



Effect of information on reducing inappropriate expectations and requests for antibiotics

Alistair Thorpe^{1*} , Miroslav Sirota², Sheina Orbell² and Marie Juanchich²

¹Department of Population Health Sciences, University of Utah, School of Medicine, Salt Lake City, Utah, USA

²Department of Psychology, University of Essex, Colchester, UK

People often expect antibiotics when they are clinically inappropriate (e.g., for viral infections). This contributes significantly to physicians' decisions to prescribe antibiotics when they are clinically inappropriate, causing harm to the individual and to society. In two pre-registered studies employing UK general population samples ($n_1 = 402$; $n_2 = 190$), we evaluated the relationship between knowledge and beliefs with antibiotic expectations, and the effects of information provision on such expectations. We conducted a correlational study (study 1), in which we examined the role of antibiotic knowledge and beliefs and an experiment (study 2) in which we assessed the causal effect of information provision on antibiotic expectations. In study 1, we found that both knowledge and beliefs about antibiotics predicted antibiotic expectations. In study 2, a 2 (viral information: present vs. absent) \times 2 (antibiotic information: present vs. absent) experimental between-subjects design, information about antibiotic efficacy significantly reduced expectations for antibiotics, but viral aetiology information did not. Providing antibiotic information substantially diminishes inappropriate expectations of antibiotics. Health campaigns might also aim to change social attitudes and normative beliefs, since more complex sociocognitive processes underpin inappropriate expectations for antibiotics.

The rise of antibiotic resistance – whereby bacteria evolve resistance to drugs that were previously effective in combatting them – is one of the most serious threats to public health. Failure to effectively combat increasing global antibiotic resistance will have catastrophic consequences and a post-antibiotic era, in which bacterial infections and complications in routine medical procedures cannot be treated, is a real possibility (WHO, 2014). To address this threat, public health departments have called for campaigns and interventions to modify public use of antibiotics. In the United Kingdom, for example, the Department of Health and Social Care recommended optimizing antibiotic prescribing practices by educating the general public about responsible antibiotic use (Davies & Gibbens, 2013). However, current understanding of the most effective targets for educational interventions remains rudimentary. The goal of the present research was to enhance our understanding of the role of modifiable knowledge and beliefs associated

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*Correspondence should be addressed to Alistair Thorpe, Department of Population Health Sciences, University of Utah, 295 Chipeta Way, Salt Lake City, UT 84108, USA (email: alistair.thorpe@hsc.utah.edu).

with antibiotic expectations and requests. Specifically, we tested the role that prior knowledge and information provision regarding viral illness aetiology and antibiotic efficacy might play in expectations and requests for antibiotics. In study 1, we examined the strength of the relationship between antibiotic knowledge and inappropriate expectations and requests for antibiotics alongside other theoretically derived dimensions. In study 2, we tested the causal effect of information provision on inappropriate expectations and requests for antibiotics.

Clinically inappropriate prescriptions of antibiotics fuel antibiotic resistance (Goossens, Ferech, Vander Stichele, & Elseviers, 2005). This happens because clinically inappropriate prescriptions result in the suboptimal exposure of bacteria to antibiotics (e.g., the wrong dosage, the wrong course length, or the wrong class of antibiotic). Suboptimal exposure to antibiotics actually provides bacteria with greater opportunity to mutate and share genes in a way which increases the likelihood of them becoming resistant to antibiotics (Davies, Spiegelman, & Yim, 2006).

Research has documented substantial overprescribing of antibiotics for respiratory tract infections in primary care (Pouwels, Dolk, Smith, Robotham, & Smieszek, 2018). As most upper respiratory tract infections (i.e., the common cold) are of viral aetiology, and bacterial complications are rare, antibiotic treatment provides little to no benefit (Tan, Little, & Stokes, 2008; Turner, 2010). In the United Kingdom, antibiotics are not available 'over the counter' and must be prescribed by a qualified medical practitioner. Clinical guidelines produced by Public Health England (PHE) and the National Institute for Health and Care Excellence (NICE) recommend a no prescribing or delayed antibiotic prescribing strategy for otherwise healthy adults consulting with respiratory tract infections (PHE, 2017). However, primary care patients continue to receive antibiotics for respiratory tract infections that they do not need. Pouwels et al. (2018) examined medical records of more than a million primary care consultations in England and revealed that the rate of antibiotic prescribing for some respiratory tract infections (e.g., rhinosinusitis) is as high as 88%, whereas the ideal rate of prescribing for this condition based upon prescribing guidelines is 11%. Thus, reducing clinically inappropriate antibiotic prescriptions is a priority for primary care practitioners (Pouwels et al., 2018).

While many factors may contribute to physicians overprescribing antibiotics for respiratory tract infections, including clinical presentation or physician characteristics, several lines of evidence suggest that a good deal of inappropriate prescribing originates in patients themselves and in clinically irrelevant but psychologically important processes. Indeed, primary care physicians have reported that satisfying patient expectations and requests for antibiotics is a factor in their decisions to issue clinically inappropriate antibiotic prescriptions (Hamm, Hicks, & Bembem, 1996; Macfarlane, Holmes, Macfarlane, & Britten, 1997). In a large general population survey, the authors found that primary care patients who request antibiotics from their physician are rarely denied them (McNulty, Nichols, French, Joshi, & Butler, 2013). More recently, experimental evidence has shown that the presence of patient's expectations for receiving antibiotics directly increases the likelihood of physician willingness to issue an inappropriate antibiotic prescription (Sirota, Round, Samaranayaka, & Kostopoulou, 2017). The authors presented UK primary care physicians (General Practitioners) with vignettes describing a patient presenting with symptoms of a viral infection but manipulated whether the patient's expressed either a high or low expectation of a prescription. The authors found that the physicians were more likely to say they would prescribe antibiotics when the patient insisted that the physician should do something to help them recover from the symptoms compared to when the patients did not express any expectations. Crucially, in both

scenarios the physicians reported that they believed the symptoms indicated a viral infection. These findings revealed how patient expectations influenced physician prescribing intentions despite physicians believing that the infection was viral and did not require antibiotics.

In sum, evidence suggests that in order to address primary care antibiotic overprescribing and its consequences, psychological strategies are needed that might on the one hand modify unnecessary consulting behaviour by patients and, on the other hand, empower physicians to reduce and resist clinically inappropriate antibiotic expectations and requests during those consultations. However, despite their established influence on physicians' antibiotic prescribing behaviour, current understanding of inappropriate expectations for antibiotics is undeveloped.

To date, hypotheses regarding why people expect antibiotics have been mostly generated from interviews with patients who consult for respiratory tract infections in primary care and emergency departments or from the results of large population surveys. For instance, interviews with patients have revealed that patients often view receiving antibiotics as validation of their time investment in visiting their physician and as reassurance that the physician took their health concerns seriously (Butler, Rollnick, Pill, Maggs-Rapport, & Stott, 1998; Stearns, Gonzales, Camargo, Maselli, & Metlay, 2009). One of the most consistent findings from population-level surveys is that members of the public often display poor knowledge of illnesses and antibiotics (Grigoryan et al., 2007; McCullough, Parekh, Rathbone, Del Mar, & Hoffmann, 2015). An appropriate target for research is therefore to identify modifiable patient knowledge and beliefs that contribute to inappropriate expectations and requests for antibiotics.

In order to build on existing insights into why patients expect antibiotics inappropriately, we identified two key questions that remain unanswered. First, to what extent does knowledge and beliefs drive expectations and requests for antibiotics? Second, what elements of clinical information provision within a consultation might modify expectations and requests and thereby the likelihood of inappropriate antibiotic prescriptions? Theoretical models of illness self-regulation such as the common sense self-regulation model (Leventhal, Leventhal, & Breland, 2011) suggest that the decision to consult a doctor to seek treatment for a cold might be understood in terms of an individual's representation of his or her cold. According to the model, illness representations concerning the timeline of the symptoms experienced, their consequences for daily functioning, their cause and coherence, together with beliefs regarding the treatability of the illness, will govern the decision to consult the doctor. For example, a patient may experience a cold that lasts longer than expected or is more severe than usual and this might lead a patient to cope by consulting their doctor. An individual may know that antibiotics cannot treat viral illness, or that antibiotics have side effects, but his or her personal representation of a particular cold might be an important guide to action. Consideration of illness representations and antibiotic beliefs alongside the dimensions of knowledge typically focussed on in educational campaigns (e.g., viral aetiology, antibiotic efficacy, usage, and resistance) has the potential to provide further insight into the cognitive and motivational mechanisms underlying inappropriate expectations and requests for antibiotics but has to date been overlooked. Our first study adopted an extended model of illness representations proposed by Hagger and colleagues (Hagger, Koch, Chatzisarantis, & Orbell, 2017) to investigate the roles of illness representations and illness beliefs in antibiotic expectations and requests.

Our second aim was to identify which elements of clinical information provision are most effective at correcting public misconceptions and reducing inappropriate

expectations for antibiotics during a consultation. Targeting misconceptions about illnesses and antibiotics represents an important route to promote more judicious antibiotic use by patients and the general public (Broniatowski et al., 2018; Broniatowski, Klein, & Reyna, 2015). Previous research conducted in emergency departments has shown that participants who complete an educational intervention went on to report reduced desires for antibiotics (Price, MacKenzie, Metlay, Camargo, & Gonzales, 2011). However, various methodological constraints, such as the absence of a control group and the inability to account for illness severity, limit the conclusions that can be drawn about the efficacy of these educational components. Although it is not clear which, if any, of these elements of information provision are effective, this approach is typical in educational campaigns, which often provide leaflets or online materials containing complex combinations of information regarding illnesses (e.g., durations, symptoms, causes) and antibiotics (e.g., efficacy, appropriate usage, and resistance).

As some health campaigns and online surveys have shown that information provision can have a counterproductive impact and increase public demand for antibiotics (McNulty, Nichols, Boyle, Woodhead, & Davey, 2010; Roope et al., 2018), there is a pressing need for information-based interventions to be thoroughly tested before they are deployed on a large scale. Successfully isolating which of these didactic elements, or combinations of these elements, is most effective at diminishing inappropriate expectations and requests for antibiotics might contribute to reducing unjustified antibiotic prescribing through the improved design of interventions and educational campaigns.

The present research

The aim of the current study was to provide an assessment of the magnitude of the effect of knowledge and information provision on inappropriate expectations and requests for antibiotics. We evaluated this effect in two pre-registered studies (study 1: <https://aspred.icted.org/8f32v.pdf>; study 2: <https://aspredicted.org/63vb8.pdf>) conducted amongst general population participants in the United Kingdom.¹

In a correlational study (study 1), we estimated the magnitude of the relationship between prior knowledge and inappropriate expectations and requests for antibiotics alongside illness representations and antibiotic beliefs as specified by a revised and extended common sense model of illness representations (Hagger et al., 2017; Leventhal, Phillips, & Burns, 2016) that incorporates behavioural beliefs from the theory of planned behaviour (Ajzen, 1991). In our pre-registration, we hypothesized that increased erroneous knowledge, attitudes, and beliefs about antibiotics would be positively associated with increased inappropriate antibiotic expectations and requests (hypothesis 1). We also predicted that increased erroneous knowledge, attitudes, and beliefs about a specific upper respiratory tract infection (the common cold) would be positively associated with increased inappropriate antibiotic expectations and requests (hypothesis 2). Additionally, given that patients who receive antibiotics from their physician are more likely to expect them in the future (e.g., Little et al., 1997) we expected that increased frequency of receiving antibiotics for both viral and bacterial infections in the past would

¹ We originally planned to run study 1 first (correlational design) and study 2 (experimental design) second. However, due to the complexity of developing the measures in study 1 we ended up completing it a few weeks after running study 2 (funding for which was time-limited). Given that the timing of the studies has no bearing on the results, we chose to present the studies in the logical order they were planned (correlational design followed by experimental design) and thus do not adhere to a chronological order in the manuscript.

be associated with increased antibiotic expectations (hypothesis 3). In an experimental study (study 2), we evaluated the causal association between the provision of information about illnesses and antibiotics and inappropriate expectations and requests for antibiotics while keeping other factors constant. Based on normative decision-making theory, it is assumed that relevant information, provided at no extra cost, should help people make better decisions. We predicted that the provision of clinical information from a family physician about the viral nature of the infection (hypothesis 4) and the ineffectiveness of antibiotics (hypothesis 5) would, therefore, reduce inappropriate expectations and requests for antibiotics. We also predicted that the combination of viral and antibiotic information provision would produce the greatest reduction in inappropriate expectations and requests for antibiotics (hypothesis 6).

STUDY I

Method

Participants

Participants from the general adult population were contacted via a recruitment panel (Prolific: <https://www.prolific.co/>) and invited to express their opinion about upper respiratory tract infections and treatments. The data collection for this study was conducted in September 2018. A total of 422 participants started the study and were initially paid £1.00 upon completion of the study estimated to last 12 min. The study took around 17 min on average to complete, so to ensure that the hourly rate of pay was over £5.00, a bonus payment of £0.50 was retrospectively given to all participants (the final average reward was £5.70 per hour). Only participants who were residents of the United Kingdom were eligible to participate. Following a priori criteria, we excluded 20 participants: (1) 17 participants who did not fully complete the study or took over two hours to complete the study and (2) three participants who had less than four correct answers (out of seven) to instructed bogus items to ensure high-quality data (Meade & Craig, 2012). The final sample size was sensitive enough to detect a small-to-medium correlation ($\rho = .16$), assuming $\alpha = .05$ and $1 - \beta = .90$, two-tailed (Faul, Erdfelder, Lang, & Buchner, 2007). In the final sample of 402 participants, 101 identified as male, 300 female and 1 as other. The sample age ranged from 18 to 64 years ($M = 35.3$, $SD = 9.9$ years). The substantial majority, 97%, of participants indicated that they were registered with a family physician. Most participants identified as White (94%) and were employed (66%), with an annual median income between £30,000 and £39,999 per year. Participants' level of education varied as follows: professional trade qualification or no formal educational qualification (6%), GCSE (18%), A levels or national diplomas (33%), and undergraduate or further degree (43%). In the last 12 months, 9% of participants had not experienced a cold, 67% had experienced between one to two colds, 21% had experienced three to four colds, and 3% had experienced five or more colds. At the time of testing, 24% of participants had experienced a cold in the last 30 days.

Design

This was a correlational study with antibiotic knowledge, antibiotic beliefs, illness representations, past consultation behaviour, and past antibiotic prescriptions as independent variables. Expectations and requests for antibiotics were the dependent variables. Participants were randomized to complete the dependent variables before or

after the independent variables. The presentation order of the predictive variables was also randomized, as well as the order of the items within these constructs.

Materials and procedure

Participants first provided informed consent before responding to items assessing their antibiotic knowledge, antibiotic beliefs, illness representations, and their expectations for and likelihood of requesting antibiotics. Participants were instructed to respond to all items in the context of imagining ‘How it feels when you have a cold for which you would go and see your doctor’. Lastly, participants were asked to provide some information regarding their consultation behaviour, antibiotic prescription frequency, and some general demographic information. All items were developed specifically for this research. Internal consistency coefficients and descriptive statistics for measures used in study 1 and study 2 are presented in Table 1.

Antibiotic knowledge

We first generated a questionnaire consisting of 14 items intended to capture participants’ clinical knowledge about the medical efficacy of antibiotics, their appropriate usage, and about antibiotic resistance. We recovered a portion of these items from existing studies that have addressed public knowledge about antibiotics (see Questionnaire A and Table S1 in the Supporting Information for all items). Aligned with the recommendations of Costello and Osborne (2005), items were subjected to exploratory factor analysis using principal axis factoring with direct oblimin rotation. Analysis of the items related to knowledge revealed three factors – with a minimum of four items – with eigenvalues greater than 1 (see Table S2). These corresponded to *Knowledge of efficacy* (e.g., ‘Antibiotics are effective in treating infections caused by bacteria’), *Knowledge of appropriate usage* (e.g., ‘A course of antibiotics should always be completed’), and *Knowledge of resistance* (e.g., ‘The unnecessary use of antibiotics makes them ineffective’). Loadings in these factors ranged between .33 and .91. All antibiotic knowledge items were expressed on a six-point scale ranging from 1 (*Strongly disagree*), via 2 (*Disagree*), 3 (*Somewhat disagree*), 4 (*Somewhat agree*), 5 (*Agree*), to 6 (*Strongly agree*).

Antibiotic beliefs

For antibiotic beliefs, we were interested in items that would provide more insight into the attitudes, emotions, and social context with which people perceive antibiotics compared to the clinical understanding of how and when antibiotics should be used and what antibiotic resistance is, which was provided by the antibiotic knowledge items. To do so, we first generated a questionnaire consisting of 54 items. We recovered a portion of these items from existing studies that have addressed beliefs about antibiotics (see Questionnaire A and Table S1 in the Supporting Information for all items). The remaining items were generated as specified by Ajzen’s (1991) theory of planned behaviour. In addition to variables specified by that theory, we also included items to assess descriptive norms and anticipated regret (Conner & Norman, 2015; Sheeran & Orbell, 1999). Results revealed nine factors with eigenvalues greater than 1. After removing three free-loading items and ambiguously loaded items, repeated analysis suggested seven factors with a minimum of five items (eigenvalues greater than 1 and loadings between .31 and .92) that were

Table 1. Descriptive statistics and Cronbach's alpha (α) of the questionnaire items and dependent measures

	Study 1		Study 2	
	Mean \pm SD	Cronbach's α	Mean \pm SD	Cronbach's α
Illness beliefs: IPQ-R (adapted for the common cold)				
Identity	3.67 \pm 1.13	.95	3.62 \pm 1.05	.93
Timeline chronic	3.15 \pm 1.17	.93	3.01 \pm 1.15	.93
Timeline cyclical	3.69 \pm 0.91	.77	3.58 \pm 0.96	.77
Consequences	2.72 \pm 0.94	.80	3.09 \pm 0.89	.76
Personal control	3.83 \pm 0.93	.82	4.38 \pm 0.79	.71
Treatment control	2.04 \pm 1.18	.94	2.76 \pm 1.45	.93
Illness coherence	4.42 \pm 0.94	.88	4.48 \pm 1.08	.90
Emotional representations	3.66 \pm 1.04	.84	3.70 \pm 0.98	.78
Antibiotic knowledge and beliefs				
Knowledge of antibiotic efficacy	4.98 \pm 0.81	.56	4.74 \pm 0.85	.52
Knowledge of appropriate antibiotic usage	5.39 \pm 0.77	.74	5.16 \pm 0.81	.51
Knowledge of antibiotic resistance	5.23 \pm 0.73	.81	5.18 \pm 0.73	.74
Negative attitudes towards taking antibiotics	3.33 \pm 0.88	.64	3.36 \pm 0.89	.65
Anticipated regret concerning receiving antibiotics	3.99 \pm 1.44	.96	3.75 \pm 1.48	.95
Anticipated regret concerning not receiving antibiotics	2.25 \pm 1.24	.95	2.39 \pm 1.44	.97
Positive attitudes towards taking antibiotics	2.28 \pm 1.11	.93	2.91 \pm 1.28	.92
Subjective social norm perception	2.19 \pm 0.90	.80	2.64 \pm 1.14	.82
Descriptive social norm perception	2.11 \pm 0.99	.90	2.74 \pm 1.22	.91
Self-efficacy to ask for antibiotics	2.54 \pm 1.25	.90	3.20 \pm 1.31	.88
Summary attitudes towards taking antibiotics	2.20 \pm 1.15	.93	2.72 \pm 1.44	.93
Dependent variables				
Expectations that antibiotics are an appropriate treatment	2.33 \pm 1.16	.88	2.66 \pm 1.42	.92
Expectations of the physicians' prescribing behaviour	2.48 \pm 1.29	.88	2.87 \pm 1.52	.92
Likelihood of requesting antibiotics	1.78 \pm 0.94	.89	2.29 \pm 1.31	.92

consistent with the originally grouped dimensions of the theory of planned behaviour and additional variables (see Table S3 in the Supporting Information). These are summarized as *Summary attitudes towards taking antibiotics* (e.g., 'Taking antibiotics when I have a cold would be unnecessary/necessary'), *Negative attitudes towards antibiotics* (e.g., 'When I have a cold, taking antibiotics will cause me side effects such as diarrhoea'), and *Positive attitudes towards taking antibiotics* (e.g., 'When I have a cold, antibiotics will help me get better more quickly'), *Subjective social norm* (e.g., 'People who are important to me would encourage me to take antibiotics for a cold'), *Descriptive social norm* (e.g., 'People who are important to me take antibiotics when they have a cold'), *Self-efficacy to ask for antibiotics* (e.g., 'If I had a cold, I would find it easy to ask my doctor for antibiotics'), *Anticipated regret concerning not receiving antibiotics* (e.g., 'If I visit my doctor for a cold and do not get antibiotics, I would feel disappointed'), and *Anticipated regret concerning receiving antibiotics* (e.g., 'If I visit my doctor for a cold and get antibiotics, I would feel disappointed'). All antibiotic belief items were expressed on a six-point scale ranging from 1 (*Strongly disagree*), via 2 (*Disagree*), 3 (*Somewhat disagree*), 4 (*Somewhat agree*), 5 (*Agree*), to 6 (*Strongly agree*).

Illness representations

To measure the views of healthy adults about the common cold, we adapted the Revised Illness Perception Questionnaire (IPQ-R) as recommended by the authors (Moss-Morris et al., 2002), and as practiced in other studies of the common cold (Henderson, Hagger, & Orbell, 2007). Analysis revealed 10 factors with eigenvalues greater than 1. Five items were removed from any further analysis due to low loadings (below .3) and forming two-item factors. Repeated analysis resulted in an eight-factor solution with loadings between .34 and .98 (see Table S4 in the Supporting Information). The eight factors corresponded to the well-established original scaling of the revised common sense model in the IPQ-R, which can be summarized as *Identity* (an indication of the severity of cold symptoms), *Timeline* (e.g., 'I think my cold will be long lasting rather than temporary'), *Cyclical timeline* (e.g., 'I think the symptoms of my cold will change a great deal from day to day'), *Consequences* (e.g., 'I think my cold will have important consequences on my day to day life'), *Personal control* (e.g., 'I think that the course of my cold depends on me'), *Treatment control* (e.g., 'I think antibiotics will be effective in treating my cold'), *Coherence* (e.g., 'I have a clear picture or understanding of my cold'), and *Emotional representation* (e.g., 'When I have a cold I feel depressed'; see Questionnaire B in the supplemental materials for all items). All illness representation items were expressed on a six-point scale ranging from 1 (*Strongly disagree*), via 2 (*Disagree*), 3 (*Somewhat disagree*), 4 (*Somewhat agree*), 5 (*Agree*), to 6 (*Strongly agree*), with the exception of the identity items, which were expressed on a five-point scale ranging from 1 (*Not severe at all*), via 2 (*Mild*), 3 (*Moderate*), 4 (*Severe*), to 5 (*Very severe*).

Past consultation behaviour and past antibiotic prescriptions

Participants were asked to respond to single-item measures of past frequency of receiving antibiotics for viral (*How often are you prescribed antibiotics for viral infections (i.e., common cold)?*) and bacterial (*How often are you prescribed antibiotics for bacterial infections (i.e., pneumonia)?*) infections. A single item was used to assess consultation behaviour (*When I have a cold I go and see my doctor*). Responses to these three items

were expressed on a five-point scale ranging from 1 (*Never*), via 2 (*Sometimes*), 3 (*About half the time*), 4 (*Most of the time*), to 5 (*Always*).

Expectations and requests for antibiotics

We operationalized three different measures of expectation. The first measure, *Expectations that antibiotics are an appropriate treatment*, was designed to capture what participants expect should happen (e.g., ‘I should get a prescription of antibiotics’). The second measure, *Expectations of the physicians’ prescribing behaviour*, regards what participants expect will happen (e.g., ‘I think I will be prescribed antibiotics by my doctor’). The third measure, *Likelihood of requesting antibiotics*, concerned whether participants expect to ask for antibiotics directly (e.g., ‘I would request a prescription of antibiotics’).

Expectations that antibiotics are an appropriate treatment (see Dependent variables items A1-A4 in the supplemental materials for all items) and of the physicians’ prescribing behaviour (see Dependent variables items B1-B4 in the supplemental materials for all items) were measured using four items. Participants reported their agreement with these items on a six-point scale ranging from 1 (*Strongly disagree*) via 2 (*Disagree*), 3 (*Mildly disagree*), 4 (*Mildly agree*), 5 (*Agree*), to 6 (*Strongly agree*). The likelihood of requesting antibiotics (see Dependent variables items C1-C4 in the supplemental materials for all items) was also measured using four items on a six-point scale, which ranged from 1 (*I certainly would not*) via 2 (*I would not*), 3 (*I probably would not*), 4 (*I probably would*), 5 (*I would*), to 6 (*I certainly would*).

Statistical analyses

We planned to run zero-order correlation matrices² and multiple regression models to estimate the effect of antibiotic knowledge, antibiotic beliefs, illness representations, consultation behaviour, and past antibiotic prescriptions, on our three dependent measures: expectations that antibiotics are an appropriate treatment, expectations of the physicians’ prescribing behaviour, and the likelihood of requesting antibiotics.

As failing to reject the null hypothesis does not logically necessitate accepting the null hypothesis, we planned to quantify the evidence supporting the null or alternative hypothesis by computing JZS Bayes factor (BF) equivalents for the correlation matrices and multiple regression models using default prior scales in JASP and the ‘Bayes-Factor’ package in R, respectively (JASP Team, 2020; Morey & Rouder, 2014; Rouder, Morey, Speckman, & Province, 2012). The university ethics committee granted ethical approval for both studies reported in this paper.

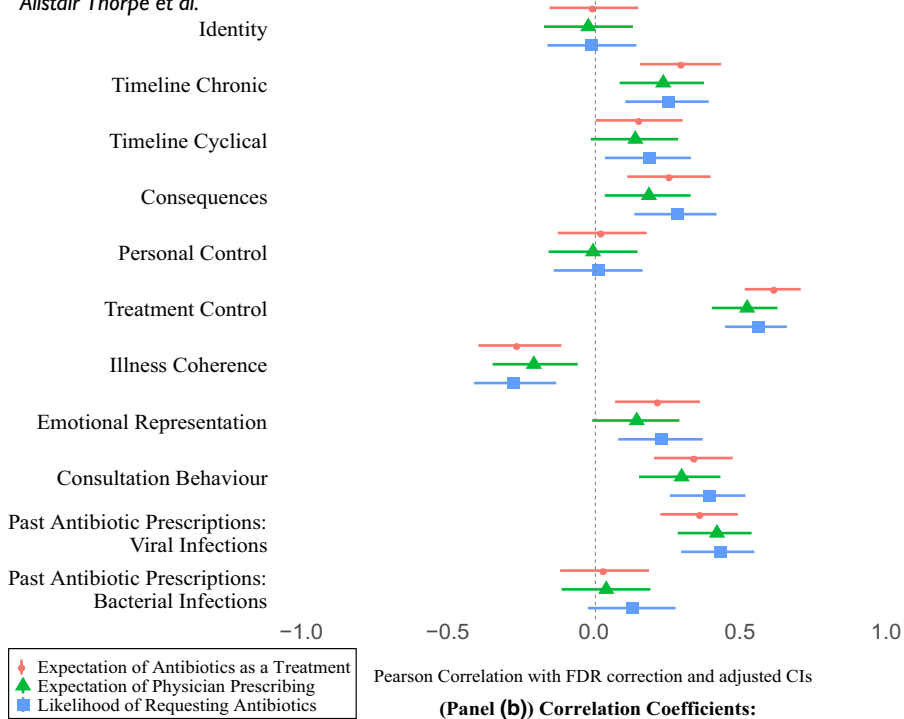
Results and discussion

We found that erroneous knowledge, attitudes, and beliefs about antibiotics (hypothesis 1) and about the common cold (hypothesis 2) were associated with increased inappropriate antibiotic expectations and requests (all correlation coefficients amongst study variables are shown in Figure 1). Indeed, greater knowledge of antibiotic efficacy,

² To control for multiple comparisons, p values and confidence intervals (CIs) were adjusted using the false discovery rate (FDR) correction (both the raw values and adjusted values are available in the Supporting Information).

(Panel (a)) Correlation Coefficients:
Illness Beliefs with Expectations and Requests

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(Panel (b)) Correlation Coefficients:
Antibiotic Knowledge and Beliefs with Expectations and Requests

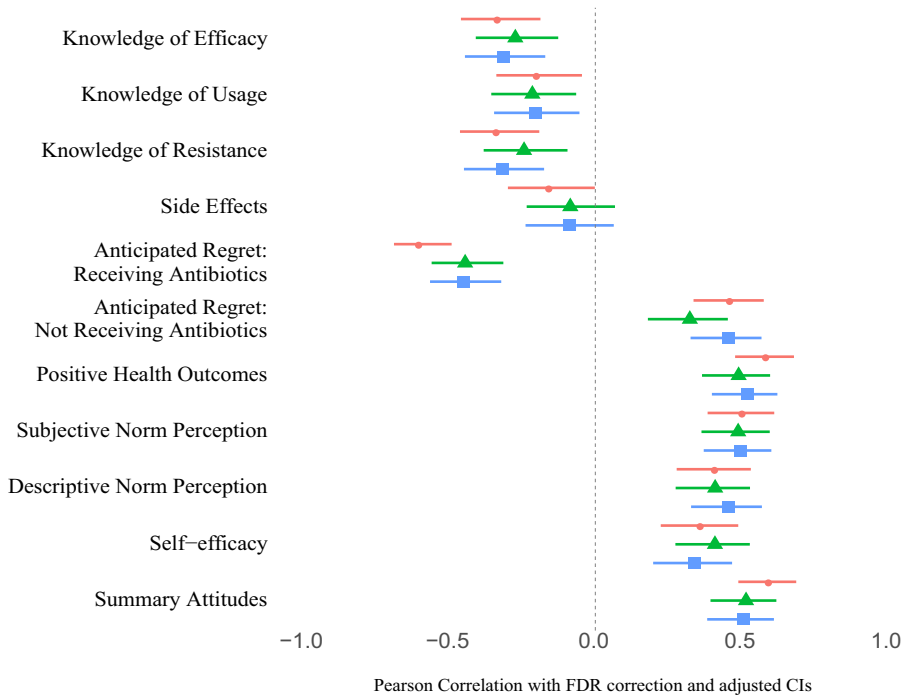


Figure 1. Correlation coefficients for dimensions of illness beliefs (Panel A), antibiotic knowledge and beliefs (Panel B) with expectations that antibiotics are an appropriate treatment, expectations of physician prescribing, and the likelihood of requesting antibiotics. The point symbols represent zero-order correlations, and the error bars represent adjusted 95% confidence intervals with FDR correction.

usage, and resistance was associated with lower expectations and a reduced likelihood of requesting antibiotics, as expected. However, these associations tended to be descriptively weaker (r values ranging from $-.20$ to $-.33$), than the associations with dimensions related to antibiotic beliefs. For example, perceived subjective norm for taking antibiotics was correlated with expectations that antibiotics are an appropriate treatment ($r = .51$, $p_{(\text{FDR})} < .001$), expectations of the physicians' prescribing behaviour ($r = .49$, $p_{(\text{FDR})} < .001$), and the likelihood of requesting antibiotics ($r = .49$, $p_{(\text{FDR})} < .001$).

We also predicted that increased frequency of receiving antibiotics for both viral and bacterial infections in the past would be associated with increased antibiotic expectations (hypothesis 3). As predicted, we found significant positive correlations between receipt of antibiotic prescriptions for viral infections in the past and both inappropriate antibiotic expectations and requests. However, while we also found positive correlations for past receipt of antibiotic prescriptions for bacterial infections and inappropriate expectations and requests, these were not statistically significant (all correlation coefficients, Bayes Factors, raw, and FDR-corrected p values and CIs are reported in Table S5 and Table S5a in the Supporting Information).

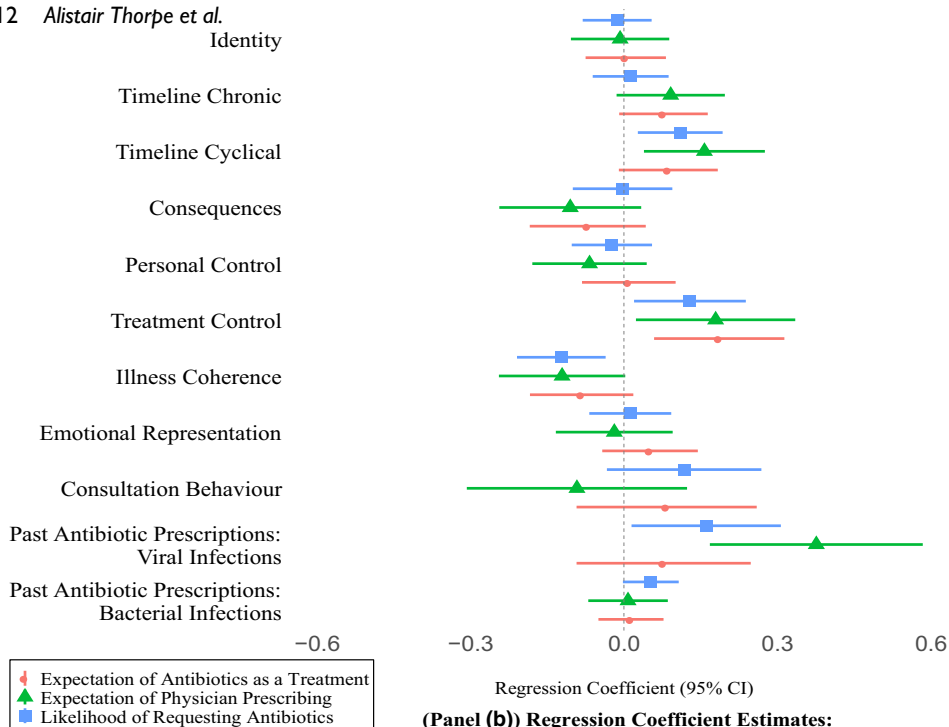
Expectations that antibiotics are an appropriate treatment, expectations of the physicians' prescribing behaviour, and the likelihood of requesting antibiotics were each regressed on antibiotic knowledge together with antibiotic beliefs, illness representations, consultation behaviour, and past antibiotic prescriptions. All the variables that were present in the correlational analyses (i.e., antibiotic knowledge, antibiotic beliefs, common cold illness representations, and past consultation behaviour and past antibiotic prescriptions) were entered into the regression models in one step (forced entry). Regression coefficients amongst study variables are shown in Figure 2 (see also Tables S6–S8 in the Supporting Information). A significant regression equation was obtained for each dependent variable: expectations that antibiotics are an appropriate treatment, $F(22, 379) = 18.77$, $p < .001$, $R^2 = .52$, expectations of the physicians' prescribing behaviour, $F(22, 379) = 12.30$, $p < .001$, $R^2 = .42$, and the likelihood of requesting antibiotics $F(22, 379) = 14.59$, $p < .001$, $R^2 = .46$. Inspection of beta values showed that illness representations, antibiotic beliefs, and past experience obtained significant values in all three models, whereas knowledge of antibiotic efficacy, usage, and resistance was reduced to non-significance in these multivariable models ($p > .05$). As recommended by Rouder and Morey (2012), we computed JZS Bayes factors to quantify evidence for the null or alternative hypothesis for each regression model. This analysis revealed that the data provide decisive evidence in favour of the expectations that antibiotics are an appropriate treatment ($\text{BF}_{10} = 1.39 \times 10^{44}$), expectations of the physicians' prescribing behaviour ($\text{BF}_{10} = 2.50 \times 10^{29}$), and the likelihood of requesting antibiotics ($\text{BF}_{10} = 8.63 \times 10^{34}$) models against the intercept-only models (i.e., the null model assuming no effect).

STUDY 2

In study 1, participants reported on an instance of a cold that would lead them to visit their physician. Our results indicate that while knowledge was negatively associated with inappropriate expectations and requests for antibiotics other variables were more strongly correlated with such inappropriate expectations and requests (e.g., illness timeline and social norm perceptions). To supplement this correlational evidence on the role of knowledge, it is also necessary to provide a test of the causal role of information on

**(Panel (a)) Regression Coefficient Estimates:
Illness Beliefs on Expectations and Requests**

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**(Panel (b)) Regression Coefficient Estimates:
Antibiotic Knowledge and Beliefs on Expectations and Requests**

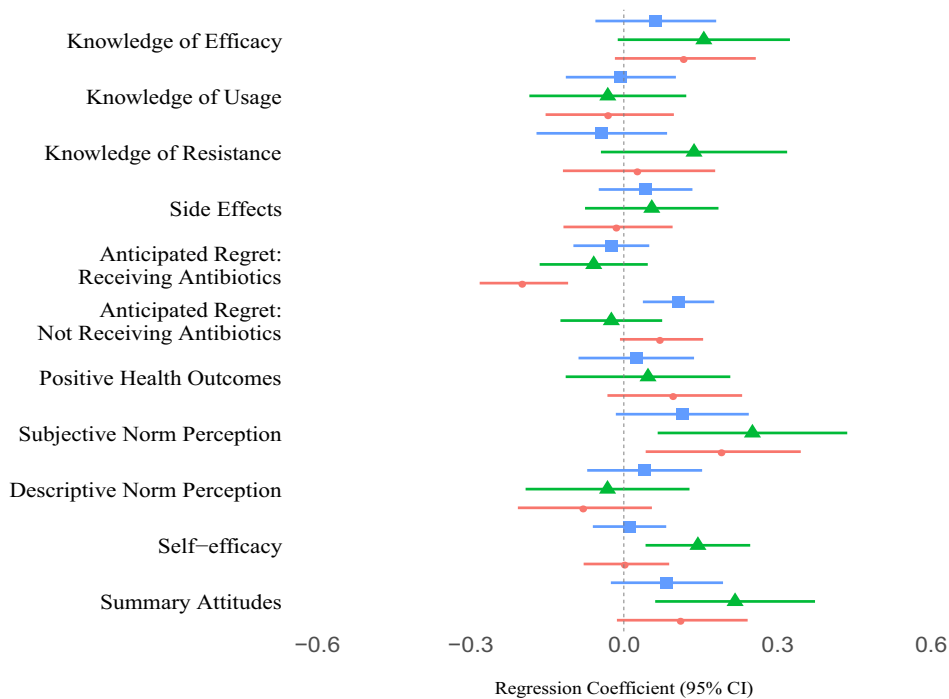


Figure 2. Regression coefficient estimates for dimensions of illness beliefs (Panel A), antibiotic knowledge and beliefs (Panel B) on expectations that antibiotics are an appropriate treatment, expectations of physician prescribing, and the likelihood of requesting antibiotics. The point symbols represent regression coefficient estimates, and the error bars represent 95% confidence intervals.

expectations and requests. Study 1 relied on participants' recollection of a specific memory of a cold and natural variations of participants' knowledge. In study 2, participants read a scenario where they imagined having a cold and consulting their physician, but we experimentally manipulated the information about illness aetiology and antibiotic efficacy provided by the physician. Information on illness aetiology and antibiotic efficacy was provided as they are the central elements of most educational campaigns and encompass the necessary information for a person to understand that antibiotics are unnecessary. Prior knowledge, antibiotic beliefs, and illness representations were employed as covariates, in order to isolate the independent effects of information provision on clinically unjustified expectations and requests.

Method

Participants

We set an a priori stopping rule of 187 participants. The sample size was selected prior to data collection in order to maximize the precision of our estimates while accounting for the funding that was available for participant recruitment. The data collection for this study was conducted in July 2018. We recruited adult participants from the general population via an email list of participants registered to take part in social science research held by the University. Due to recruiting participants in groups, a total of 192 participants completed the experiment in the laboratory. Two individuals did not consent to participating in the study and did not complete the experiment. Sensitivity analysis with $\alpha = .05$ and $1 - \beta = .90$ indicated that the final sample size was sufficient to detect a medium effect ($\eta_p^2 = .06$) for a 2×2 between-subjects ANOVA (Faul et al., 2007). All participants received £4 as a show-up fee and then another £4 upon completion of the study (£8 in total). The study took around 40 minutes to complete. In the final sample of 190 participants, 71 identified as male, 117 female, 1 as other, and 1 chose not to respond. The sample age ranged from 18 to 79 years ($M = 32.5$, $SD = 14.1$ years). The substantial majority, 97%, of participants indicated that they were registered with a family physician and stated that they were residents of the United Kingdom (83%). Most participants identified as White (71%) and were employed (61%) with an annual median income between £20,000 and £29,999 per year. Participants' level of education varied as follows: professional trade qualification or no formal educational qualification (1%), GCSE (6%), A levels or national diplomas (23%), and undergraduate degree or further degree (70%). In the last 12 months, only 12% of participants had not experienced a cold, 58% had experienced between one to two colds, 24% had experienced three to four, and 6% had experienced five or more. At the time of testing, 18% of participants had experienced a cold in the last 30 days.

Design

We tested our hypotheses in a 2 (viral information: present vs. absent) \times 2 (antibiotic information: present vs. absent) factorial between-subjects design with expectations that antibiotics are an appropriate treatment, expectations of the physicians' prescribing behaviour, and likelihood of requesting antibiotics as our dependent variables. The manipulations were provided within a hypothetical medical scenario describing a consultation with a physician for cold symptoms. The scenario was modelled according to the vignette employed by Sirota et al. (2017) and aligned with guidelines from the

National Institute for Health and Care Excellence of a situation in which antibiotics are not clinically justified (Tan et al., 2008). The viral information manipulation consisted of a single sentence from the family physician stating that a viral infection was the cause of the symptoms. Likewise, the antibiotic information manipulation consisted of a sentence from the physician stating that antibiotics are only effective for bacterial infections, have no positive effect on viral infections, provide no symptom relief, and may have side effects such as diarrhoea, vomiting, and rash (see the Full Vignette in the Supporting Information).

Materials and procedure

First, participants reported their prior knowledge, antibiotic beliefs, and illness representations by answering the same questions as described in study 1. Participants were then randomly assigned to read one of four hypothetical medical scenarios describing a consultation with a physician for cold-like symptoms. Having read the scenario participants indicated their expectations that antibiotics are an appropriate treatment, their expectations of the physicians' prescribing behaviour, and the likelihood of requesting antibiotics. Items assessing these dependent measures were identical to those used in study 1.

As in study 1, participants were asked to provide some information regarding their consultation behaviour and antibiotic prescription frequency. Lastly, participants answered some unrelated questions on nutrition labels and general demographic questions.

Statistical analyses

We planned to conduct a two-way factorial ANOVA to test the effect of illness and antibiotic information provision on expectations and requests for antibiotics. We also planned to run two-way factorial ANCOVAs to again test the effect of illness and antibiotic information provision on expectations and requests for antibiotics with the dimensions of antibiotic knowledge, antibiotic beliefs, illness representations, consultation behaviour, and past antibiotic prescriptions as covariates. Evidence to support the null or alternative hypothesis was quantified by computing a JZS Bayes factor (BF) ANOVA and ANCOVAs with default prior scales using the 'Bayes-Factor' package in R and JASP, respectively (JASP Team, 2020; Morey & Rouder, 2014; Rouder et al., 2012).

Results and discussion

The ANOVA (Figure 3) showed that the provision of information regarding antibiotics decreased individuals' expectations that antibiotics are an appropriate treatment $F(1, 186) = 7.55, p = .007, \eta_p^2 = .04$. There was no significant effect of viral information on expectations that antibiotics are an appropriate treatment ($F < 1, p = .789$) nor was there any interaction ($F < 1, p = .859$). Similarly, the provision of information regarding antibiotics decreased individuals' expectations of the physicians' prescribing behaviour $F(1, 186) = 22.78, p < .001, \eta_p^2 = .11$, but the provision of viral information did not ($F < 1, p = .900$). There was also no interaction ($F < 1, p = .891$). Descriptively, as indicated in Figure 3 (Panel C), the likelihood of requesting antibiotics was decreased by the provision of antibiotic information, but this was not statistically significant $F(1, 186) = 3.46, p = .065, \eta_p^2 = .02$. Again, no effect of viral information ($F < 1, p = .843$) or interaction was found ($F < 1, p = .501$).

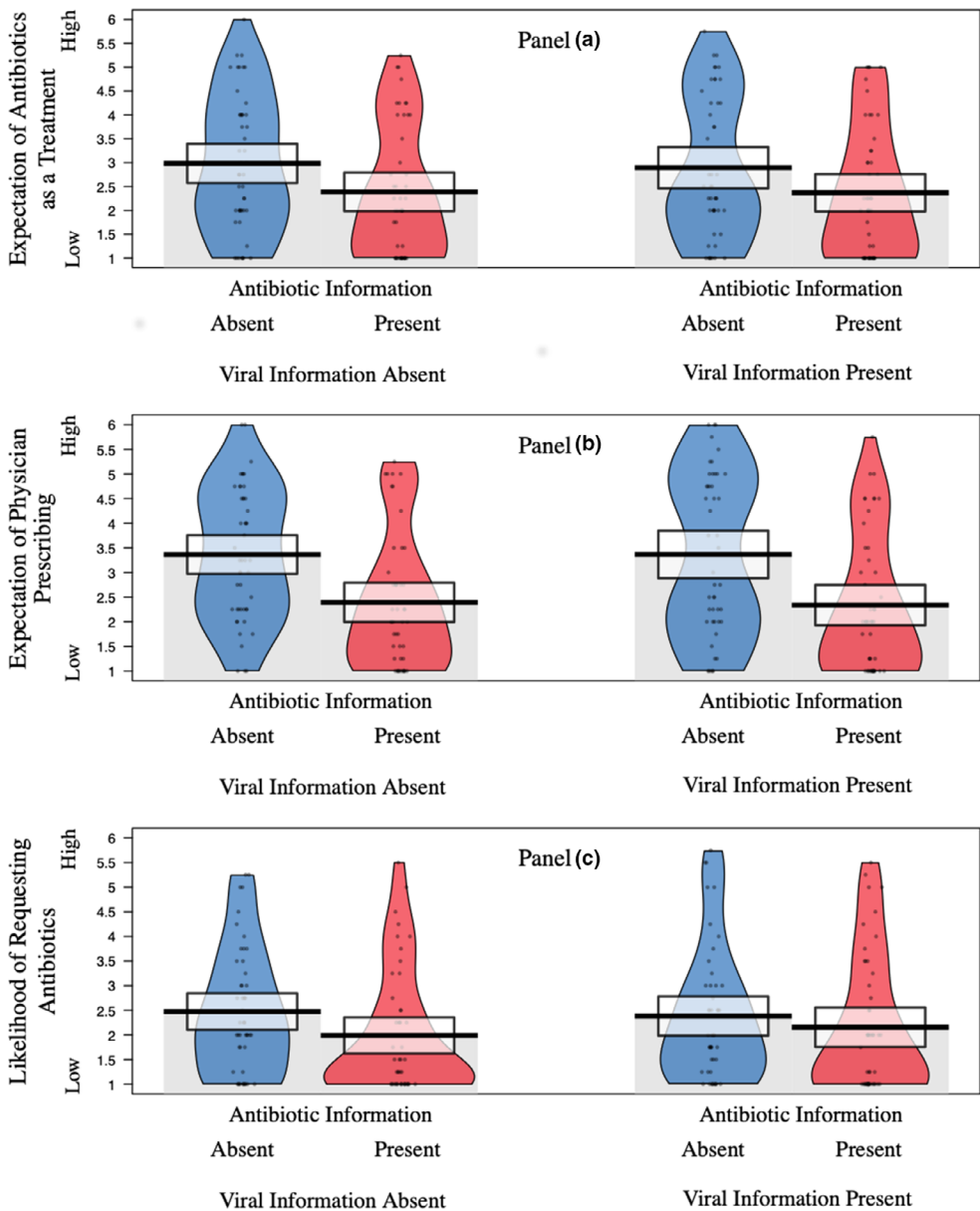


Figure 3. Effect of information provision (antibiotic information vs. viral information) on expectations that antibiotics are an appropriate treatment (Panel A), expectations of physician prescribing (Panel B), and requests for antibiotics (Panel C). The middle bold line represents the arithmetic mean, and the box borders represent 95% confidence intervals.

A JZS Bayes factor ANOVA (JASP Team, 2020; Morey & Rouder, 2014; Rouder et al., 2012) with default prior scales favoured the antibiotic information model to the intercept-only (null) model for both expectations that antibiotics are an appropriate treatment and of the physicians' prescribing behaviour, but not for the likelihood of requesting antibiotics (see Table 2). The data provide substantial evidence that antibiotic

Table 2. Quantified evidence for models (BFs)

BF denominator intercept-only models	BF numerator			
	Model 1 $BF_{A/}$	Model 2 $BF_{V/}$	Model 3 $BF_{A+V/}$	Model 4 $BF_{A+V+A \times V/}$
Expectations that antibiotics are an appropriate treatment	5.33	0.16	0.84	0.18
Expectations of physician to prescribe antibiotics	4,688.79	0.16	717.86	154.57
Likelihood of requesting antibiotics	0.79	0.16	0.12	0.03

Note. BF = Bayes factors; A = antibiotic information (factor 1); V = viral information (factor 2); A \times V = interaction term of antibiotic and viral information. Evidence category for BF_{01} as described by Wetzels et al. (2011): evidence to support H_0 : decisive evidence (>100), very strong evidence ($100 - 30$), strong evidence ($30 - 10$), substantial evidence ($10 - 3$), and anecdotal evidence ($3-1$). Evidence to support H_1 : decisive evidence ($<1/100$), very strong evidence ($1/100 - 1/30$), strong evidence ($1/30 - 1/10$), substantial evidence ($1/10 - 1/3$), and anecdotal evidence ($1/3 - 1$). $BF_{10} = 1/BF_{01}$.

information reduces expectations that antibiotics are an appropriate treatment ($BF_{10} = 5.33$); decisive evidence in favour for the provision of antibiotic information reducing expectations of the physicians' prescribing behaviour ($BF_{10} = 4688.79$); and no evidence that antibiotic information influences the likelihood of requesting antibiotics ($BF_{10} = 0.79$). Additionally, there was substantial evidence that data were more likely under the main effects models than the models including the interaction. The results of these analyses are consistent with the results of the classic ANOVAs and, as expected, provide support for the exclusive effect of antibiotic information on reducing expectations for antibiotics (hypothesis 5). Also aligned with the results of the classic ANOVAs, these results do not offer support for the hypotheses that viral information provision alone reduces expectations for antibiotics (hypothesis 4) or that combining both types of information offers an advantage (hypothesis 6).

To examine the effect of information provision after controlling for initial differences in participants' knowledge, antibiotic beliefs, illness representations, and past experiences, we entered these variables as covariates in subsequent two-way factorial ANCOVAs (see Tables S9–S11 in the Supporting Information). The main effect of antibiotic information in reducing expectations that antibiotics are an appropriate treatment and expectations of physicians' prescribing behaviour was unaffected by the introduction of covariates. However, the inclusion of illness representations and antibiotic knowledge and beliefs as covariates in the analysis of likelihood of requesting antibiotics resulted in a significant main effect of provision of antibiotic information (Table S11). The emergence of this main effect only after the inclusion of covariates in the model indicates that the effect of information provision on the likelihood of making a request for antibiotics in the scenario varied according to prior beliefs.

GENERAL DISCUSSION

Patients' expectations and requests for antibiotics influence physician prescribing behaviour (Sirota et al., 2017) and can increase clinically unjustified prescriptions of antibiotics in primary care (Davies, 2018). Strategies are needed that might on the one hand modify unnecessary consulting behaviour by patients and on the other hand

empower physicians to manage expectations and requests during those consultations. The present results provide important insights that might inform such strategies and advance understanding of the cognitive mechanisms underlying inappropriate expectations and requests. In two studies, we evaluated the role of prior knowledge and clinical information provision on inappropriate expectations and requests for antibiotics. Study 1 showed that poor antibiotic knowledge was associated with increased inappropriate expectations and requests for antibiotics. Study 2 provided causal evidence that information about the lack of efficacy and side effects of taking antibiotics reduced inappropriate expectations and requests for antibiotics, but that providing information confirming the viral nature of an infection did not. Findings from both studies indicate that while prior knowledge and clinical information provision influence inappropriate expectations and requests, a more complex network of illness and antibiotic beliefs is associated with expectations and requests than is typically appreciated in health campaigns and clinical interventions.

An extended common sense model of self-regulation was employed in study 1, as recently recommended by Hagger et al. (2017). Findings support this approach, since both illness representations and antibiotic beliefs contributed to the explanatory model. Participants were asked to consider a cold they had experienced that led them to go to the doctor. In this scenario, participants' expectations that antibiotics are an appropriate treatment and should be prescribed were positively associated with the belief that other people would approve of them taking antibiotics, the belief that antibiotics are effective at treating and controlling a cold, and inversely associated with anticipated regret if antibiotics were prescribed – that is – people who anticipated regret if they took antibiotics were less likely to consider them an appropriate treatment. Examination of the regression of people's expectations that a physician will prescribe them an antibiotic revealed that it was associated with a different set of variables. Participants who expected to receive a prescription reported cyclical timeline illness representations, had positive attitudes towards antibiotics and believed they would control their illness, had higher self-efficacy to ask for antibiotics, and also believed that significant others would approve of them taking antibiotics. These findings endorse the idea that obtaining antibiotics is a goal-driven deliberative act on the part of patients. Finally, increased likelihood of requesting antibiotics was reliably associated with lower illness coherence and stronger endorsement of cyclical timeline. This implies that a cold that may lead to the adoption of an antibiotic request coping response is characterized by unpredictable day-to-day variability in symptoms that are hard to comprehend (as opposed to the duration or severity of symptoms), together with the belief that antibiotics will offer an effective solution. Participants' feelings of anticipated regret if they requested and did not receive antibiotics were also associated with likelihood of requesting antibiotics, perhaps offering some insight into why physicians so often accede to requests. Anticipated annoyance and dissatisfaction both motivate people to ask, and perhaps also motivate physicians to avoid this outcome for their patients.

Study 2 controlled for illness characteristics by presenting participants with a description of a cold scenario physician consultation in vignette format, in order to provide a critical test of the causal role of information provision about illnesses and antibiotics on inappropriate expectations and requests for antibiotics. As predicted, we found that the provision of information regarding the lack of efficacy and side effects of antibiotics decreased expectations. For participants who are aware that colds are caused by viruses, this information would confirm that antibiotics would be unnecessary. Furthermore, the information about the harmful consequences of taking antibiotics

inappropriately might have prevented participants from discounting these side effects and, in turn, discouraged the adoption of a 'why not take a risk' strategy (Broniatowski et al., 2015, 2018). The direction of the effect was the same for our other key outcome (the likelihood of requesting antibiotics) although this effect was not statistically significant without the inclusion of covariates. People are often hesitant to communicate openly with their physician and directly requesting any kind of treatment from a physician can be seen as a particularly sensitive issue (Levy et al., 2018). It is possible that the lack of significant effect was because the situation described in the vignette was not sufficiently severe enough for participants to be willing to communicate directly with their physician in this way. Another reason for this could be that intentions to request antibiotics may be held more strongly than expectations and therefore less susceptible to the type of information provided in the vignettes.

Contrary to our second prediction, we observed no effect of information relating to the illness aetiology on expectations or requests. Participants who were told that the symptoms were caused by a viral infection were no less likely to expect or request antibiotics than those who did not receive this information. Thus, the findings of the experiment did not provide any evidence supporting this prediction. Given that so many adults think that antibiotics can kill viruses (Cals et al., 2007; Hoffmann, Ristl, Heschl, Stelzer, & Maier, 2014; van Rijn, Haverkate, Achterberg, & Timen, 2019), the obvious explanation for this is that a large proportion of the participants in this experiment believed that antibiotics are effective at treating viruses. In this case, simply providing information confirming that the infection was viral would not change their belief that antibiotics would be an appropriate treatment. This is an important consideration for physicians who might only choose to focus on educating patients about the nature of their infection without also providing a clear assertion that antibiotics will not help.

We also observed no statistically significant advantage in combining the two types of information. One explanation for this lack of significant effect could be due to a floor effect given that expectations and requests for antibiotics were already low overall. It may also have been the case that the viral information offered no additional benefit as most participants already knew that the described symptoms are typical of a viral infection. Alternatively, recent findings suggest that an action bias (a preference for harms caused by doing something compared to lesser, or equal, harms that come from doing nothing) might also partly explain why some participants in this condition still expected and would request antibiotics even though they were informed that they offer no clinical benefit and pose risk of harm (Thorpe, Sirota, Juanchich, & Orbell, 2020a).

Our findings are aligned with existing research that educational interventions may reduce desires for antibiotics (Madle, Kostkova, Mani-Saada, Weinberg, & Williams, 2004; Price et al., 2011; Roope et al., 2020; Thorpe et al., 2020a; Thorpe, Sirota, Juanchich, & Orbell, 2020b), but offer a distinct contribution by controlling for illness characteristics (severity and duration) and indicating that physicians might be empowered to change patient expectations during a consultation in which antibiotics are clinically inappropriate by providing information that specifically addresses ineffectiveness of antibiotics for the condition presented, and their side effects. Providing both illness and antibiotic information is recommended by NICE guidelines (PHE, 2017), and it is important to clarify that based on these findings we do not believe or recommend that physicians should not provide information on illness aetiology. Communicating information on illness aetiology and antibiotics to patients is not substantially more time-consuming than providing information about antibiotics alone and may confer other benefits. This is particularly important in the light of prior research, which found that 23% of people who asked for an

antibiotic when they visited their physician were given one without any discussion with their physician about the presenting illness (McNulty et al., 2013).

Recently, there has been an increase in the deployment of interventions aimed at reducing inappropriate antibiotic prescribing in primary care in the United Kingdom. These include the Quality Premium and the Keep Antibiotics Working Campaign³. Past research has shown that multifaceted interventions, which simultaneously incorporate educational elements with physician training and strategies such as delayed prescriptions, have been shown to be most effective at improving antibiotic prescribing (Arnold & Straus, 2006; Gonzales et al., 2005; Huttner, Goossens, Verheij, & Harbarth, 2010). However, to date, the success of the public/patient-targeted component of these interventions is unconvincing (Cross, Tolfree, & Kipping, 2016; Haynes & McLeod, 2015). In our work, we found that family physicians' sharing information with patients was instrumental in reducing inappropriate antibiotic expectations. This could be because in our study it was a trusted medical professional who shared the information and not an institution. In the United Kingdom, family physicians are a trusted source of information and this trust may be a condition to the effect occurring (Thorpe et al., 2020b).

Our findings also suggest that one reason why interventions focussed on patient education yield such mixed effects is that they overestimate the impact of didactic information about illnesses and antibiotics and neglect the influence of patient-related non-clinical factors such as their perception of the social norm for taking antibiotics or their anticipated regret concerning leaving a consultation empty-handed. Taken together, findings from study 1 and study 2 suggest that although informing patients does not always help them have more accurate knowledge of illnesses and antibiotics it may influence emotional responses to taking antibiotics, which can be an alternative pathway to behaviour change. Therefore, future interventions might also focus on modifying specific beliefs that antibiotics can treat a cold, creating more negative evaluations of antibiotics, encouraging people to consider potential regrets associated with taking antibiotics and changing the subjective norm (Prentice & Miller, 1993) by providing information that most other people think antibiotics should not be prescribed or taken for a respiratory tract infection. In particular, given the previous success of social norm feedback in reducing antibiotic prescribing by physicians (Hallsworth et al., 2016), it would be expected that normative appeals to the public might be a valuable method for reducing inappropriate prescriptions. Evidence that expectations and requests arise when an individual has failed to achieve illness coherence (Leventhal et al., 2011), perhaps because the course of illness does not seem to have an improving trajectory, but instead comes and goes from day to day in spite of efforts to control symptoms, suggests a further educational target. While clinical guidelines propose that physicians advise patients on average illness durations (Tan et al., 2008), education regarding normally expected variability in the progress of a cold associated with immune function activity and appropriate coping responses may also be useful.

While some theoretical consideration has been applied to physician's beliefs regarding antibiotic use (Donald, 2016), we believe this is the only study to have systematically examined the influence of prior knowledge alongside illness representations and treatment beliefs on the cognitive and motivational mechanisms underlying inappropriate expectations and requests for antibiotics. In the light of recent work assessing the effect of

³ The Quality Premium: <https://www.england.nhs.uk/ccg-out-tool/qual-prem/>. Keep Antibiotics Working: <https://campaignresources.phe.gov.uk/resources/campaigns/58-keep-antibiotics-working>

different combinations of messaging on inappropriate antibiotic expectations (Roope et al., 2020; Thorpe et al., 2020a, 2020b), the current research provides important causal evidence for the effect of specific types of clinical information provision on inappropriate antibiotic expectations and requests.

We acknowledge some limitations present in the methods employed in this research. First, though the use of clinical vignettes has been validated and applied in research assessing clinical judgements of health professionals (Sirota et al., 2017), they have not received similar validation when applied to the general public. As respondents did not physically experience any symptoms, the lack of ecological validity is self-evident and may partly explain why no direct effect of antibiotic information provision was found on the more sensitive questions regarding the likelihood of requesting antibiotics. We acknowledge that this procedure is limited in its ability to assess affective/symptomatic responses to the illness and perceived need for antibiotics. However, as our focus is on the cognitive mechanisms and representations underlying inappropriate expectations and requests for antibiotics, we believe that this is not a substantial drawback, particularly as our methods are comparable to those of mass educational campaigns, which often target the general public and patients consulting with respiratory tract infections (Ranji, Steinman, Shojania, & Gonzales, 2008). Future research that can explore ways to collect data on the illness representations, treatment beliefs, and coping strategies of individuals who have just contracted an acute viral infection would provide useful insights into how patients suffering from acute viral illnesses represent their illness, potential treatments (i.e., antibiotics), and how these representations relate to potential coping strategies and health outcomes. Second, women were more represented in our sample in study 1. Future studies, which can achieve a more equal number of male and female respondents, would better represent what is observed in the general adult population and would increase the generalizability of the present findings. Third, we acknowledge that we cannot assert whether the changes found here are stable over time; however, identifying effective techniques for campaigns to reduce inappropriate expectations and requests for antibiotics even temporarily can have a positive effect on health care particularly during periods of high incidences of viral infections. To overcome the listed limitations, future research might also focus on the relationship between reductions in self-reported expectations, and requests, and patients' actual consulting behaviours to enhance our understanding of how reducing expectations leads to reduced levels of inappropriate prescribing.

Conclusion

Both prior knowledge and information provision influence expectations and requests for antibiotics. We show that the provision of information regarding the efficacy and side effects of antibiotics decreases but does not eliminate clinically inappropriate expectations and requests of antibiotics. We suggest that interventions attempting to reduce expectations and requests should extend educational campaigns and training of primary care physicians to include other factors (e.g., social factors) for a synergic effect.

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aspredicted.org/blind.php?x=45tj4w. Study 2 was funded by an ESSEXLab Seedcorn grant, awarded to Alistair Thorpe.

Conflicts of interest

All authors declare no conflict of interest.

Author contributions

Alistair Thorpe (Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Visualization; Writing – original draft; Writing – review & editing) Miroslav Sirota (Conceptualization; Formal analysis; Funding acquisition; Methodology; Supervision; Writing – review & editing) Sheina Orbell (Conceptualization; Formal analysis; Methodology; Writing – review & editing) Marie Juanchich (Conceptualization; Methodology; Writing – review & editing).

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Supporting Information

The following supporting information may be found in the online edition of the article:

Appendix S1. Supporting information