impact of deprivation results of various factors beyond inequalities as such. The finding that employment was as explanatory as health foregrounds the complex relationship between social and medical determinants that need to be tackled in efforts to reduce unwarranted prescribing.

The significance of the education, skills, and training domain in explaining prescribing was observed in a previous study calculated on the 2004 IMD.[2] However, the practical significance of this finding was not fully explored. Public misconceptions about antimicrobial resistance were argued to hamper campaigns to reduce prescribing.[15] And yet, residents in both affluent and deprived areas expressed misconceptions about antimicrobial resistance[16,17,18]and antibiotic demand and consumption showed both negative and positive correlations with patients' education levels.[19,20]The indicator for education deprivation may thus reflect a host of factors involved in shaping antibiotic demand or provision. More specific studies should probe this indicator to identify regions calling for more effort to enhance public understanding of antibiotics use and misuse.

The role of employment, education and health as determinants of prescribing is illustrative of the complex causal nexus underlying the effects of deprivation on prescribing. Prescribing and deprivation are measured for each LSOAs, which are often composed of heterogenous populations. For this reason, any inference concerning the impact of individuals' deprivation on antibiotic consumption or demand needs to be viewed with extreme caution, and in conjunction with other datasets or studies of specific areas whenever available. But when a deprivation index is used, the values of the component indices should be taken into consideration as well. In addition to painting a more detailed picture of deprivation and its effects, they can be useful in identifying region-specific factors than need to be addressed when evaluating the prescribing of antibiotics and when designing interventions to reduce their consumption.

Acknowledgements

The author thanks Julian Flowers, Susan Hopkins (Public Health England) and Elizabeth Beech (NHS Improvement) for their useful advice.

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