Associations between socioeconomic deprivation and pharmaceutical prescribing in primary care in England

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Key Messages

- Prescribing rates of many medications are associated with socioeconomic deprivation
- We identify novel associations between prescribing and deprivation
- Drugs prescribed at higher rates in more deprived practices include non-opioid analgesics and salbutamol
- Contraceptives and travel vaccination prescriptions are associated with affluence
- Further investigation is required to confirm these relationships

Abstract

Background Socioeconomic deprivation is associated with health inequality. Previous studies have described associations between primary care prescribing rates and deprivation for individual drugs or drug classes. We explore the correlation between socioeconomic deprivation and the rate of prescribing of individual pharmaceutical drugs, and drug classes, in primary care in England, to identify prescribing inequalities that would require further investigation.

Methods In this cross-sectional study, national primary care prescribing data, by GP practice, were retrieved for the calendar year 2019 in England. Socioeconomic deprivation was quantified using the Index of Multiple Deprivation (IMD) score. Correlations were calculated using Spearman's rank correlation coefficient (ρ), adjusting for practice list size and demographics, with a Bonferroni-corrected *p* value threshold of $5x10^{-5}$.

Results We included 1.05 billion prescription items dispensed from 6896 England practices. 142/206 (69%) drug classes and 505/774 (65%) drugs were significantly correlated with IMD score ($p<5x10^{-5}$). Of the 774 included drugs, 31 (4%) were moderately positively associated with IMD score ($\rho>0.4$). Only one was moderately negatively correlated with IMD score ($\rho< -0.4$), suggesting higher prescribing rates in more affluent areas. The drug classes most strongly associated with IMD score included opioid and non-opioid analgesics, antipsychotics and reflux medications. Drug classes most strongly associated with affluence included adrenaline, combined oral contraceptives and hormone replacement therapy.

Conclusion We identify novel associations of prescribing with deprivation. Further work is required to identify the underlying reasons for these associations so that appropriate interventions can be formulated to address drivers of inequality.

Keywords: common illnesses, community medicine, health disparities, primary care, socioeconomic status, underserved populations,

Introduction

Health inequalities may be reflected in prescribing rates across selected drug classes. For example, higher volumes of statins are prescribed in more socioeconomically deprived parts of England, even after adjusting for the increased prevalence of cardiovascular diseases and diabetes in these communities[1]. Although prescriptions for antibiotics are generally falling, there is 20% more antibiotic prescribing in the most deprived centile of England compared to the most affluent centile[2]. Benzodiazepines and opioids are also prescribed in higher rates in English primary care practices serving more deprived populations[3,4]. Whilst this may, in part, reflect a higher prevalence of chronic pain and anxiety disorders in these areas, other hypotheses are offered. For example, GPs in more socioeconomically deprived areas may be more likely to be under significant time pressures because of the higher level of healthcare demand in the communities they're serving, in turn having less capacity for medication reviews. Furthermore, alternatives to medications, such as social prescribing, may not be as effective in areas where both resources and uptake are low[5]. Regardless of the underlying reasons, areas with increased prescribing are likely to have a higher incidence of medication-related side-effects and dependency. This iatrogenic morbidity could result in increased costs and even greater pressures on resources in these communities. It is also possible that some drugs are prescribed with higher frequency in areas of affluence.

Understanding the relationship between deprivation and prescribing is the first step in exploring the underlying reasons for differential prescribing and identifying where prescribing may be optimised. The aim of this investigation was to explore the correlation between socioeconomic deprivation and the rate of prescribing of individual pharmaceutical drugs, and drug classes, in primary care in England, to identify prescribing inequalities that would require further investigation.

Methods

Data Sources

This is a cross-sectional study using publicly available, nationally collected primary care data from England in 2019. Monthly primary care dispensing data between January and December 2019 were downloaded from NHS digital[6], along with the age and sex distribution of registered patients at each GP practice[7]. These datasets include, for each GP practice in England, the number of items dispensed for each unique drug preparation, as defined by British National Formulary (BNF) codes. Socioeconomic deprivation was quantified using the national Index of Multiple Deprivation (IMD) score for 2019 - a relative measure of deprivation. IMD scores for each practice were obtained from Public Health England's National General Practice Profiles[8].

Data Processing

BNF codes are 15-character codes that specify a unique drug product, dose and formulation. A unique drug, irrespective of dose, formulation or route is identified from the first nine digits of the code, and a drug "class" was defined to be a BNF paragraph (e.g. antibacterials, fibrinolytic drugs), as identified by the first seven digits of the BNF code. Monthly prescribing data for 2019 were aggregated by practice to create a single dataset for the year. Separate aggregations were then made by (1) individual drug and (2) individual drug class. Prescribing data were linked, by a unique GP practice identifier, to practice list size, the proportion of over-65s and males in the practice, and practice IMD scores. Only drugs and drug classes from the first 14 chapters of the BNF were analysed. This excluded chapters on anaesthesia, preparations used in diagnosis (e.g. X-ray contrast media), "other drugs and preparations" (e.g. poison antidotes and homeopathic preparations), dressings and appliances (e.g. stoma bags). Rarely prescribed items, defined as fewer than 1000 prescriptions being dispensed over the year across England, were also excluded.

Data Analysis

Prescribing rates were calculated as the number of items dispensed per 1000 registered patients in a practice. The association between drug, or drug class, prescribing rate and practice IMD score was calculated using Spearman's rank correlation coefficient. Adjusted (partial) correlation coefficients were calculated to account for practice list size, the proportion of males and the proportion of over-65s in each practice. All correlation coefficients presented here are adjusted. To account for multiple testing, a Bonferroni-adjusted significance threshold was used. We anticipated that there would be a maximum of 1000 tests performed, and thus set an *a priori* threshold of $p < 5 \times 10^{-5}$. Data were visually presented using bubble charts, with bubble size proportional to the total number of items prescribed. Adjusted correlation coefficient cut-offs of +/-0.2 and +/-0.4 represent weak and moderate correlations. All data processing and analysis was performed, and all plots generated, using the software R (v3.6)[9]. Interactive versions of the included figures, and the R code written to perform the analysis and generate the plots, are available on the GitHub page https://github.com/sirsazofduck/2020MooneyJ. No ethical approval was required as all datasets used are publicly available and contain non-identifiable aggregate data.

Results

In total, 774 drugs and 206 drug classes were included in the analysis, with 1.05 billion prescription items dispensed from 6896 practices. The prescribing rate of most analysed drugs have a significant association with practice IMD score, using the Bonferroni-adjusted *p* value threshold (*Suppl. Figure S1*). Medications are more likely to be positively correlated with IMD score than negatively correlated (see below and *Figure 1*), i.e. it is more common for drugs to be prescribed at higher rates in practices with more socioeconomically deprived patients, rather than at higher rates in more affluent practices.

Individual Drugs and Drug Classes

Of 206 included drug classes, 64 (31%) had an adjusted ρ between 0.2 and 0.4, and a further 30 (15%) had an adjusted ρ greater than 0.4. Only 4 drug classes (2%) had an adjusted correlation coefficient less than -0.2, with just one being moderately correlated with affluence ($\rho < -0.4$, *Suppl. Figure S2 and S3*). Similar results were seen with individual drugs: of the 774 included drugs, 137 (18%) had an adjusted ρ between 0.2 and 0.4, and a further 31 (4%) had an adjusted ρ greater than 0.4, suggesting a moderate correlation between prescribing rate and IMD score. Conversely, only 10 drugs (1.2%) had an adjusted correlation coefficient less than -0.2, with only one drug having a correlation coefficient less than -0.4 (i.e. with prescribing rates that were higher in more affluent areas).

The drug classes most strongly positively correlated with socioeconomic deprivation are shown in *Table 1*. These included both non-opioid and opioid analgesics (adjusted ρ=0.67 and 0.57, respectively), adrenoreceptor agonists (ρ=0.64, such as salbutamol) and drugs used to treat epilepsy (ρ=0.56). Listing drugs individually, tramadol (ρ=0.59) and gabapentin (ρ=0.57) were most correlated with deprivation (*Suppl. Table S1*). Indeed, five of the top ten drugs most associated with deprivation were analgesics.

Table 1. The ten drug classes with prescribing rates most positively correlated with Index of Multiple Deprivation score.

The prescribing rates of these drug classes tend to be greater in more socioeconomically deprived practices. Ranking based on partial ρ values, adjusted for practice age and sex distribution and practice list size. Drug class defined as a paragraph within the British National Formulary. Number of items are aggregated across all included practices in 2019.

		Unadjusted		Adjusted	
Drug Class	**Items Prescribed**	**rho (ρ)**	**p value**	**partial rho (ρ)**	**p value**
Non-opioid analgesics	34,165,830	0.43	$< 1 \times 10^{-20}$	0.67	$< 1 \times 10^{-20}$
Adrenoceptor agonists (e.g. salbutamol)	23,140,066	0.46	$< 1 \times 10^{-20}$	0.64	$< 1 \times 10^{-20}$
Opioid analgesics	22,911,035	0.26	$< 1 \times 10^{-20}$	0.57	$< 1 \times 10^{-20}$
Epilepsy medications	28,554,014	0.37	$< 1 \times 10^{-20}$	0.56	$< 1 \times 10^{-20}$
Antimuscarinic bronchodilators	5,426,604	0.32	$< 1 \times 10^{-20}$	0.56	$< 1 \times 10^{-20}$
Antispasmodic agents	4,614,661	0.30	$< 1 \times 10^{-20}$	0.54	$< 1 \times 10^{-20}$
Topical non-steroidals and rubefacients	7,040,637	0.40	$< 1 \times 10^{-20}$	0.52	$< 1 \times 10^{-20}$
Corticosteroids (respiratory)	21,016,562	0.27	$< 1 \times 10^{-20}$	0.52	$< 1 \times 10^{-20}$
Nitrates	6,373,770	0.31	$< 1 \times 10^{-20}$	0.52	$< 1 \times 10^{-20}$
Drugs used in nausea and vertigo	5,978,801	0.27	$< 1 \times 10^{-20}$	0.51	$< 1 \times 10^{-20}$

Drug classes that were most strongly negatively correlated with deprivation (i.e. that were prescribed at higher rates in more affluent areas) were those relating to allergic emergencies (ρ= -0.49), combined hormonal contraceptives (ρ= -0.33) and female sex hormones (hormone replacement therapy, ρ= -0.24, *Table 2*). At the individual drug level, adrenaline prescribing was most strongly associated with affluence (ρ= -0.48, *Suppl. Table S2*). Of the top ten drugs most correlated with affluence, six were female reproductive hormones used for contraception, menstrual bleeding disorders and hormone replacement therapy, and three were travel-related vaccines.

A complete list of all studied drugs and drug classes, along with the unadjusted and adjusted correlation coefficients and *p* values, is given in *Supplementary Table S3* and *S4*, respectively.

Table 2. The ten drug classes with prescribing rates most negatively correlated with Index of Multiple Deprivation score.

The prescribing rates of these drug classes tend to be greater in more affluent (less socioeconomically deprived) practices. Ranking based on partial rho values, adjusted for practice age and sex distribution and practice list size. Drug class defined as a paragraph within the British National Formulary. Number of items are aggregated across all included practices in 2019.

		Unadjusted		Adjusted	
Drug Class	**Items Prescribed**	**rho (ρ)**	**p value**	**partial rho (ρ)**	**p value**
Allergic emergencies (e.g. adrenaline auto-injectors)	377,707	-0.53	$< 1 \times 10^{-20}$	-0.49	$< 1 \times 10^{-20}$
Preparations for vaginal/vulval changes	1,642,317	-0.56	$< 1 \times 10^{-20}$	-0.34	$< 1 \times 10^{-20}$
Combined hormonal contraceptives/systems	3,658,554	-0.42	$< 1 \times 10^{-20}$	-0.33	$< 1 \times 10^{-20}$
Female sex hormones & their modulators	3,913,946	-0.45	$< 1 \times 10^{-20}$	-0.24	$< 1 \times 10^{-20}$
Herpesvirus infections	968,545	-0.37	$< 1 \times 10^{-20}$	-0.17	$< 1 \times 10^{-20}$
Vehicles & emulsifying agents	69,865	0.00	0.9	-0.17	2.4×10^{-14}
Oral preparations for acne	104,077	-0.12	$< 1 \times 10^{-20}$	-0.15	$< 1 \times 10^{-20}$
Sunscreening preparations	375,962	-0.38	$< 1 \times 10^{-20}$	-0.11	1.6×10^{-18}
Topical preparations for acne	1,546,097	-0.02	0.053	-0.09	1.7×10^{-13}
Quinolones	522,424	-0.26	$< 1 \times 10^{-20}$	-0.08	1.1×10^{-10}

British National Formulary Chapters

The BNF chapter with the drug classes having the greatest association with deprivation was that relating to the central nervous system (*Figure 2*). Other than opioid analgesics and drugs used to control epilepsy (which include gabapentin and pregabalin, both of which are also used in the management of chronic pain), this section includes antipsychotics (ρ=0.49), selective serotonin reuptake inhibitors (such as fluoxetine, ρ=0.42) and tricyclic antidepressants (ρ=0.47).

Another BNF chapter with a number of drug classes strongly correlated with deprivation was that relating to the respiratory system (*Figure 3*). All but one of these classes are prescribed in greater amounts in more deprived practices, including mucolytics (ρ=0.47), theophylline (ρ=0.42), and antihistamines (ρ=0.38).

In addition to the top ten list given in *Table 1*, other drug classes moderately positively correlated with deprivation include proton pump inhibitors (ρ=0.44), insulin (ρ=0.45), other antidiabetic drugs (ρ=0.44), and antiplatelet agents (ρ=0.40).

A complete set of figures showing the correlation coefficients and significance of drug classes for each BNF chapter is given in *Supplementary Figures S4 to S17*.

Discussion

We explored the correlation between socioeconomic deprivation and the rate of prescribing of individual pharmaceutical drugs, and drug classes, in primary care in England, to identify prescribing inequalities that would require further investigation. Medication prescriptions for most individual drugs and drug classes increased with increasing deprivation. After adjusting for practice list size and age and sex make-up, this positive correlation was at least moderate for 31/774 (4%) of individual drugs and 30/206 (15%) of drug classes. Only one drug and one drug class were moderately negatively correlated with deprivation (prescribed more frequently in more affluent settings), although there were many other drugs with weaker statistically significant negative correlations. In seeking an explanation for these findings, further work would require an exploration of a combination of societal factors (including the wider determinants of health, such as education and employment), healthcare system factors (such as prescribing habits and staffing adequacy) and patient-level factors (such as differences in the prevalence of chronic disease).

Comparison to Previous Literature

Some of the associations found in this study align with previous research, and other findings are novel. The drug categories that are most strongly correlated with deprivation include analgesics, both opioids - such as tramadol and co-codamol - and non-opioids, including non-steroidal anti-inflammatory drugs (NSAIDs), gabapentin and pregabalin. An association between opioid prescribing and deprivation In England has previously been described[3], although that study did not adjust for covariates. A recent review into medications associated with dependence by Public Health England also found that gabapentinoid and opioid use was associated with deprivation, and that co-prescribing of both drug classes was 1.4 times more common in the most deprived practices[10]. The prevalence of chronic pain has been shown to be correlated with low socioeconomic status, for both musculoskeletal[11] and neuropathic pain[12]. Furthermore, deprivation is associated with poor outcomes following pain management[13]. Taken together, it is possible that the increased prescribing rate of analgesics in

deprived practices reflects the underlying prevalence and duration of chronic pain. However, further work is needed to exclude other potential contributors, such as lack of access to drug dependency services and the prevalence of complex mental health problems.

There are many other health conditions whose prevalence varies with deprivation. This underlying variation may partially explain differential levels of prescribing. For example, epilepsy drugs (including those other than gabapentinoids) were found to have one of the strongest correlations with deprivation in this study. Epilepsy is known to have a higher incidence in more deprived areas[14]. Cardiovascular disease, asthma, COPD and diabetes have a well-characterised association with deprivation in terms of prevalence and severity[15-20]. Social and behavioural factors play a key role in the pathogenesis and severity of these conditions[21]. We found that drugs used to manage these chronic diseases are prescribed in higher rates in the most deprived areas, including nitrates, antiplatelets, lipid-lowering medications, inhalers, theophylline, and antidiabetic drugs such as metformin and insulin.

A simple explanation for these findings would be that prescribing rates are purely a reflection of underlying disease burden and thus of healthcare need. However, there is a possibility that inequalities in prescribing or wider management exist in addition to inequalities in health status. Indeed, we previously found that higher rates of antipsychotics were prescribed in more deprived areas after adjusting for the prevalence of psychosis, dementia and depression, as well as for demographic factors[22]. In that case, the higher prescribing may reflect a lack of alternative non-pharmacological management options in areas of socioeconomic deprivation, such as psychological therapy and social support, although this is yet to be investigated. In another study of asthma, we found that rates of salbutamol inhaler prescribing were higher in more deprived areas after adjusting for the prevalence of asthma, COPD and smoking[23]. High salbutamol use is related to inadequate day-to-day management of asthma, and further investigation found that practices with higher salbutamol prescribing were also less likely to provide asthma patients with regular medication reviews. These

examples suggest that prescribing inequalities require investigation as they may highlight wider inequalities that need to be addressed beyond the mere prevalence or severity of a disease. Possibilities include issues with health literacy, inadequate provision for those using languages other than English, sub-cultural preferences for alternative therapies, and difficulties in attending appointments.

Interestingly, prescribing in areas of women's health is significantly correlated with deprivation, with both hormone replacement therapy (HRT) and combined oral contraception being prescribed more in affluent areas. A study from 2009 suggested that women from lower and middle social classes were less likely to use contraception in general[24], and this may still be the case. We recently described the finding of increased HRT prescribing in areas of affluence, where this association remained after adjusting for additional factors that may influence prescribing, such as smoking, obesity and cardiovascular disease[25]. Whilst contraception can be obtained from alternative services, such as community genitourinary medicine clinics and pharmacies (which are not represented in the analysed data), our findings suggest the possibility of a gap of provision, or in accessing provision, of women's healthcare services.

Other novel associations found in this study include the higher rate of adrenaline and travel-related vaccine prescribing in more affluent practices, and the higher rate of antihistamine, antacid and topical dermatological agents, and of vitamin supplementation, in more deprived practices. In the case of adrenaline, which is often prescribed in the form of auto-injectors for those at risk of a severe allergic reaction, it is possible that individuals in more affluent areas are more likely to seek medical attention for allergies. The higher prescribing rates of certain upper gastrointestinal medications in areas of deprivation, along with vitamin supplements, may be influenced by differences in diet or in health-seeking behaviours, or may reflect an inability for individuals to afford over-the-counter options. Such hypotheses will need to be the focus of further investigation.

Strengths, Limitations and Further Work

This work examined prescribing in all NHS primary care practices in England, as captured by NHS Digital. As such, it has used a robust and unbiased data source for reviewing prescribing associations. The Index of Multiple Deprivation score was recently updated (in 2019), so the deprivation scores assigned to individual practices are an up-to-date marker of their population deprivation status. A hypothesis-free approach was taken to examining the associations between deprivation and prescribing, and a conservative *p* value threshold to account for multiple testing was used to minimise the risk of reporting falsely significant correlations.

There are limitations to the current study. Firstly, data are from one year only, and prescription rates and deprivation were aggregated at the primary care practice level, so it is not known which individuals were given specific prescriptions, nor how many or for what reasons. For example, some epilepsy drugs may be prescribed for epilepsy or the management of pain, and it is impossible to identify the indications from aggregate data. Secondly, the IMD score is used as a surrogate marker of deprivation but is not a direct measure. Finally, this study aimed to identify which drugs are potentially significantly associated with deprivation. It is important to acknowledge these as preliminary findings that need to be used as the foundation for further work, specifically examining prescribing at the individual patient level, adjusting for underlying clinical and demographic factors to confirm associations, and they may not apply to healthcare settings outside of England. Where these exist, investigation is required into the reasons for prescribing inequalities, to identify where corrective intervention is required in order to improve outcomes for patients.

Conclusion

Socioeconomic deprivation is correlated with higher rates of prescriptions for a large number drugs, though a few are also correlated with affluency. The reason behind many of these associations is unclear and may be explained through a combination of differences in disease prevalence rates, in the wider determinants of health including behavioural factors, in access to health and social care, and in the prescribing and management practices in different settings. More research is required into each of these associations to confirm the findings, to identify the underlying reasons for the observed inequality between communities, and to formulate appropriate interventions to ensure that every individual receives the level of care that they require.

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Data Availability Statement: The data sources used in this study are publicly available and have been referenced within the manuscript. The analysis code is available on the project GitHub page:

https://github.com/sirsazofduck/2020MooneyJ

References

1. Ashworth M, Lloyd D, Smith RS, Wagner A, Rowlands G. Social deprivation and statin prescribing: a cross-sectional analysis using data from the new UK general practitioner 'Quality and Outcomes Framework'. *J Public Health (Oxf).* 2007;29(1):40-47.
2. Wise J. Antibiotic prescribing is higher in deprived areas of England. *BMJ.* 2015;351:h6117.
3. Mordecai L, Reynolds C, Donaldson LJ, de CWAC. Patterns of regional variation of opioid prescribing in primary care in England: a retrospective observational study. *Br J Gen Pract.* 2018;68(668):e225-e233.
4. Soyombo S, Stanbrook R, Aujla H, et al. Socioeconomic status and benzodiazepine and Z-drug prescribing: a cross-sectional study of practice-level data in England. *Fam Pract.* 2020;37(2):194-199.
5. Pescheny J, Randhawa G, Pappas Y. Patient uptake and adherence to social prescribing: a qualitative study. *BJGP Open.* 2018;2(3):bjgpopen18X101598.
6. NHS Digital , 2019. Practice-Level Prescribing Data. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/practice-level-prescribing-data [Last accessed May 2020].
7. NHS Digital, 2019. Patients Registered at a GP Practice. Available at: https://digital.nhs.uk/data-and-information/publications/statistical/patients-registered-at-a-gp-practice [Last accessed May 2020].
8. Public Health England, 2019. National General Practice Profiles. Available at: https://fingertips.phe.org.uk/profile/general-practice [Last accessed May 2020].
9. R Core Team, 2019. R: A Language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: http://www.R-project.org [Last accessed May 2020].
10. Taylor S, Annand F, Burkinshaw P et al. Dependence and withdrawal associated with some prescribed medicines: an evidence review. Public Health England, London. 2019.
11. Gran JT. The epidemiology of chronic generalized musculoskeletal pain. *Best Pract Res Clin Rheumatol.* 2003;17(4):547-561.
12. Torrance N, Smith BH, Bennett MI, Lee AJ. The epidemiology of chronic pain of predominantly neuropathic origin. Results from a general population survey. *J Pain.* 2006;7(4):281-289.
13. Carr JL, Moffett JA. The impact of social deprivation on chronic back pain outcomes. *Chronic Illn.* 2005;1(2):121-129.
14. Heaney DC, MacDonald BK, Everitt A, et al. Socioeconomic variation in incidence of epilepsy: prospective community based study in south east England. *BMJ.* 2002;325(7371):1013-1016.
15. Collins PF, Stratton RJ, Kurukulaaratchy RJ, Elia M. Influence of deprivation on health care use, health care costs, and mortality in COPD. *Int J Chron Obstruct Pulmon Dis.* 2018;13:1289-1296.
16. Jacobs E, Tonnies T, Rathmann W, Brinks R, Hoyer A. Association between regional deprivation and type 2 diabetes incidence in Germany. *BMJ Open Diabetes Res Care.* 2019;7(1):e000857.
17. Poyser MA, Nelson H, Ehrlich RI, et al. Socioeconomic deprivation and asthma prevalence and severity in young adolescents. *Eur Respir J.* 2002;19(5):892-898.
18. Pujades-Rodriguez M, Timmis A, Stogiannis D, et al. Socioeconomic deprivation and the incidence of 12 cardiovascular diseases in 1.9 million women and men: implications for risk prediction and prevention. *PLoS One.* 2014;9(8):e104671.
19. Schultz WM, Kelli HM, Lisko JC, et al. Socioeconomic Status and Cardiovascular Outcomes: Challenges and Interventions. *Circulation.* 2018;137(20):2166-2178.
20. Ward K, Hubbard R. Is adult height related to the risk of having chronic obstructive pulmonary disease? *J Epidemiol Community Health.* 2011;65(3):226-229.
21. Meader N, King K, Moe-Byrne T, et al. A systematic review on the clustering and co-occurrence of multiple risk behaviours. *BMC Public Health.* 2016;16:657.

22. Ridha A, Stanbrook R, Proto W et al. The relationship between antipsychotic prescribing and the proportion of those with psychosis with a care plan: a cross-sectional study of practice-level data in England. Conference abstract: Society for Academic Primary Care Conference, Bristol, UK. 2020.
23. Saravanamuthu P, Roberts S, Aujla H et al. The association between salbutamol prescribing and socioeconomic deprivation: a cross-sectional analysis of primary care practice-level data in England. Conference abstract: Midlands Academy of Medical Sciences Conference, Birmingham, UK. 2019.
24. Bentley R, Kavanagh A, Smith A. Area disadvantage, socioeconomic position and women's contraception use: a multilevel study in the UK. *J Fam Plann Reprod Health Care.* 2009;35(4):221-226.
25. Hillman S, Shantikumar S, Ridha S, Todkill D, Dale J. Socioeconomic status and HRT prescribing: a study of practice-level data in England. *Br J Gen Pract.* 2020 (in press).

Figure 1. Correlation coefficients of prescribing rates and practice Index of Multiple Deprivation score relationships by individual drug.

Each bubble represents one drug, with the area of the bubble proportional to the number of items dispensed in 2019 in England. Drugs are ordered along the x-axis by their position in the British National Formulary (BNF) and colour-coded by chapter. Drug names and *p* values are not shown here but can be viewed on the interactive online version. A similar plot showing *p* values can be found in *Supplementary Figure S1*.

Figure 2. Correlation coefficients of central nervous system drug classes and their association with Index of Multiple Deprivation score.

Drug classes are given along the x-axis in their order in the British National Formulary (chapter 4). Bubble area is proportional to the number of prescriptions dispensed in primary care in 2019. Statistically significant associations are signified by red bubbles. A positive correlation coefficient reflects a tendency towards greater prescribing in more socioeconomically deprived practices. Some bubbles are annotated. All drug class names, number of items, correlation coefficients and *p* values can be viewed on the interactive online version.

Figure 3. Correlation coefficients of respiratory system drug classes and their association with Index of Multiple Deprivation score.

Drug classes are given along the x-axis in their order in the British National Formulary (chapter 3). Bubble area is proportional to the number of prescriptions dispensed in primary care in 2019. Statistically significant associations are signified by red bubbles. A positive correlation coefficient reflects a tendency towards greater prescribing in more socioeconomically deprived practices. Some bubbles are annotated. All drug class names, number of items, correlation coefficients and *p* values can be viewed on the interactive online version.