Association between paediatric antibiotic prescribing and socioeconomic deprivation: insights from a pilot project in West Yorkshire, United Kingdom

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Short Report

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Abstract

Background

Inappropriate antibiotic use in settings including human and veterinary medicine and a lack of novel therapies have contributed to a global antimicrobial resistance (AMR) crisis. In January 2025, the UK Health Security Agency revised the UK Access, Watch, Reserve (AWaRe) antibiotic list to guide prescribing of 90 antibiotics. This pilot study investigated relationships between socioeconomic deprivation and paediatric antibiotic prescribing in secondary care in the Mid Yorkshire Teaching NHS Trust region, UK.

Methods

Retrospective antibiotic prescribing data was obtained from the NHS Trust's electronic prescribing system for patients aged 0–2 years prescribed systemic antibiotics between April 2022 and January 2025, the start of the Born and Bred in Wakefield (BaBi) Wakefield project. Demographic data retrieved from electronic clinical and management information system included ethnicity, admission and discharge date, ICD-10 diagnostic codes, and IMD decile, converted to quintile for statistical analysis. Quasi-Poisson count regression approach was used to explore the relationship between the rate of antibiotic prescription, socioeconomic deprivation, and region.

Results

A total of 780 patients and 2204 antibiotic prescriptions were identified from hospital prescribing report. Adjusted models identified four key findings. Firstly, length of stay (LOS) in hospital and number of diagnostic codes were highest in the most deprived group (Q1). Secondly, the number of unique antibiotics prescribed (adjusted per admission) was highest in the least deprived group(Q5) although this relationship was not statistically significant. Thirdly, the number of unique antibiotics (adjusted per LOS) was highest in Q5, and this was statistically significant (p = xxx). Finally, in contrast with other studies in the UK, ethnicity was not significantly associated with the use of systemic antibiotics.

Conclusion

Our findings suggest that children from more deprived areas with more comorbidities/ diagnosis received less antibiotics in secondary care settings compared with their peers from least deprived areas. The LOS and number of diagnostic codes also decreased from Q1 to Q5. Future prescribing trends among children aged 0-2years should account for contextual factors to ensure that children from the most deprived communities are not disproportionately exposed to less antibiotics despite of suffering more comorbidities.

Introduction

Inappropriate antibiotic use in all settings, including human and veterinary medicine, and the lack of novel therapies, have contributed to a global antimicrobial resistance (AMR) crisis. AMR has evolved from a silent pandemic to a global public health emergency resulting in increased mortality and longer hospitalisation, with negative impact on the economies of families, communities and countries [1]. The World Health

Organisation (WHO) has declared AMR as one of the top ten threats to global health security [2]. It is indiscriminate of country border or income levels and causes about 9% of all global deaths [3].

AMR directly causes 1.3 million deaths annually, with a further 5 million associated deaths, 20% of which occur in children under five years of age [4]. This surpasses deaths from Human immunodeficiency virus (HIV), malaria and tuberculosis combined. By 2050, over 39 million people are projected to die from antibiotic-resistant infections [5]. The World Bank estimates that, without effective control, AMR could lead to US$3.4 trillion annual losses to gross domestic product by 2030 and an additional US$1 trillion health care costs by 2050, pushing 28 million people into extreme poverty [6].

Rational use of antibiotics is a critical measure for controlling AMR. The United Kingdom Health Security Agency (UKHSA) updated the UK Access, Watch, Reserve (AWaRe) antibiotic list in January 2025 to provide guidance on use of 90 antibiotics for healthcare professionals in primary and secondary care [7]. However, between 8.8% and 23.1% of antibiotic prescriptions in England are deemed inappropriate [8]. In England, higher antibiotic prescribing levels have been associated with Index of Multiple Deprivation (IMD) and certain geographical locations. Of the seven English regions, there is disproportionately high number of prescriptions per 100,000 population in North West (56.3%), and North East and Yorkshire (26.7%) [9].

Several studies have examined factors associated with high rates of antibiotic prescribing in the UK. A study conducted in England from 2014-18 investigated the relationship between primary care antibiotic prescription and area-level deprivation as well as region, after controlling for a range of other confounding variables, including rurality, ethnicity and health need [10]. A time series analysis in England from 2014–22 explored the link between primary care antibiotic prescriptions, locality and deprivation. [9]. A Welsh study from 2013–17 examined the association between primary care antibiotic prescribing and deprivation, controlling for common chronic conditions and other potential confounders [11]. While the three studies investigated antibiotic prescription patterns in primary care, none of them focused on the exposure to antibiotics among paediatric and neonatal patients, nor did they investigate antibiotic prescription in secondary care. To fill the gap in literature, our group aimed to explore the association between socioeconomic deprivation and exposure to antibiotics among children in secondary care settings in the UK.

In this study, we aimed to identify relationships between paediatric antibiotic prescribing and IMD in the Mid Yorkshire Teaching NHS Trust region (Wakefield and North Kirklees Integrated Care Board Places, West Yorkshire, UK).

Methods

Using the Trust's electronic prescribing system (Medchart®, Dedalus, Italy), patients aged 0–2 years who had been prescribed and administered antibiotics from 28 April 2022, the start of the Born and Bred in Wakefield (BaBi) Wakefield project, to 19 January 2025 were identified. BaBi Wakefield is a long-term research project that involves the collection of data during pregnancy about mothers and babies to provide a wider picture of the factors affecting local family's health and wellbeing [12].

Only patients with a Wakefield (WF) postcode were considered, including WF postcodes in Kirklees, a metropolitan borough of West Yorkshire [1[3]. Antibiotics were defined following the British National Formulary Chap. 5 specification. Only intravenous and oral antibiotics were included in the main analysis as these were considered the targets for antimicrobial stewardship and main drivers of AMR. Antibiotics were then grouped according to the WHO AWaRe classification. Microbiology clinical results, including blood, urine, sputum and clinical swabs were collated from iLAB® (iLAB solutions LLC, Agilent technologies Inc, California, USA). Demographic data were retrieved from eCAMIS® (Electronic clinical and management information system, University Hospitals Southampton, UK), including ethnicity, admission and discharge date, ICD-10 (International Classification of Diseases; WHO, 2019) diagnostic codes, IMD decile, converted to quintile for statistical analysis.

Using a Quasi-Poisson count regression approach, we tested the hypothesis that socioeconomic deprivation influences the rate of antibiotic prescriptions for patients aged 0–2 years in hospital. The sample population was divided into quintiles by socioeconomic status, with Q1 being the most deprived and Q5 the least deprived. Q4 and 5 were combined, allowing comparison of the most deprived 40% with the least deprived 40%. The distribution of Q3 was not consistent with the other quintiles, and so it was treated separately.

The response variable captured the interaction between the number of drugs prescribed and the number of diagnoses, reflecting treatment complexity. This is referring to the multifaceted nature of delivering healthcare to patients, particularly when managing multiple medical conditions simultaneously. In the context of this study, treatment complexity specifically reflects the combined influence of the number of medications prescribed (unique antibiotics) and the number of medical conditions being treated (diagnoses). This combination is an important indicator of how intricate a patient's care regimen is.

For example, a higher number of unique antibiotics prescribed suggests that more medications are being used, which may be due to the need to address multiple, possibly interrelated conditions. Similarly, a greater number of diagnoses typically indicates more health issues to manage, further complicating treatment decisions. When these two factors are considered together as an interaction, they represent the compounded intricacies involved in addressing a patient's healthcare needs.

Treatment complexity also inherently considers: (i) medication interactions, where the potential for prescribed drugs to interact with each other requires careful monitoring and adjustments; (ii) resource utilisation, where the level of healthcare resources, coordination, and diverse expertise are needed to manage the patient's care effectively; and (iii) patient outcomes, representing the challenges in achieving desired health outcomes, as treatment complexity can increase the risk of complications or reduce treatment adherence. In this study, treatment complexity is quantified as the interaction between the number of unique drug names and the number of diagnoses, providing a meaningful measure of the challenges healthcare providers face in delivering appropriate care.

To ensure the model estimated rates rather than raw counts, the logarithm of the number of hospital admissions was included as an offset. The analysis was conducted using R version 4.4.3 (R Foundation for Statistical Computing, Vienna, Austria).

Approval for this project was given by the Trust's research committee through an internal pump-priming grant to enable a National Institute for Health and Care Research grant application. Ethics approval was not required as this was considered a service improvement project with a view to further research.

Results

A total of 780 patients and 2204 antibiotic prescriptions were identified from the initial hospital prescribing report. Intravenous and oral antibiotics were grouped for further analysis (690 patients; 1907 prescriptions). The breakdown of population by IMD quintiles was Q1–313 (45%), Q2–154 (22%), Q3–109 (16%), Q4–88 (13%), and Q5–26 (4%). The average number of antibiotics per admitted patient, per IMD quintile, is shown in Table 1.

The total length of stay (LOS) for all admitted patients reduced on moving from Q1 to Q5 as reflected in Table 1. The number of diagnostic codes also reduced from Q1 to Q5. The number of unique antibiotics (adjusted per admission) increased from Q1 to Q5, and this was not statistically significant. However, the number of unique antibiotics (adjusted per LOS) increased from Q1 to Q5, and this was statistically significant ($p < 0.05$).

Table 1
IMD quintile vs number of admitted patients and average number of antibiotics per admitted patient in Wakefield [13].

IMD quintile	Population IMD by LSOA# - Wakefield Total (%)	Total number of admitted patients within IMD quintile (%)	Average number of antibiotics per admitted patient	Average length of stay*	Average Number of diagnostic codes*	Average number of unique antibiotics (adjusted per admission)*	Average number of antibiotics per admitted patient*
1 (Most deprived)	30.00	313 (45)	2.64	5.94	13.28	1.17	2.77
2	28.30	154 (22)	3.05				
3	13.30	109 (16)	2.58	4.4	10.42	1.14	2.58
4	18.40	88 (13)	2.95	4.4	9.21	1.11	2.90
5 (Least deprived)	10.00	26 (4)	2.73				

**Average obtained by combining quintiles (1–2) and combining quintiles (4–5).*

 # Lower Layer Super Output Areas (LSOAs) are small geographic areas created by The Office for National Statistics (ONS) for statistical analysis and reporting in England and Wales. Each LSOA contains approximately 1,000 to 3,000 residents, allowing for a detailed examination of local demographics, social conditions and economic factors.

The total number of antibiotics prescribed did not significantly differ across IMD quintiles following the generation of both preliminary Poisson model coefficients and the alternative Quasi-Poisson or Negative Binomial model ($p > 0.1$). The number of unique antibiotics prescribed did not substantially differ across IMD quintiles and this was borne out by both the preliminary Poisson model coefficients and the alternative Quasi-Poisson model.

The final Quasi-Poisson model, offset by the log transformed LOS, was re-estimated using the interaction of the number of unique antibiotics and the number of diagnoses as the response. Considering combined Q1 and Q2 as the reference, the model showed that the interaction between unique antibiotics and diagnoses was significant in the combined Q4 and Q5 (coefficient= -0.4261, $p = 0.0096$) while gender ($p = 0.6897$) and race ($p = 0.5947$) were not statistically significant.

Discussion

Our project identified that more patients were admitted to hospital from Q1 and Q2 (most deprived; 67% vs 58.3% in the general population) compared to 17% vs 28.4% from Q4 and Q5. The LOS and number of diagnostic codes decreased from Q1 to Q5 while there was a statistically significant increase in the use of antibiotics from Q1 to Q5. This suggests that more deprived children with more diagnoses (more comorbidity) received less antibiotics compared with those in Q4 and Q5. The longer LOS among the children from the lower quintiles could have played a role in the observed differences although the exact nature of the relationship remains unclear. The longer LOS should have theoretically exposed the children to more antibiotic courses, but the reverse appeared to be the case. It is possible that the more deprived children (who also appeared to have more comorbidities) were more extensively investigated resulting in longer LOS but less use of antibiotics as non-infectious diagnoses were uncovered during the course of the admission. We used the number of unique antibiotics prescribed to represent antibiotic consumption. It is possible that the use of other more standardised indices for measuring antibiotic consumption, such as the Defined Daily Dose (DDD), could have provided deeper insights. The DDD is defined as the assumed average maintenance dose per day for a drug used for its main indication in adults [14]. Further research is required to fully understand this preliminary data.

We found that ethnicity was not significantly associated with the use of systemic antibiotics. This contrasts with reports from other studies in the UK that showed a strong link between ethnicity and antibiotic consumption [15–17]. In a recent scoping review, 32/58 studies (55%) included race/ethnicity and 22/58 (38%) showed an association between race/ethnicity and antibiotic use, particularly in acne and dental infections [18].

Despite concerted efforts by national governments and health systems to tackle AMR through antimicrobial stewardship (AMS), antibiotics continue to be prescribed needlessly for self-limiting conditions. Respiratory tract infections are responsible for 74.4% of antibiotic prescriptions in children [19], despite their marginal beneficial effects [20]. However, exposing children to antibiotics is not without its risks. Antibiotic use alters the diversity of the gut microbiome thus impairing immunity, colonisation resistance, and metabolic homeostasis [21]. Analysis of a birth cohort of 12,422 children born at full term found a notable attenuation of weight and height gain during the first 6 years of life after neonatal antibiotic exposure in boys with significantly higher body mass index in both boys and girls who were exposed to antibiotics after the neonatal period but during the first 6 years of life [22]. A systematic review and meta-analysis of 160 observational studies investigating 21 outcomes in 22,103,129 children showed that antibiotic exposure was associated with an increased risk of atopic dermatitis, food allergies, allergic rhinoconjunctivitis, asthma, obesity, juvenile idiopathic arthritis, psoriasis and neurodevelopment disorders [23]. Thus, appropriately limiting the exposure of children to antibiotics has both short- and long-term benefits.

To deliver targeted antimicrobial stewardship (AMS) and tackle AMR locally, further research is needed to explore antibiotic prescription practice and use in local communities. The British National Formulary [24] defines AMS as an organizational or healthcare system-wide approach to fostering and monitoring the judicious use of antimicrobials to preserve their future effectiveness and prevent antimicrobial resistance. Addressing AMR through enhancing stewardship remains a national medicines optimization priority, led by NHS England. In Fig. 1 we propose a conceptual framework depicting core elements of a package of AMS strategies that be deployed to tackle antimicrobial resistance in local healthcare systems and communities. Figure 1 was adapted from the UK’s summary of 2024–2029 National Action Plan for tackling antimicrobial resistance in the UK [25]. The conceptual framework can be used to investigate how inputs (in this case the AMS strategies) can lead to intermediate outcomes and how outcomes can lead to anticipated longer-term impacts. The conceptual framework also outlines a program theory (see the upper part of Fig. 1) of how the AMS programme of work is expected to generate a change along with contextual factors that can influence change. It is important to emphasize that, as our pilot project investigated antimicrobial prescription in secondary care within the local healthcare system, we have selected six most relevant AMS strategies for inclusion in second column of Fig. 1. These are namely: 1) Infection prevention, control and management; 2) Public engagement activities; 3) AMR Surveillance processes; 4) Workforce education and training; 5) Using AMR information for action and decision-making; and 6) Addressing health disparities and inequalities. We believe that the sustained implementation of these strategies would trigger intermediate outcomes shown in the third column of Fig. 1 and that these will in turn generate four anticipated long-term impacts of: 1) high-quality patient care, 2) reduced AMR-related morbidity and mortality, 3) progress towards UN sustainable development goal (SDG) -3 of improved health for people of all ages, and 3) progress towards SDG-10, of reduced inequities and disparities within countries.

Our pilot was not without limitations. First, we were unable to utilise internationally recognised measures of antibiotic consumption due to the retrospective nature of the pilot. Second, we were unable to explore further some of the trends we identified such as the significant increase in the use of antibiotics from Q1 to Q5. Third, the study was restricted to quantitative, secondary data analysis. We did not have qualitative data to complement our analysis. This would have provided us with further insights into the contextual factors associated with antibiotic prescription and consumption in our community. However, our work represents an important first step towards understanding a complex issue and proposing context-specific strategies to mitigate this global threat.

In conclusion, our findings support the need for further investigation into contextual drivers of antibiotic prescribing practices in more deprived populations in Mid Yorkshire. The next phase of this work will focus on exploring the interrelationships we have identified in this pilot such as the link between LOS, antibiotic use and IMD in local communities. Only by applying a social determinants of health (SDH) lens to understanding these drivers can targeted public health strategies and interventions in Fig. 1 be implemented to stem the tide of disability and death from AMR in Mid Yorkshire and similar contexts. While the strategies listed in Fig. 1 are not meant to be exhaustive, applying a SDH lens to implement them will accelerate the achievement of SDGs. Notable for AMR in our pilot study are: goal 3 of ensuring healthy lives and improving well-being, and goal 10 of reducing socioeconomic inequalities as well as disparities in age, sex, disabilities etc. in accessing quality healthcare services. We recommend the field-testing of Fig. 1 to determine its utility in different contexts.

Declarations

Conflict of Interest: None to declare.

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Clinical Trial Number: Not applicable

Ethics, Consent to Participate, and Consent to Publish declarations: not applicable.

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Figures

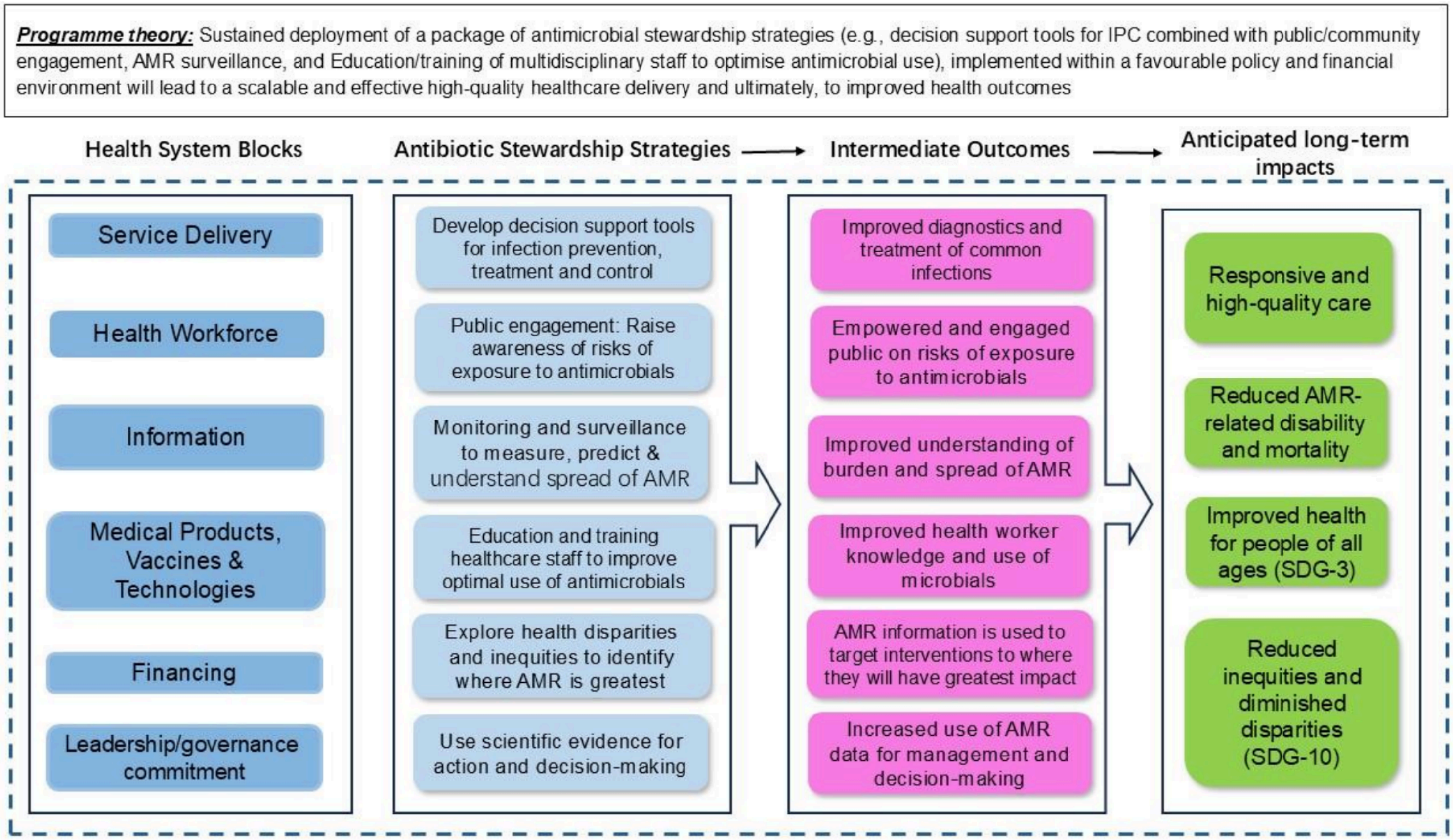

Figure 1

Conceptual framework for understanding and evaluating antimicrobial stewardship programmes