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Analysing incompliant attitudes towards antibiotic prescription completion in the UK

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Objectives: To analyse demographic, social and geographic predictors of incompliant attitudes towards prescription completion in the UK.

Methods: Two waves of the Eurobarometer survey (85.1 and 90.1) were analysed, with a final sample size of 2016. Using logistic regression, the best-fitting combination of a set of identified variables was specified. The regression output and the model-averaged importance of each variable were analysed.

Results: Compared with a median prevalence region, respondents in the Nomenclature of Territorial Units for Statistics (NUTS) 1 London (OR = 2.358, 95% CI = 1.100–5.398) and Scotland (OR = 2.418, 95% CI = 1.083–5.693) regions were most likely to report an incompliant attitude. Respondents who correctly answered questions about whether unnecessary use of antibiotics could make them ineffective in future (OR = 0.353, 95% CI = 0.230–0.544), whether antibiotics kill viruses (OR = 0.644, 95% CI = 0.450–0.919) and whether antibiotics treat colds (OR = 0.412, 95% CI = 0.287–0.591) were less likely to report incompliant attitudes. Conversely, respondents who correctly responded that antibiotics can cause side effects (OR = 1.419, 95% CI = 1.014–1.999) were more likely to report incompliant attitudes. There was some evidence of associations between political orientation and level of compliance. Uncooperative survey respondents (OR = 2.001, 95% CI = 1.108–3.526) were more likely to report incompliant attitudes.

Conclusions: Incompliant attitudes towards antibiotic prescription compliance in the UK are associated with a variety of factors, including regional geographic variation in attitudes. Knowledge about antibiotics can relate to good stewardship attitudes, but concerns over side effects are associated with poor attitudes. Further research should examine the underlying attitudes and beliefs that political orientation may be a marker for in the context of antibiotic stewardship. Survey samples reliant on self-selection are likely to be biased towards good stewardship.

Introduction

Antimicrobial resistance (AMR) has a biological mechanism and socially patterned drivers and consequences. One example of such a driver is incompliance with prescription instructions leading to patients underdosing and potentially later self-medicating with antibiotics. The NHS website informs the public that ‘taking antibiotics when you do not need them can mean they will not work for you in the future’ and highlights that antibiotics should be taken ‘as instructed by your GP or pharmacist’. Compliance with instructions for medication-taking is influenced by several identified factors, including age, patient–physician relationship, beliefs about medications, misconceptions about disease conditions, experience and management of side effects and individual personality traits. Meta-analyses of adherence to medication have shown that individuals believing that the medication is necessary for their health are more likely to follow medication-taking instructions, while individuals who have strong concerns about the medication such as beliefs about side effects are less likely to follow instructions. In the Wellcome Monitor survey, 60% of respondents who reported not taking their antibiotics as prescribed said it was because they felt better, with 25% saying that it was because they experienced side effects.

One mechanism of action in AMR public health interventions is the raising of public awareness through education. This occurs through the provision of information about consequences of inappropriate antibiotic use alongside information about how to take antibiotics appropriately and, commonly, the use of credible professional sources for intervention implementation. Interventions have had mixed results when targeting the general public and it has been argued that in addition to improving understanding of appropriate antimicrobial use, interventions should
promote the role of the public in addressing AMR and its risks for
individuals, their loved ones and the wider population.10

Increased knowledge about antibiotics and AMR has been
found to correlate inconsistently with behavioural outcomes.
Knowledge about antibiotics and AMR has been associated with
good stewardship attitudes and behaviours11–17 as well as with
negative behaviours such as self-medication or possession of left-
overs.17,18 Relationships between prior knowledge, attitudes and
behaviour around antibiotics are key areas of interest for interven-
tions aiming to improve antibiotic stewardship in the community
and this interest is addressed in this study by examining associa-
tions between specific areas of prior knowledge and attitudes
towards prescription compliance.

Political orientation has been suggested as a marker for under-
lying attitudes, values and beliefs relating to health.19 Individual-
level political orientation has been correlated with health15,20 and
health-related attitudes and behaviours,21–24 and research in pol-
itical psychology has argued that left- and right-orientated individ-
uals have substantively different thought styles, with liberal/leftist
and conservative/rightist political ideologies being associated
with differing psychological needs.25,26 Conservative ideology,
for example, has been positively associated in meta-analyses with
uncertainty avoidance and intolerance for ambiguity,26 traits that
have also been associated with higher national levels of antibiotic
consumption using Hofstede’s Uncertainty Avoidance national-
level cultural dimension.27 Individuals with different political
orientations may think about health issues differently with possibly
different attitudinal or behavioural outcomes such as compliance
with antibiotic prescription instructions. These differences may
impact the effectiveness of public health interventions’ framings.

Surveys are widely used to examine attitudes and behaviours
regarding antibiotic consumption. Faster and lower-cost non-prob-
ability sampling methods that are reliant on self-selection and lack
specifiable probabilities of selection for each included observation
are becoming increasingly popular28,29 and have been used in the
study of antibiotic use.15,16,30 While respondents in a non-probability
sample may be demographically identical distributed to a prob-
able sample, they are not necessarily attitudinally or behaviourally
identical.31 An important consideration for survey research is the
behaviour of respondents, for example their motivation and willing-
ness to provide good-quality data and whether participation itself
is correlated with attitudinal or behavioural outcomes of interest.
This study examined whether survey cooperation is an issue for
the measurement of attitudes towards prescription compliance
through the analysis of a random probability survey sample
(in which non-response can be adjusted for) with a survey interview-
er-recorded variable for respondent cooperation.

The primary aim of this study was to examine predictors of vari-
ation in the UK public’s attitude towards antibiotic prescription
compliance. This study also examines the relative importance of
chosen candidate variables for the prediction of inconstant
attitudes among the general public.

Materials and methods

Data and analysis

The data for this study were drawn from Eurobarometers 85.132 and
90.1.23 The Eurobarometer uses a stratified sampling approach in a random
probability sampling methodology. The combined 2016 and 2018 UK
samples contain 2330 observations. To compare models, rows with missing
values on candidate variables were excluded so that each candidate
model would be analysing identical samples. The final subset contained
2016 cases. Supplied non-response weights incorporating sex, age,
Nomenclature of Territorial Units for Statistics (NUTS) 2 regions and size of
locality were used in the analysis.32,33

Variable and model specification

The dependent variable for logistic regression in this study was based on
the question ‘When do you think you should stop taking antibiotics once
you have begun a course of treatment?’. The response was binary coded
with the base as ‘When you have taken all of the antibiotics as directed by
your doctor’ and the contrast as ‘When you feel better’, ‘Other’ and ‘Don’t
know’. The independent variable representing political orientation was
measured in the survey by self-placement on a 10-point scale from left
to right and condensed for this study to five categories (1–2 = left,
3–4 = centre-left, 5–6 = centre, 7–8 = centre-right, 9–10 = right).

Model and variable selection was undertaken using the package
glmulti34 in RStudio. Candidate predictor variables were chosen from the
Eurobarometer dataset and were fitted in all combinations of 20 main
effects. The best 100 models based on lowness of Akaike Information
Criterion (AIC) were stored and used to determine the best-fitting model
(model with lowest AIC,35 AICmin) and relative importance of each candi-
date variable.

The relative importance of the 20 candidate variables is presented in
Figure 1 in terms of the summed Akaikes weights of models in which
the variable appears. Each model’s Akaikes weight is calculated as the
relative likelihood of each model in the candidate set (for model i:
exp (−(−AICi−AICmin))) divided by the summed relative likelihoods of all 100
candidate models, representing the probability that model i is the best
model for the data in the set of specified models.35

Regional and community geographies were consistently important for
examining variation in attitudes towards prescription compliance, along
with certain demographic characteristics and respondents’ cooperation
with their survey interviewers. Antibiotic-related variables of importance
were specific areas of knowledge about antibiotics and antibiotic resistance
(ABR), respondents’ perception of whether individuals have a role in
addressing ABR and reporting trust in official health websites and personal
blogs as sources of information about antibiotics. Time spent in education,
trust in either doctors or social media for information about antibiotics,
the presence of children in the household and recent reception of warning in-
formation about not taking antibiotics unnecessarily were rarely present in
the best 100 models and consequently may be considered less important
for explaining variation in compliance attitudes. The model with AICmin was
considered the best-fitting model and included 16 variables, which are
shaded black in Figure 1.

Results

Of 2016 respondents, 220 (11% of the sample) reported an
attitude response other than taking antibiotics as directed by
their doctor. The results of the multivariable AICmin logistic regression
model are presented in Table 1 with estimated ORs and 95% confi-
dence limits (CLs). Statistical significance was determined using
CLs, with ORs where the interval between CLs [the confidence
interval (CI)] did not include one considered significant at a 95% level
of confidence.

Demographics

Inconstant attitudes towards doctors’ instructions regarding
antibiotics were associated with multiple demographic
characteristics. Older members of the public were less likely to report an incompliant attitude towards doctors’ instructions (29–40 years OR = 0.642, 95% CI = 0.413–0.995; 41–52 years OR = 0.493, 95% CI = 0.303–0.794; 53–66 years OR = 0.257, 95% CI = 0.144–0.444; 67+ years OR = 0.221, 95% CI = 0.121–0.391). These results suggest that levels of compliance with antibiotic prescription instructions are higher among older members of the public and that this association is clearer in the oldest quintiles compared with younger quintiles.

Male (OR = 1.479, 95% CI = 1.064–2.067) respondents were more likely to report an incompliant attitude than female respondents, whilst self-employed respondents (OR = 2.034, 95% CI = 1.160–3.519) were more than twice as likely to report an incompliant attitude than respondents who were not in work. Respondents who had been prescribed antibiotics in the past 12 months (OR = 0.692, 95% CI = 0.470–1.004) were not substantially different from respondents who had not. Alongside this, recent reception of warning information was a relatively unimportant variable in the model selection process, which suggests that recency of contact with either a healthcare professional or intervention are substantially less important for explaining variation in compliance than other candidate variables included in this analysis.

**Geography**

There is regional variation in the predicted probability of respondents reporting incompetent attitudes, shown in Figure 2. The smallest region size available in these data is NUTS 1 level, with populations between 3 and 7 million people. Respondents in North East England had the lowest and most precise probability of reporting an incompetent attitude and the probabilities associated with the East of England and South West England were also both relatively low and precise. Compared with the differences between most regions’ means, which were relatively small, Londoners were substantially more likely to report an incompetent attitude despite a wide CI.

When contrasted with the East Midlands (one of the median regions in terms of proportion of incompetent responses) there were three significantly different areas in the regression. Respondents in London (OR = 2.358, 95% CI = 1.100–5.398) and Scotland (OR = 2.418, 95% CI = 1.083–5.693) presented higher

**Figure 1.** Model-averaged importance of candidate variables, with those included in the best-fitting (AICmin) regression model shaded black.
Table 1. Results of best-fitting (AICmin) multivariable regression model

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>OR</th>
<th>2.5% CL</th>
<th>97.5% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15–28 (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>29–40</td>
<td>0.642&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.413</td>
<td>0.995</td>
</tr>
<tr>
<td>41–52</td>
<td>0.493&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.303</td>
<td>0.794</td>
</tr>
<tr>
<td>53–66</td>
<td>0.257&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.144</td>
<td>0.444</td>
</tr>
<tr>
<td>67+</td>
<td>0.221&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.121</td>
<td>0.391</td>
</tr>
<tr>
<td>Community size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>large urban (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>small urban</td>
<td>0.626&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.417</td>
<td>0.945</td>
</tr>
<tr>
<td>rural</td>
<td>0.739</td>
<td>0.380</td>
<td>1.386</td>
</tr>
<tr>
<td>Employment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>not working (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>self-employed</td>
<td>2.034&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.160</td>
<td>3.519</td>
</tr>
<tr>
<td>employed</td>
<td>0.755</td>
<td>0.518</td>
<td>1.100</td>
</tr>
<tr>
<td>Level of cooperation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excellent (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>fair</td>
<td>1.326</td>
<td>0.838</td>
<td>2.059</td>
</tr>
<tr>
<td>average/bad</td>
<td>2.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.108</td>
<td>3.526</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Midlands (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>London</td>
<td>2.358&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.100</td>
<td>5.398</td>
</tr>
<tr>
<td>East of England</td>
<td>0.643</td>
<td>0.193</td>
<td>1.918</td>
</tr>
<tr>
<td>North East England</td>
<td>0.151&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.010</td>
<td>0.818</td>
</tr>
<tr>
<td>North West England</td>
<td>2.130</td>
<td>0.947</td>
<td>5.033</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>1.018</td>
<td>0.450</td>
<td>2.415</td>
</tr>
<tr>
<td>Scotland</td>
<td>2.418&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.083</td>
<td>5.693</td>
</tr>
<tr>
<td>South East England</td>
<td>1.357</td>
<td>0.604</td>
<td>3.196</td>
</tr>
<tr>
<td>South West England</td>
<td>1.099</td>
<td>0.402</td>
<td>2.941</td>
</tr>
<tr>
<td>Wales</td>
<td>1.452</td>
<td>0.447</td>
<td>4.327</td>
</tr>
<tr>
<td>West Midlands</td>
<td>1.024</td>
<td>0.430</td>
<td>2.509</td>
</tr>
<tr>
<td>Yorkshire and The Humber</td>
<td>1.779</td>
<td>0.767</td>
<td>4.301</td>
</tr>
<tr>
<td>Political orientation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>centre (reference)</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>left</td>
<td>1.797&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.010</td>
<td>3.115</td>
</tr>
<tr>
<td>centre-left</td>
<td>0.646&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.409</td>
<td>0.998</td>
</tr>
<tr>
<td>centre-right</td>
<td>0.900</td>
<td>0.529</td>
<td>1.485</td>
</tr>
<tr>
<td>right</td>
<td>0.712</td>
<td>0.271</td>
<td>1.642</td>
</tr>
<tr>
<td>don’t know or refuse</td>
<td>0.577</td>
<td>0.257</td>
<td>1.209</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>female</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>male</td>
<td>1.479&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.064</td>
<td>2.067</td>
</tr>
<tr>
<td>Antibiotics taken in past 12 months on prescription</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>no</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>yes</td>
<td>0.692</td>
<td>0.470</td>
<td>1.004</td>
</tr>
<tr>
<td>Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>2018</td>
<td>0.863</td>
<td>0.723</td>
<td>1.028</td>
</tr>
<tr>
<td>Trust in information sources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trust in source not mentioned</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>trust in official health web for information mentioned</td>
<td>0.571&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.332</td>
<td>0.941</td>
</tr>
<tr>
<td>trust in personal health blog for information mentioned</td>
<td>0.160</td>
<td>0.003</td>
<td>1.203</td>
</tr>
</tbody>
</table>

Continued
likelihoods of incompliant responses. Conversely, respondents in North East England (OR = 0.151, 95% CI = 0.010–0.818) were less likely to report an incompliant response.

These results suggest that a regional geography at the NUTS 1 level, visualized using predicted probabilities in Figure 3, persists after controlling for other factors including local geography.

The regression suggests that the local geography of incompliant attitudes is predominantly urban. Respondents who lived in small urban areas (OR = 0.626, 95% CI = 0.417–0.945) were less likely than respondents in large urban areas to respond that they would not adhere to a doctor’s instructions when taking antibiotics and there was no significant association for rural (OR = 0.739, 95% CI = 0.380–1.386) respondents contrasted with respondents from large urban areas.

**Knowledge about antibiotics**

Four knowledge questions were included in the model. Correct responses to three of these questions were associated with lower probabilities of incompliant attitude responses in regions of the UK. CI calculated using the Goldstein and Healy procedure for graphical comparison of multiple means.

[Table 1. Continued]

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>OR</th>
<th>2.5% CL</th>
<th>97.5% CL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotic knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>incorrect response to</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>each question</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>antibiotics kill</td>
<td>0.644&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.450</td>
<td>0.919</td>
</tr>
<tr>
<td>viruses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>antibiotics can treat</td>
<td>0.412&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.287</td>
<td>0.591</td>
</tr>
<tr>
<td>colds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unnecessary use of</td>
<td>0.353&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.230</td>
<td>0.544</td>
</tr>
<tr>
<td>antibiotics can make</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>them ineffective</td>
<td>1.419&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.014</td>
<td>1.999</td>
</tr>
<tr>
<td>antibiotics commonly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cause side effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level at which ABR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>should be addressed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>level other than</td>
<td>(reference)</td>
<td>(reference)</td>
<td>(reference)</td>
</tr>
<tr>
<td>individual</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or family level</td>
<td>1.839&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.294</td>
<td>2.599</td>
</tr>
</tbody>
</table>

<sup>a</sup>Denotes evidence of significance at a 95% level of confidence.

![Figure 2. Mean predicted probabilities of incompliant attitude responses in each region of the UK. CIs calculated using the Goldstein and Healy procedure for graphical comparison of multiple means.](image)

![Figure 3. Map of regional mean predicted probabilities of incompliant attitude responses, grouped by natural breaks detailed in Tables S1 and S2 (available as Supplementary data at JAC Online). This figure appears in colour in the online version of JAC and in black and white in the print version of JAC.](image)
likelihoods of respondents reporting incompliant attitudes. The strongest of these associations was for whether unnecessary use of antibiotics could make them ineffective in future (OR = 0.353, 95% CI = 0.230–0.544), followed by whether antibiotics are useful to treat colds (OR = 0.412, 95% CI = 0.287–0.591) and whether antibiotics kill viruses (OR = 0.644, 95% CI = 0.450–0.919). These results suggest that the piece of knowledge most strongly associated with a higher likelihood of prescription compliance is knowledge about the relationship between antibiotic overuse and ABR. Conversely, respondents who correctly answered that antibiotics commonly cause side effects (OR = 1.419, 95% CI = 1.014–1.999) were more likely to report incompliant attitudes.

### Attitudes: trusted information, political orientation and individual-level roles

Of the two trusted information sources included in the model, only trust in official health websites for information about antibiotics (OR = 0.571, 95% CI = 0.332–0.941) was significantly associated with compliant attitudes. This could mean that the official health websites in the UK are successfully communicating that antibiotic prescriptions should be finished. However, it could also mean that respondents who are more inclined to trust government-sourced online health information are also respondents who are more likely to be compliant with their doctor’s instructions anyway. In either case, this result suggests that there are substantially different groups of internet users in the context of behaviours regarding antibiotic prescriptions. Very few (n = 18) respondents reported trusting personal health blogs, which likely explains the wide CIs.

Left orientation had a stronger association with prescription compliance than right orientation. Respondents who placed themselves on the left of the scale (OR = 1.797, 95% CI = 1.010–3.115) compared with in the centre were more likely to respond that they would not adhere to a doctor’s instructions when taking antibiotics. In contrast, centre-left-placed respondents (OR = 0.646, 95% CI = 0.409–0.998) were less likely to report an incompliant attitude. The results suggest a greater association between left placement than right placement and attitudes towards prescription compliance; however, the pattern of this relationship is not a clear image of left-leaning individuals in general having specific predilections towards or against compliance.

The regression suggests that perceptions of personal responsibility matter for prescription compliance. Independently of political orientation, respondents who believed that it is ‘most effective to tackle the resistance to antibiotics’ at the individual level (OR = 1.839, 95% CI = 1.294–2.599) as opposed to regional, national, EU or global levels were more likely to report an incompliant attitude. These results suggest perceptions of personal responsibility in addressing ABR are associated with prescription compliance independent of political orientation, which itself could be a marker for compliance-related attitudes among groups of left-leaning individuals.

### Discussion

Incompliance with prescription instructions leading to patients underdosing and potentially later self-medicating with antibiotics is a socially patterned driver of AMR. There is debate over the validity of generic advice to complete courses of antibiotics; however, the prevailing advice from the NHS is to consume antibiotics as directed by a healthcare professional. A set of variables in the Eurobarometer surveys was used in this study to examine variation in attitudes to antibiotic prescription compliance in the UK.

### Implications of geographic findings

The findings of this study suggest that there is geographic variation in compliance attitudes regarding antibiotic prescriptions in the UK that persists independently from several individual-level factors. This study suggests that respondents in small urban areas are less likely to report an incompliant attitude towards following a doctor’s instructions when taking antibiotics. There is also evidence of a regional geography persisting once several individual-level factors are accounted for. In terms of the regions analysed in this study, the evidence from regression suggests that this geographical variation manifests at the extremes, with most regions not significantly different from the median. Respondents in London and Scotland, for example, are more likely to report incompliant attitudes than median region respondents, while respondents in North East England are less likely to do so. A limitation of this analysis is the resolution of the regions available for analysis.

Further research should examine this geography of attitudes at a higher resolution to enable a clearer comparison with geographies of prescribing such as those presented by Curtis et al. for example on dimensions of deprivation, population or cultural characteristics. If high-prescribing areas are positively correlated with areas exhibiting higher levels of poor attitudes to prescription compliance, this could suggest prioritization of specific areas requiring attention from public health interventions to improve prescription practice and compliance by patients. These geographies may, however, have different characteristics, as Curtis et al. found that ruralness was associated with higher levels of prescribing, whilst this study suggests that rural areas are not significantly different from large urban areas in terms of attitude. Instead, attitudinal differences in prescription compliance manifest between large and small urban areas.

### Implications of knowledge-related findings

This study provides further evidence of an association between specific areas of respondents’ knowledge about appropriate use of antibiotics and ABR, and attitudes towards antibiotic prescription compliance. Whilst the data are cross-sectional and limiting to causal inference, this analysis suggests that members of the public who are aware that antibiotics are not effective against colds and other viral infections, and that unnecessary use of antibiotics can lead to them becoming ineffective in future, are less likely to be incompliant with prescriptions. This may reflect the commonness suggested by McParland et al. of information about the consequences of inappropriate use alongside information on how to take antibiotics appropriately in AMR public health interventions. Conversely, and in line with findings from meta-analyses on necessity/concerns framework beliefs relating to medication, respondents who correctly responded that antibiotics cause side effects were more likely to report an incompliant attitude towards finishing their prescription. The most desirable message for public health interventions suggested by this study is that unnecessary use of antibiotics can render them ineffective in future.

Respondents who reported trust in official health websites for information about antibiotics were less likely to hold an
incompliant attitude towards antibiotic prescriptions. Neither trust in doctors nor social media were important predictors of compliance attitudes. This is a more specific finding than that which has been previously reported from analysis of this data. These findings may suggest that information dissemination through the official websites, such as that of the NHS, has had a positive impact on antibiotic stewardship; however, it may also mean that members of the public who are already likely to comply with a doctor’s instructions are also more trusting of ‘credible’ professional online sources of information through which interventions are implemented.

**Political orientation in context of other research**

Political orientation has been suggested as a marker for underlying health-related beliefs and attitudes. Whilst movement towards right orientation has been associated with more medicalized attitudes and other health-related behaviours in previous studies, there was no evidence of substantial difference found in this study between respondents who placed themselves on the political right in contrast to the centre in terms of compliant attitudes. There were, however, differing associations between left-leaning placements and the centre in terms of antibiotic prescription compliance, as compliance was more likely for left-placed respondents and less likely for centre-left-placed respondents. Independently, respondents who believed the individual level was the most effective level at which to address ABR were more likely to be inconsistent than those who believed the most effective level was above the individual.

Social politics has been proposed as a better predictor of thought than economic politics, but without the data to examine social and economic politics separately the inferences that can be made from the associations in this study are limited. For example, the lack of evidence for association between right-leaning orientations and prescription compliance could be because there is no association between right placement and prescription compliance, but it could also be due to bias from differences between libertarians and social conservatives within this wing of the scale. Similarly, left- and centre-left-placed respondents were differently associated with compliance, suggesting that in terms of this health-related attitude, there is some substantive difference between groups that cannot be illuminated further with this data. This difference could, for example, relate to contextually bound obedience to authority (centre-left respondents may perceive doctors as being on their social or political ‘team’, for example), differences in underlying psychological needs, or styles of thought or morality (for example, left-placed respondents may be averse to institutional authority in the context of health).

Further research should examine the relationship between differently politically orientated antibiotic consumers and their levels of compliance, with attention to cognitive styles and social/economic politics, as this may be suggestive of specific and effective framings for future public health interventions addressed to the different thought styles of these groups.

**Implications of survey interview-related findings**

The positive association presented in the model for respondents who were reported by interviewers as having had average or bad levels of cooperation has implications for future survey research in this area. The deployment of non-probability sampling approaches, which have been used in the area of antibiotic use, relies on the self-selection of respondents into surveys, which can lead to biases on attitudinal and behavioural measures even where samples are demographically representative. These biases are introduced because individuals who self-select for specific studies are different on both measured and unmeasured characteristics, such as agreeableness and interest in the topic, than individuals who do not take part. Random probability samples such as those used in this study do not exhibit these biases because unmeasured characteristics in the wider population are randomly sampled along with the measured variables. The findings of this study suggest that members of the public who are less motivated to take part in surveys and provide good-quality data are also individuals who are more likely to exhibit poorer attitudes towards antibiotic stewardship. This means that non-probability-based inferences are likely to be biased towards respondents with better stewardship attitudes and that greater efforts will need to be expended to reach inconsistent individuals and avoid samples based predominantly on agreeable and interested respondents.

**Conclusions**

Inconsistent attitudes towards antibiotic prescription compliance in the UK are associated with a variety of factors including local and regional geography, prior knowledge about antibiotics and ABR, and demographics characteristics. There may be an association between political orientation as a marker for underlying attitudes and antibiotic prescription compliance and more specific research is needed to examine this area. Finally, survey respondents who are less motivated to take part in surveys are also more likely to report inconsistent attitudes towards antibiotic prescriptions. This suggests that biases in survey data from samples reliant on self-selection may be a significant problem for the measurement of prescription incomplete attitudes.

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**Transparency declarations**

None to declare.

**Supplementary data**

Tables S1 and S2 are available as Supplementary data at JAC Online.

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