International Journal of Pharmacy Practice, 2023, **XX**, 1–8
https://doi.org/10.1093/ijpp/riad089
Advance access publication 13 December 2023
Research Paper

IJPP International Journal of Pharmacy Practice

OXFORD

Beliefs about antibiotics, perceptions of antimicrobial resistance, and antibiotic use: initial findings from a multi-country survey

Annie S.K. Jones[1,2,*], Amy H.Y. Chan[1,3,4], Kebede Beyene[3], Chloe Tuck[4], Diane Ashiru-Oredope[4], Victoria Rutter[4], Rob Horne[1]

[1]Centre for Behavioural Medicine, University College London (UCL) School of Pharmacy, UCL, London, UK
[2]Health Psychology Section, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, UK
[3]School of Pharmacy, Faculty of Medical and Health Sciences, The University of Auckland, Grafton, Auckland, New Zealand
[4]Commonwealth Pharmacists' Association, London, UK

[*]**Correspondence:** Health Psychology Section, Institute of Psychiatry, Psychology & Neuroscience, King's College London, 5th floor Bermondsey Wing, Guy's Hospital, London, SE1 9RT, UK. E-mail: annie.s.jones@kcl.ac.uk

Abstract

Objectives: To examine public beliefs about antibiotics, AMR, and knowledge of antibiotic use, and how these relate to self-reported antibiotic use.

Methods: Two hundred and fifty participants from 23 countries completed a cross-sectional, online survey assessing beliefs about antibiotics and AMR, knowledge of antibiotics, and antibiotic use. Descriptive statistics, Mann–Whitney *U* tests and Spearman's ρ correlations were used to understand relationships between outcomes.

Key findings: Respondents generally viewed antibiotics positively, with particularly strong beliefs regarding their benefit (M = 16.48 out of 20, SD = 2.62) and few concerns regarding their harm (M = 3.98 out of 10, SD = 1.82). Greater benefit beliefs about antibiotics were associated with fewer concerns about their overuse ($P < .0001$) and harm ($P < .0001$). Stronger perceived importance of AMR was associated with greater beliefs about the benefits of antibiotics ($P = .006$), greater concerns about their overuse ($P = .009$), and increased knowledge of appropriate use ($P = .006$). Those who reported inappropriately using their last antibiotics had greater concerns about overuse ($P = .12$) and less knowledge regarding appropriate use ($P = .015$), compared to those who did not.

Conclusions: Generally, the public tends to view antibiotics as having strong benefits and have few concerns about their harm, which may have implications for inappropriate use. These initial findings highlight beliefs that could be targeted in messages to reduce inappropriate demand for antibiotics.

Keywords: antimicrobial resistance; antibiotics; medication beliefs

Antimicrobial resistance (AMR) is an increasing global problem [1]. A key driver of AMR is antibiotic consumption, which is also increasing worldwide [2, 3]. Preventing the inappropriate use of antibiotics is important to reduce unnecessary consumption and to slow the progression of AMR [4]. At the patient level, inappropriate use includes using antibiotics without a prescription or when these are not clinically indicated, such as self-medicating with over-the-counter antibiotics or using 'leftover' doses, which may be shared with family and friends [5, 6]. Understanding the drivers of inappropriate antibiotic use is therefore key to ensure effective interventions are designed to reduce unnecessary antibiotic consumption and demand.

Behavioural science theory suggests that the way people think about medicines influences their decisions to use these [7]. The necessity-concerns framework (NCF) is a well-established model for understanding how beliefs about a specific medicine influence the way that people interact with these [8, 9]. The NCF suggests that the use of a specific medicine is influenced by how necessary a person believes a given medicine is for them, versus their concerns about taking it. Ultimately, however, the NCF suggests this appraisal is influenced by more general beliefs and schemas that people hold about medicines as a class of treatment, including their perceived intrinsic *harm*, their perceived *overuse*, and the perceived *benefit* of using medicines [7]. There is evidence that the public holds these types of general beliefs about antibiotics as a class of medicines [10–14], and that these beliefs may influence inappropriate use such as self-medication [15]. This includes beliefs about the benefits of antibiotics for treating viral infections [11, 13, 14], and low perceived personal risk in regards to the effects of antibiotic overuse [1]. Furthermore, evidence suggests these beliefs influence patient demand for antibiotics [16], which increases the unnecessary prescribing of antibiotics by healthcare providers [17–19]. We would therefore expect that antibiotics are more likely to be

Received: 10 May 2023 Accepted: 29 November 2023

inappropriately used when they are perceived as less harmful, less overused, and to have greater benefits.

It may therefore be that these types of general beliefs about antibiotics as a class of medicines are driving the inappropriate use of antibiotics. It is also likely that beliefs about antibiotics are linked to and influenced by knowledge about antibiotics and perceptions of AMR. Indeed, recent research has shown that seeking and consuming antibiotics is strongly associated with having reduced awareness about AMR and misconceptions about appropriate antibiotic use [20]. Furthermore, research has shown that beliefs about antibiotics vary between cultures and within regions [21–24], suggesting these are influenced by culture, local regulations, and country income. This necessitates an exploration at a multi-country level to explore how individuals from different countries may differ in their beliefs about antibiotics, knowledge of antibiotics, and perceptions of AMR. The primary aim of this cross-sectional, exploratory study was therefore to examine global, general beliefs about antibiotics as a class of medicines, using an adapted version of the beliefs about medicines questionnaire [25]. We were also interested in examining knowledge of appropriate antibiotic use and perceptions about AMR, and how these relate to beliefs about antibiotics. Subsidiary aims included exploring how perceptions and knowledge may relate to self-reported use of antibiotics and whether differences exist in beliefs about antibiotics between countries or regions.

Methods

Ethics

No ethical approval was necessary for this survey as non-sensitive, completely anonymous survey procedures were used, and no identifying data were collected, as per institution guidelines [26].

Participants and design

A convenience sample was recruited from Amazon mechanical Turk (mTurk) and invited to complete an online, cross-sectional survey. Amazon mTurk is a crowdsourcing online platform, which has increasingly been used to gather samples for health research [27]. Respondents were invited to complete a survey regarding their views about antibiotics. The survey was informally piloted with colleagues prior to opening recruitment to assess whether wording and flow were clear. Eligible participants were those who were aged over 18 and who self-reported having previously taken antibiotics at any time. Those who provided informed consent were invited to proceed with the survey. The survey opened on 16 January 2018 and was closed on the same day after the initial target of 200 responses was achieved. Following this initial sampling, the study authors additionally distributed the survey via personal and research networks in the Commonwealth Pharmacists Association to attempt to receive responses from additional countries. Respondents who completed the survey were reimbursed US$0.05, in line with recommended Amazon mTurk pay guidelines.

Measures

Demographics

Respondents provided their country of residence, age, and gender.

Beliefs about antibiotics

Beliefs about antibiotics were measured using an adapted version of the Beliefs about Medicines Questionnaire General scale (BMQ-G) [25]. The BMQ-G was selected as this allows views towards a class of medicines to be examined, such as views towards antibiotics. This approach has previously been used to measure beliefs about analgesic medicines [28]. Items were therefore adapted to measure beliefs about antibiotics (e.g. '*Antibiotics* do more harm than good'). Items were answered on a 5-point Likert scale from 'strongly agree' (1) to 'strongly disagree' (5). Subscales include Harm (BAQ-harm; 2 items; scale range = 2–10), Overuse (BAQ-overuse; 4 items; scale range = 4–20), and Benefit (BAQ-benefit; 4 items; scale range = 4–20), with higher scores indicating stronger agreement with each of these beliefs.

Perceptions of AMR

Perceptions of AMR were assessed by asking the degree to which respondents agreed with eight commonly held beliefs about AMR. The items were adapted from the WHO Antibiotic Resistance: Multi-Country Public Awareness Survey [29] (the 2018 WHO survey was the latest version at the time of this study). Items were answered on the same 5-point response scale as the BAQ, (total score range = 8–40). Example items included 'Antibiotic resistance is one of the biggest problems the world faces', and 'Antibiotic resistance is an issue in other countries but not here' (reverse-scored). The scale demonstrated good internal consistency ($\alpha = 0.83$), and a sum score was created. Higher scores indicated stronger views regarding the importance of AMR as an issue.

Knowledge of antibiotics

Knowledge of antibiotics was assessed using a tool adapted from the WHO Antibiotic Resistance: Multi-Country Public Awareness Survey [29], whereby respondents identified whether antibiotics were an appropriate treatment for each of a list of 12 conditions (HIV/AIDS, gonorrhoea, bladder infection or urinary tract infection, diarrhoea, cold and flu, fever, malaria, measles, skin or wound infection, sore throat, body aches, headaches). Correct responses were summed to create a total score out of 12.

Antibiotic use

Previous antibiotic use was measured using items from the WHO Antibiotic Resistance: Multi-Country Public Awareness Survey [29]. Respondents provided information on the time of last antibiotic use (from options 'less than 1 month ago', '1 to 6 months ago', 'between 6-12 months ago', 'over 12 months ago', 'never' (who were excluded from the survey), 'can't remember'), whether these were obtained with a prescription (from options 'yes', 'no', 'can't remember'), whether advice was received on how to take these (from options 'yes', 'no', 'can't remember'), and where these antibiotics were received from ('medical store or pharmacy', 'stall or hawker', 'the internet', 'excess from previous doses', 'from a friend or family member', 'can't remember', or 'other'). Where 'other' was selected, respondents were asked to specify their answer in a free-text box.

Statistical analysis

Descriptive statistics were used to describe the sample demographics and outcomes. Beliefs about antibiotics, knowledge

of antibiotics, and perceptions of AMR across the sample were assessed using descriptive statistics. Associations between beliefs about antibiotics, knowledge of antibiotics, and perceptions of AMR were examined using Spearman's ρ correlations. Relationships between antibiotic use and beliefs, knowledge, and perceptions of AMR were examined using Mann–Whitney *U* tests. Tests were two-tailed and considered significant at $P < .05$. Data from Amazon MTurk were exported as a Microsoft Excel spreadsheet and imported into SPSS version 26 for cleaning and analysis. Missing cases were not included in the analyses.

Results

Demographics

Data were collected from 250 participants. Of these, two respondents reported having never taken antibiotics and were therefore excluded from the analysis leaving a remaining total sample of 248. Respondents were from 22 countries (see Table 1). The majority of participants were from high-income countries (86.5%), and most of the total sample were from the USA (79.3%). The mean (*M*) age of respondents was 41.5 years (SD = 14.4), and most identified as female (*n* = 167/248, 67.3%).

Descriptive statistics

The sample had relatively low concerns about antibiotic harm, whereby only 4.2% (10/238) of respondents scored above the BAQ-harm scale midpoint (M and SD reported in Table 1). The sample also had relatively low concerns about antibiotic-overuse, with only 20.6% (49/238) scoring above the BAQ-overuse scale midpoint. In contrast, the sample had high beliefs in the benefits of antibiotics, with 67.2% (16/238) scoring above the scale midpoint. A small majority of the sample scored above the scale midpoint on the perceptions of AMR scale (51.3%, 122/238; see Table 1 for *M* and SD of all variables). Individual item means can be seen in Supplementary Material 1 (these are graphically presented in Figs 1 and 2). BAQ subscale and AMR total scale distributions can be seen in Fig. 3.

Table 1 describes the antibiotic use in the current sample. Most respondents had taken antibiotics in the previous 12 months (51.6%, 127/246). Most participants received their last antibiotics with a prescription (91.4%, 224/245) and stated that these were from a health facility (e.g. medical store, pharmacy, or hospital) (94.3%, 231/245). Most participants also remembered receiving advice with their last antibiotics (79.0%, 196/248).

Associations between beliefs and knowledge of antibiotics and perceptions of AMR

The BAQ-overuse subscale was significantly, moderately, and positively associated with the BAQ-harm subscale ($r_{s\,(df=235)} = 0.49$, $P < .0001$), whereby stronger beliefs about the overuse of antibiotics were associated with stronger beliefs about the harm of antibiotics. The BAQ-benefit subscale was weakly, negatively, and significantly associated with both the BAQ-overuse ($r_{s\,(df=235)} = -0.28$, $P < .0001$) and BAQ-harm subscales ($r_{s\,(df=235)} = -0.44$, $P < .0001$), whereby stronger beliefs about the benefit of antibiotics were associated with fewer beliefs about their harm and overuse.

Table 1. Demographic statistics and descriptive statistics of outcomes.

Variable	Mean (SD) or *N* [%]
Age (*n* = 246)	41.5 (14.4)
Gender (*n* = 248)	
Female	167 [67.3%]
Male	78 [31.5%]
Other	1 [0.4%]
Prefer not to say	2 [0.8%]
Country income level (*n* = 245)	
High-income countries	212 [86.5%]
Australia	2 [0.8%]
Canada	2 [0.8%]
France	1 [0.4%]
Italy	1 [0.4%]
The Netherlands	2 [0.8%]
New Zealand	14 [5.7%]
Switzerland	1 [0.4%]
United Kingdom	22 [9.0%]
United States	168 [68.6%]
Low- or middle-income countries	33 [13.5%]
Afghanistan	1 [0.4%]
Algeria	1 [0.4%]
China	1 [0.4%]
India	16 [6.5%]
Laos	1 [0.4%]
Malaysia	1 [0.4%]
Mexico	1 [0.4%]
Philippines	2 [0.8%]
Romania	3 [1.2%]
Rwanda	1 [0.4%]
South Africa	1 [0.4%]
Uganda	1 [0.4%]
Zambia	1 [0.4%]
Knowledge of antibiotics (*n* = 242)	9.07 (1.92)
Perceptions of AMR (*n* = 237)	30.99 (5.84)
BAQ harm (*n* = 237)	3.98 (1.82)
BAQ overuse (*n* = 237)	12.84 (3.41)
BAQ benefit (*n* = 237)	16.48 (2.62)
Time of last antibiotic use (*n* = 246)	
Less than 1 month ago	29 [11.8%]
1–6 months ago	63 [25.6%]
Between 6 and 12 months ago	35 [14.2%]
Over 12 months ago	105 [42.7%]
Can't remember	14 [5.7%]
Last antibiotics received with a prescription (*n* = 245)	
Yes	224 [91.4%]
No or cannot remember	21 [8.6%]
Source of last antibiotics (*n* = 245)	
Medical store of pharmacy	228 [93.1%]
Stall or hawker	1 [0.4%]
The internet	2 [0.8%]
Excess from previous doses	6 [2.4%]
Friend or family member	3 [1.2%]
Cannot remember	2 [0.8%]
Other	3 [1.2%]
Last antibiotics received with advice (*n* = 248)	
Yes	196 [79.0%]
No or cannot remember	52 [21.0%]

AMR = antimicrobial resistance; BAQ = beliefs about antibiotics questionnaire.

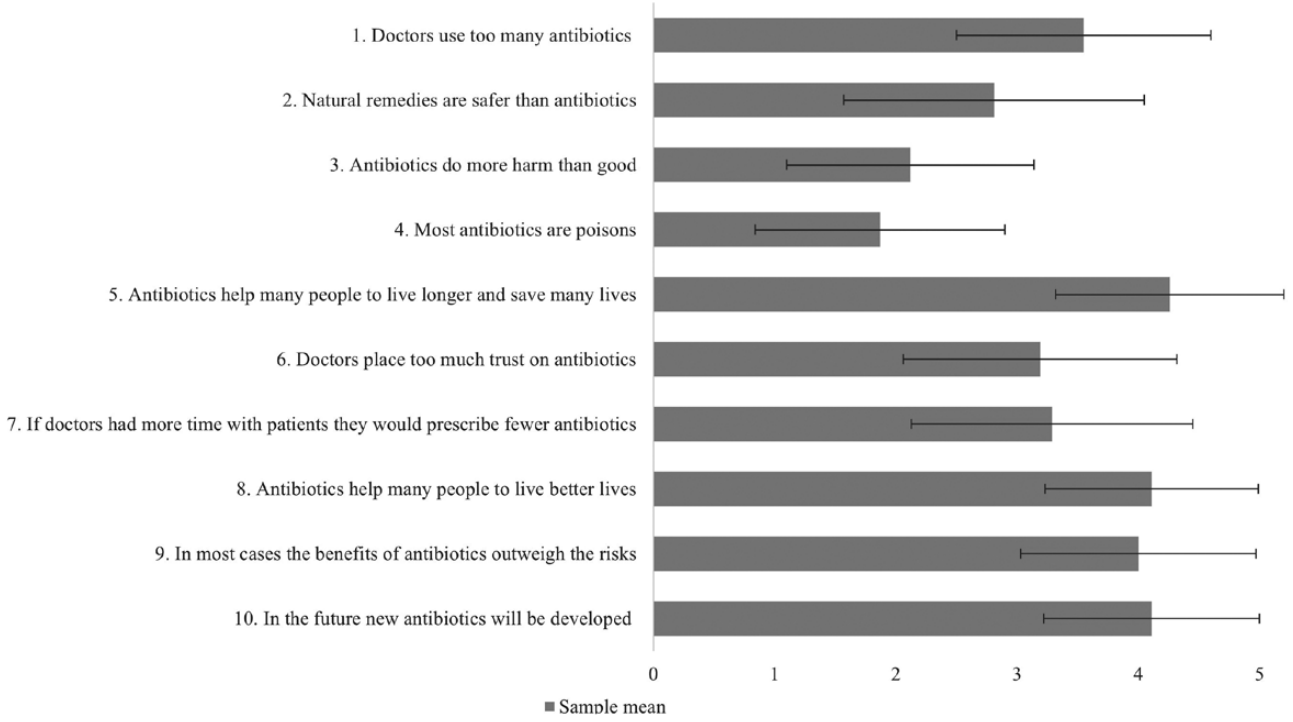

Figure 1. Beliefs about antibiotics in the total sample. Bars represent means and small bars represent standard deviation. Higher scores indicate more agreeance with the statement.

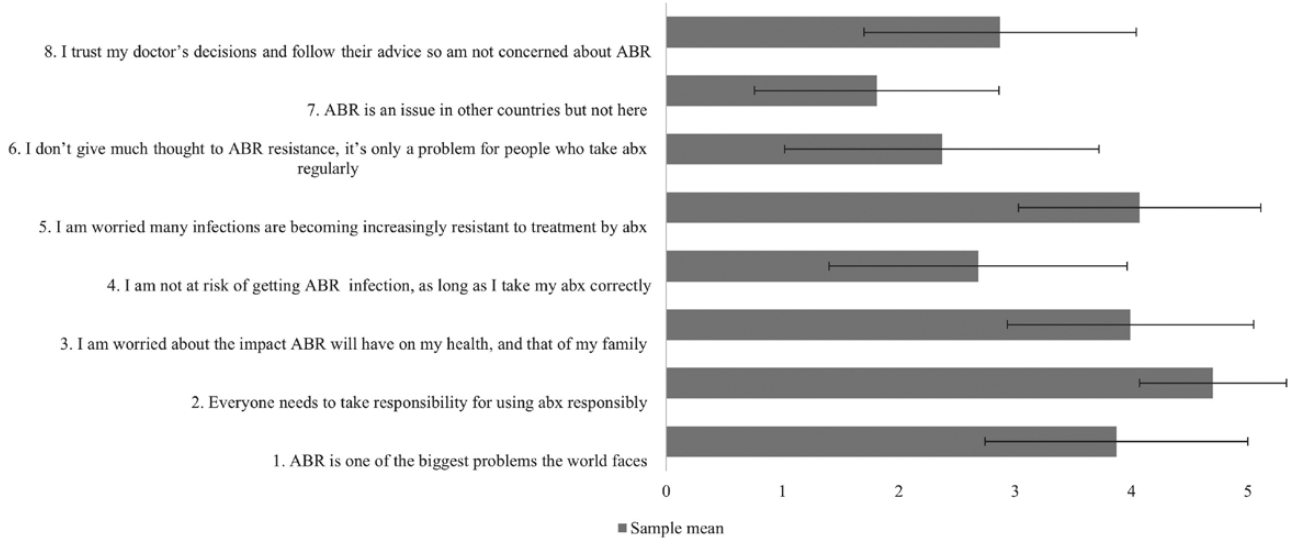

Figure 2. Perceptions of AMR in the total sample. Bars represent means and small bars represent standard deviation. Higher scores indicate more agreeance with the statement. *Note.* ABR= Antibiotic resistance.

Perceptions of AMR had a weak, significant, positive association with knowledge of antibiotic use ($r_{s\ (df=235)} = 0.18$, $P = .006$), whereby stronger perceived importance of AMR as an issue was associated with increased knowledge of antibiotic use. Perceptions of AMR were also significantly, weakly, and positively associated with the BAQ-overuse ($r_{s\ (df=235)} = 0.17$, $P = .009$) and BAQ-benefit subscales ($r_{s\ (df=235)} = 0.18$, $P = .006$), whereby greater perceptions of the importance of AMR as an issue was associated with greater beliefs about the overuse and benefit of antibiotics. Perceptions of AMR were not associated with the BAQ-harm subscale ($P > .05$).

Antibiotic use and beliefs about antibiotics, knowledge, and perceptions of AMR

Respondents who had used antibiotics in the prior 12 months had significantly higher knowledge of antibiotic use (*Mdn* = 10, IQR = 7–9), compared to those who had not or could not remember using these in the previous 12 months (*Mdn* = 8, IQR = 8–10; $U = 1460.00$, $z = -2.58$, $P = .010$). Respondents who had used antibiotics in the last 12 months also had significantly lower BAQ-overuse scores (*Mdn* = 13; IQR = 10–15), compared to those who had not used these in the past 12 months (*Mdn* = 14, IQR = 12–18; $U = 1274.00$,

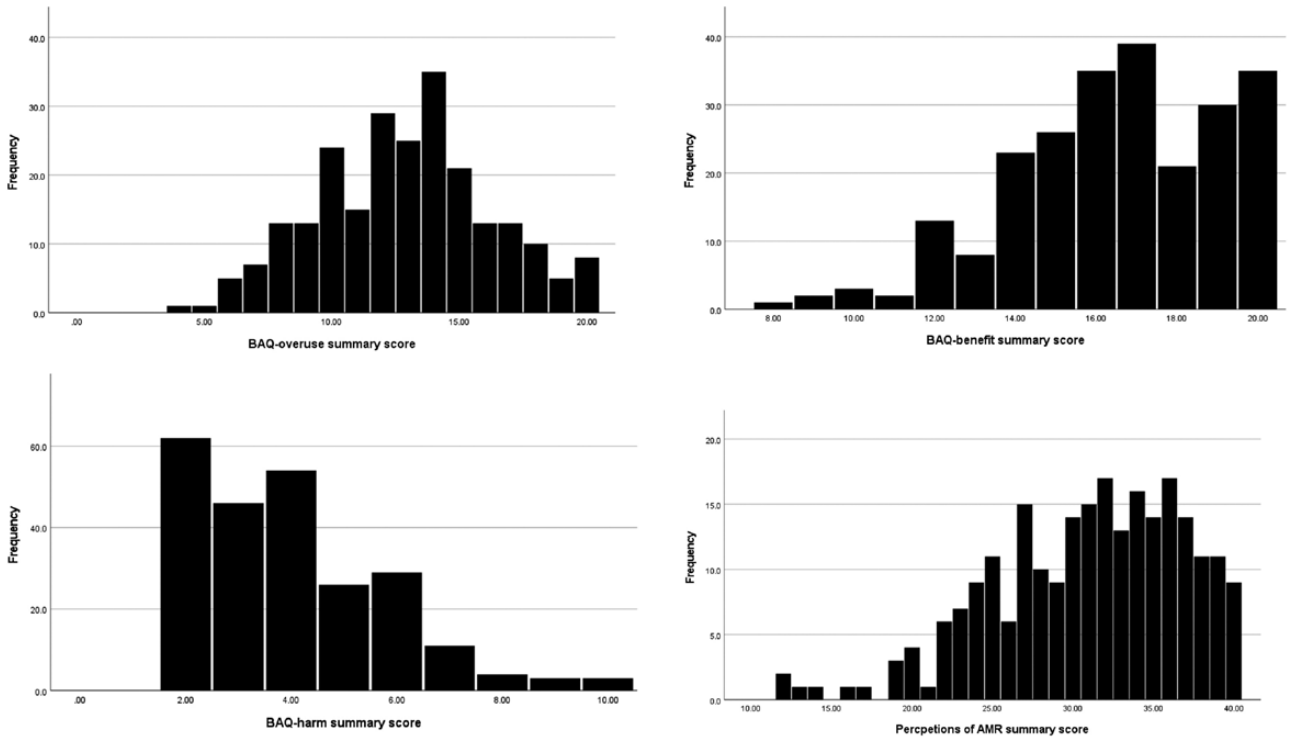

Figure 3. Distributions of scores on the BAQ-subscale scores and perceptions of AMR scores in the sample. *Note.* BAQ = Beliefs about Antibiotics questionnaire, AMR = Antimicrobial resistance.

z = –2.50, P = .012). There were no significant differences between those who had and had not used antibiotics in the previous 12 months and BAQ-harm scores or perceptions of AMR (P > .05).

Respondents who obtained their last antibiotics without a prescription or who could not remember receiving one had significantly lower knowledge of antibiotics (*Mdn* = 8.00, IQR = 7–9) compared to those who received these with a prescription (*Mdn* = 10.00, IQR = 8–10; U = 1412.00, z = –2.44, P = .015). Respondents who obtained their last antibiotics without a prescription or could not remember receiving one also had significantly higher BAQ-overuse scores (*Mdn* = 14.00, IQR = 12–18), compared to those who obtained their last antibiotics with a prescription (*Mdn* = 13.00, IQR = 10–15; U = 1274.00, z= –2.50, P = .12). There were no significant differences between antibiotic use with or without prescription and BAQ-harm and BAQ-benefit scores or perceptions of AMR (P > .05).

There were no differences in any outcomes based on whether respondents had or had not received advice with their previous antibiotics (P > .05).

Discussion

This study is the first to explore beliefs about antibiotics and their relationship with perceptions of AMR and knowledge of antibiotic use in a multi-country sample. This study suggests that the adapted beliefs about medicines questionnaire for antibiotics is a useful tool for investigating beliefs about antibiotics. This study also examined whether these factors were related to self-reported antibiotic use. We found that, in general, public views towards antibiotics were positive, demonstrated by strong beliefs in the benefits of using antibiotics with relatively low concerns, particularly regarding their harm. The sample generally perceived AMR to be important and had a fair knowledge of appropriate antibiotic use. Viewing AMR as more important was related to having greater knowledge of appropriate antibiotic use, greater concerns about the overuse of antibiotics, and viewing antibiotics as having greater benefits. We found that participants who had used antibiotics in the previous year reported greater knowledge about appropriate use and were less concerned about their overuse. We also found that participants who obtained their last antibiotics without a prescription had less knowledge about antibiotic use but were more concerned about their overuse. These initial findings suggest that there may be key belief patterns that could be targeted to try and shift patient demand for antibiotics.

To the authors' knowledge, this is the first study to look at general beliefs about antibiotics using a global survey. This sample was multi-national, providing data on beliefs and antibiotic use in a number of countries including some low- and middle-income countries (LMIC) where these have been less commonly examined [30].

A caveat to the generalisability of conclusions we can draw is the unequal sampling of participants across countries, with a particular bias towards Western countries (the USA and UK). Furthermore, a formal sample size calculation was not used for the recruitment target in the current study. As we were only able to recruit a small sample (n= 33/245, 13.5%) of individuals from LMIC, we were unable to examine whether differences existed in outcomes between countries or regions. This is an important question for future research, given it could suggest the need for context-specific interventions. Future research should include theoretically and statistically informed target sample sizes within income contexts to ensure a more representative, global sample. However, the findings related to antibiotic use in the current

study are consistent with those from large representative data sets [2, 3].

The unequal representation across countries may have been a result of utilizing Amazon mTurk for recruitment. However, previous work has suggested respondents recruited using Amazon mTurk are demographically similar to those recruited using more traditional methods in health and medical research, although respondents from areas such as South East Asia may be more well educated [27]. Furthermore, the issues of representation in the current sample would likely be present when using any online sampling methods. A further limitation of online sampling methods is that participation is restricted to those with technological literacy and access. Future work may benefit from utilizing a variety of sampling methods to increase representation from a range of countries. This would also allow future research to examine whether there are differences in beliefs about antibiotics at a country or contextual level and whether these might explain differences in antibiotic consumption. This may help to inform contextually relevant messages to change inappropriate antibiotic use and improve awareness of AMR.

In addition, antibiotic use in the current study was self-reported. It is therefore possible that social desirability may have influenced responses from participants. However, non-prescription use of antibiotics, such as self-medication or medication-sharing, can only be captured by self-report. Future research could also utilize prescription data to understand how beliefs might be driving patient demand for and the inappropriate prescription of antibiotics. Additionally, the survey was not formally piloted before use in the current study, and this may be important in future work to understand the validity of the self-reported measures of behaviour and beliefs.

Finally, these data were collected in 2018. Global views on antibiotics and AMR may have changed in recent years given, particularly as a result of the COVID-19 pandemic.

From a theoretical point of view, we would expect the positive public attitudes towards antibiotics to align with greater demand for medicines [7]. The NCF would suggest that these beliefs present a positive schema towards the use of antibiotics (i.e. having strong beliefs in their benefit with few concerns about their harm or overuse), which would likely also influence greater necessity beliefs and fewer concerns about using specific antibiotic medicines. Indeed, previous research has found that the consumption of medicines is associated with greater beliefs about their benefits [31]. It may, therefore, be that these widely held public beliefs influence antibiotic consumption. Indeed, consumption rates were high in the current sample, with 50% of patients reporting antibiotic use in the previous 12 months. However, it is possible that people with more recent use of antibiotics were more interested in taking part in our survey about their experiences of using antibiotics.

Reports of off-prescription use of antibiotics in the current sample were relatively low (8.6%). However, as highlighted above off-prescription use was associated with lower knowledge regarding appropriate use and greater concerns about overusing antibiotics. Similarly, previous research has found that favouring antibiotics for treating cold- and flu-like symptoms has been associated with greater tendencies to inappropriately use antibiotics [15, 20]. This is significant, as despite legal regulations in many countries, some community pharmacies still supply over-the-counter antibiotics [32, 33]. Furthermore, most non-prescription antibiotics available in community pharmacies are for self-limiting conditions (e.g. gastroenteritis, UTRI) for which antibiotics are ineffective [34]. An important area for future research would therefore be to investigate whether there are differences in beliefs between countries with and without regulations, which could indicate targets for public awareness campaigns.

Beliefs related to overuse are, therefore, important targets that should be addressed to try and reduce inappropriate demand and use of antibiotics, in addition to attempting to increase knowledge of appropriate use. In addition, from the perspective of the NCF, highlighting beliefs about overuse and harm as concerns following inappropriate use, may have the ability to reduce demand. Targeting beliefs may not only reduce self-medication with antibiotics but may also reduce inappropriate provider prescriptions of antibiotics, which are known to be influenced by patient beliefs [17–19]. Messages could address both the limitations of antibiotic use (i.e. their ineffectiveness against viral infections) and the consequences of their overuse (i.e. individual and societal level resistance).

Overall, the current study highlights the types of beliefs the public holds about antibiotics and provides some initial data to suggest how these may relate to antibiotic consumption. These findings support conclusions from others about the importance of addressing beliefs about antibiotics in the design of interventions to reduce inappropriate antibiotic use [11, 13]. Effective messages to reduce inappropriate use may be those which balance the benefits of antibiotics against the consequences related to harm from unnecessary use (i.e. side effects) and overuse (i.e. resistance). Recent research has demonstrated that these types of messages can change patient beliefs and demand for antibiotics, both in online [35] and primary care settings [36]. Both of these brief interventions utilized tailored messages informed by the NCF [9], to increase concerns related to the adverse effects of antibiotics and decrease necessity regarding the efficacy of antibiotics for treating cold or flu symptoms. Future research could therefore further investigate whether these types of messages are able to shift beliefs and demand for antibiotics at a wider, societal level.

Our findings suggest the importance of understanding patient beliefs about antibiotics in the context of healthcare delivery. Previous work has suggested that healthcare providers should facilitate shared decision-making in relation to antibiotic use by discussing the consequences of using antibiotics for unnecessary conditions when these are requested during consultations [17].

Conclusions

The current study provides initial data on public beliefs about antibiotics, AMR, and knowledge of appropriate antibiotic use. It also provides data on self-reported use of antibiotics at a global level. The findings suggest that concerns about the harm and overuse of antibiotics are low; therefore, targeting these beliefs may help to reduce inappropriate demand. Messages that promote the consequences of inappropriately using antibiotics both at the individual and societal level may increase awareness of AMR and reduce inappropriate demand for antibiotics. Further work is needed to build upon the current findings regarding the relationships between beliefs and inappropriate use to better inform the content of these messages.

Supplementary material

Supplementary data are available at *International journal of Pharmacy Practice* online.

Acknowledgements

The authors thank the participants of the survey and the members of the Commonwealth Pharmacists Association who helped to recruit participants by distributing the survey across their research networks. For the purposes of open access, the author has applied a Creative Commons Attribution (CC BY) licence to any Accepted Author Manuscript version arising from this submission.

Author contributions

All authors have significantly contributed to this manuscript. A.H.Y.C., R.H., C.T., D.A. and V.R. were involved in the design of the study and survey questionnaire. A.S.K.J., A.H.Y.C., K.B., and R. H. analysed and interpreted the data. A.S.K.J. led the drafting of the manuscript. All authors contributing to drafting and reviewed the final manuscript.

Conflict of interest

A.H.Y.C. reports grants and personal fees from Janssen-Cilag, consultancy fees from Spoonful of Sugar Ltd, grants from A+ charitable trust (Auckland District Health Board), Maurice and Phyllis Paykel trust, Universitas 21, New Zealand Pharmacy Education Research Fund, Auckland Academic Health Alliance, Asthma UK, the University of Auckland, Health Research Council, and Oakley Mental Health Foundation, outside the submitted work. A.H.Y.C. is also the recipient of the Robert Irwin Postdoctoral Fellowship and the Senior Research Fellowship from the Auckland Medical Research Foundation. KB reports grants from Health Research Council of New Zealand, Amgen, A+ Charitable Trust (Auckland District Health Board), Universitas 21, New Zealand Pharmacy Education and Research Foundation, the University of Auckland, and Addis Ababa University, outside the submitted work. R.H. is supported by the National Institute for Health Research (NIHR, Collaboration for Leadership in Applied Health Research and Care (CLAHRC), North Thames at Bart's Health NHS Trust and Asthma UK (AUKCAR). R.H. reports previous speaker engagements with honoraria with AbbVie, Abbott, Amgen, Astellas, AstraZeneca, Boehringer Ingelheim, Biogen, Gilead Sciences, GlaxoSmithKline, Janssen, Merck Sharp Dohme, Merck, Novartis, Pfizer, Procter & Gamble, Roche, Sanofi, Shire Pharmaceuticals, TEVA, and UCB, and personal consultancy with Amgen, Abbott, AstraZeneca and Novartis. R.H. is a Founding Director of a UCL-Business company (Spoonful of Sugar Ltd) providing consultancy on treatment engagement and patient support programmes to healthcare policy makers, providers and pharmaceutical industry. The remaining authors have none to declare.

Funding

The study was supported by Spoonful of Sugar Ltd, a UCL Business Company. The supporting source had no involvement in study design, collection, analysis, and interpretation of data, writing of the report, and has no restrictions regarding the submission of the report for publication.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author. Data were collected specifically for the purpose of the reported study. No access was therefore required.

References

1. McCullough AR, Parekh S, Rathbone J *et al*. A systematic review of the public's knowledge and beliefs about antibiotic resistance. *J Antimicrob Chemother* 2016;**71**:27–33. https://doi.org/10.1093/jac/dkv310
2. Klein EY, Van Boeckel TP, Martinez EM *et al*. Global increase and geographic convergence in antibiotic consumption between 2000 and 2015. *Proc Natl Acad Sci USA* 2018;**115**:E3463–70. https://doi.org/10.1073/pnas.1717295115
3. Van Boeckel TP, Gandra S, Ashok A *et al*. Global antibiotic consumption 2000 to 2010: An analysis of national pharmaceutical sales data. *Lancet Infect Dis* 2014;**14**:742–50. https://doi.org/10.1016/S1473-3099(14)70780-7
4. Torres NF, Chibi B, Middleton LE *et al*. Evidence of factors influencing self-medication with antibiotics in low and middle-income countries: a systematic scoping review. *Public Health* 2019;**168**:92–101. https://doi.org/10.1016/j.puhe.2018.11.018
5. Alhomoud F, Aljamea Z, Almahasnah R *et al*. Self-medication and self-prescription with antibiotics in the Middle East—do they really happen? A systematic review of the prevalence, possible reasons, and outcomes. *Int J Infect Dis*2017;**57**:3–12. https://doi.org/10.1016/j.ijid.2017.01.014
6. Beyene K, Sheridan J, Aspden T. Prescription medication sharing: A systematic review of the literature. *Am J Public Health* 2014;**104**:e15. https://doi.org/10.2105/AJPH.2013.301823
7. Horne R, Cooper V, Wileman V *et al*. Supporting adherence to medicines for long-term conditions: a perceptions and practicalities approach based on an extended common-sense model. *Eur Psychol* 2019;**24**:82–96. https://doi.org/10.1027/1016-9040/a000353
8. Foot H, La Caze A, Gujral G *et al*. The necessity-concerns framework predicts adherence to medication in multiple illness conditions: A meta-analysis. *Patient Educ Couns* 2016;**99**:706–17. https://doi.org/10.1016/j.pec.2015.11.004
9. Horne R, Chapman SCE, Parham R *et al*. Understanding patients' adherence-related beliefs about medicines prescribed for long-term conditions: a meta-analytic review of the Necessity-Concerns Framework. *PLoS One* 2013;**8**:e80633. https://doi.org/10.1371/journal.pone.0080633
10. Davey P, Pagliari C, Hayes A. The patient's role in the spread and control of bacterial resistance to antibiotics. *Clin Microbiol Infect* 2002;**8**:43–68. https://doi.org/10.1046/j.1469-0691.8.s.2.6.x
11. Norris P, Chamberlain K, Dew K *et al*. Public beliefs about antibiotics, infection and resistance: A qualitative study. *Antibiotics (Basel, Switzerland)* 2013;**2**:465–76. https://doi.org/10.3390/antibiotics2040465
12. Gaarslev C, Yee M, Chan G *et al*. A mixed methods study to understand patient expectations for antibiotics for an upper respiratory tract infection. *Antimicrob Resist Infect Control* 2016;**5**:1–9. https://doi.org/10.1186/s13756-016-0134-3
13. Cals JW, Boumans D, Lardinois RJ *et al*. Public beliefs on antibiotics and respiratory tract infections: An internet-based questionnaire study. *Br J Gen Pract* 2007;**57**:942–7. https://doi.org/10.3399/096016407782605027
14. Hawkins O, Scott AM, Montgomery A *et al*. Comparing public attitudes, knowledge, beliefs and behaviours towards antibiotics and antimicrobial resistance in Australia, United Kingdom, and

Sweden (2010-2021): A systematic review, meta-analysis, and comparative policy analysis. *PLoS One* 2022;**17**:e0261917. https://doi.org/10.1371/journal.pone.0261917
15. Grigoryan L, Burgerhof JGM, Degener JE *et al*; Self-Medication with Antibiotics and Resistance (SAR) Consortium. Determinants of self-medication with antibiotics in Europe: the impact of beliefs, country wealth and the healthcare system. *J Antimicrob Chemother* 2008;**61**:1172–9. https://doi.org/10.1093/jac/dkn054
16. Thorpe A, Sirota M, Orbell S *et al*. Effect of information on reducing inappropriate expectations and requests for antibiotics. *Br J Psychol* 2021;**112**:804–27. https://doi.org/10.1111/bjop.12494
17. McNulty CAM, Nichols T, French DP *et al*. Expectations for consultations and antibiotics for respiratory tract infection in primary care: The RTI clinical iceberg. *Br J Gen Pract* 2013;**63**:e429–36. https://doi.org/10.3399/bjgp13X669149
18. Thompson W, Tonkin-Crine S, Pavitt SH *et al*. Factors associated with antibiotic prescribing for adults with acute conditions: an umbrella review across primary care and a systematic review focusing on primary dental care. *J Antimicrob Chemother* 2019;**74**:2139–52. https://doi.org/10.1093/jac/dkz152
19. Fletcher-Lartey S, Yee M, Gaarslev C *et al*. Why do general practitioners prescribe antibiotics for upper respiratory tract infections to meet patient expectations: A mixed methods study. *BMJ Open* 2016;**6**:e012244. https://doi.org/10.1136/bmjopen-2016-012244
20. Roope LSJ, Tonkin-Crine S, Butler CC *et al*. Reducing demand for antibiotic prescriptions: Evidence from an online survey of the general public on the interaction between preferences, beliefs and information, United Kingdom, 2015. *Euro Surveill* 2018;**23**:1700424. https://doi.org/10.2807/1560-7917.ES.2018.23.25.1700424
21. Gaygısız U, Lajunen T, Gaygısız E. Socio-economic factors, cultural values, national personality and antibiotics use: A cross-cultural study among European countries. *J Infect Public Health* 2017;**10**:755–60. https://doi.org/10.1016/j.jiph.2016.11.011
22. Grigoryan L, Burgerhof JGM, Degener JE *et al*; SAR consortium. Attitudes, beliefs and knowledge concerning antibiotic use and self-medication: a comparative European study. *Pharmacoepidemiol Drug Saf* 2007;**16**:1234–43. https://doi.org/10.1002/pds.1479
23. Deschepper R, Vander Stichele RH, Haaijer-Ruskamp FM. Cross-cultural differences in lay attitudes and utilisation of antibiotics in a Belgian and a Dutch city. *Patient Educ Couns* 2002;**48**:161–9. https://doi.org/10.1016/s0738-3991(02)00017-4
24. Deschepper R, Grigoryan L, Lundborg CS *et al*. Are cultural dimensions relevant for explaining cross-national differences in antibiotic use in Europe? *BMC Health Serv Res* 2008;**8**:1–9. https://doi.org/10.1186/1472-6963-8-123
25. Horne R, Weinman J, Hankins M. The beliefs about medicines questionnaire: The development and evaluation of a new method for assessing the cognitive representation of medication. *Psychol Health* 1999;**14**:1–24. https://doi.org/10.1080/08870449908407311
26. University College London Research Ethics Committee. Exemptions. Published 2018. https://ethics.grad.ucl.ac.uk/exemptions.php
27. Mortensen K, Hughes TL. Comparing Amazon's Mechanical Turk platform to conventional data collection methods in the health and medical research literature. *J Gen Intern Med* 2018;**33**:533–8. https://doi.org/10.1007/s11606-017-4246-0
28. Mittal P, Chan OY, Kanneppady SK *et al*. Association between beliefs about medicines and self-medication with analgesics among patients with dental pain. *PLoS One* 2018;**13**:e0201776. https://doi.org/10.1371/journal.pone.0201776
29. World Health Organization. Antibiotic Resistance: Multi-Country Public Awareness Survey.; 2015. https://apps.who.int/iris/bitstream/handle/10665/194460/9789241509817_eng.pdf
30. Collignon P, Beggs JJ, Walsh TR *et al*. Anthropological and socioeconomic factors contributing to global antimicrobial resistance: a univariate and multivariable analysis. *Lancet Planet Health*. 2018;**2**:e398–405. https://doi.org/10.1016/S2542-5196(18)30186-4
31. Andersson Sundell K, Jönsson AK. Beliefs about medicines are strongly associated with medicine-use patterns among the general population. *Int J Clin Pract* 2016;**70**:277–85. https://doi.org/10.1111/ijcp.12781
32. Lescure D, Paget J, Schellevis F *et al*. Determinants of self-medication with antibiotics in European and Anglo-Saxon countries: A systematic review of the literature. *Front Public Health* 2018;**6**:370. https://doi.org/10.3389/fpubh.2018.00370
33. Cars O, Nordberg P. Antibiotic Resistance-The Faceless Threat. *International Journal of Risk and Safety in Medicine*, 2005;**17**, 3-4:103-110.
34. Auta A, Hadi MA, Oga E *et al*. Global access to antibiotics without prescription in community pharmacies: A systematic review and meta-analysis. *J Infect* 2019;**78**:8–18. https://doi.org/10.1016/j.jinf.2018.07.001
35. Chan AHY, Horne R, Lycett H *et al*. Changing patient and public beliefs about antimicrobials and antimicrobial resistance (AMR) using a brief digital intervention. *Front Pharmacol* 2021;**12**:608971. https://doi.org/10.3389/fphar.2021.608971
36. Perera AI, Thomas MG, Petrie KJ *et al*. Reducing expectations for antibiotics in patients with upper respiratory tract infections: a primary care randomized controlled trial. *Ann Fam Med* 2021;**19**:232–9. https://doi.org/10.1370/afm.2672