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Preferences regarding antibiotic treatment and the role of antibiotic resistance: A discrete choice experiment

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ABSTRACT

Objectives: To identify preferences of the Swedish public regarding antibiotic treatment characteristics and the relative weight of antibiotic resistance in their treatment choices.

Methods: A questionnaire including a discrete choice experiment questionnaire was answered by 378 Swedish participants. Preferences of the general public regarding five treatment characteristics (attributes) were measured: contribution to antibiotic resistance, cost, side effects, failure rate and treatment duration. Latent class analysis models were used to determine attribute-level estimates and heterogeneity in preferences. Relative importance of the attributes and willingness to pay for antibiotics with a lower contribution to antibiotic resistance were calculated from the estimates.

Results: All attributes influenced participants' preferences for antibiotic treatment. For the majority of participants, contribution to antibiotic resistance was the most important attribute. Younger respondents found contribution to antibiotic resistance more important in their choice of antibiotic treatments. Choices of respondents with lower numeracy, higher health literacy and higher financial vulnerability were influenced more by the cost of the antibiotic treatment. Older respondents with lower financial vulnerability and health literacy, and higher numeracy found side effects to be most important.

Conclusions: All attributes can be considered as potential drivers of antibiotic use by lay people. Findings also suggest that the behaviour of lay people may be influenced by concerns over the rise of antibiotic resistance. Therefore, stressing individual responsibility for antibiotic resistance in clinical and societal communication has the potential to affect personal decision making.

1. Introduction

The rapid development of multi-drug-resistant bacteria is one of the most significant threats to public health globally [1]. In Europe alone, the overall societal cost of antibiotic resistance (AR) has been estimated to result in extra healthcare costs and productivity losses of at least EUR 1.5 billion each year [2], and to be the direct cause of approximately 33,000 deaths each year [3].

As antibiotic use is the main driver of AR [4,5], a reduction in the use of antibiotics is urgently required. The excessive use of antibiotics is also an issue in countries where antibiotics are prescription drugs (i.e. where they can only be dispensed to patients if there is a medical prescription). Patients can influence antibiotic prescription by showing positive expectations for antibiotic treatment, but it is also the case that prescribers can assume that patients want to be prescribed these drugs. It has been shown that prescribers tend to prescribe antibiotics more often when they believe that their patients expect them [6,7]. Antibiotic prescription is not determined merely by medical exigencies but is also heavily influenced by social factors. AR is a collective action dilemma; it can be mitigated only if sufficiently large numbers of people contribute to the common good and refrain from harmful behaviour.

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For this reason, effective stewardship approaches should include appropriately targeted awareness campaigns that can positively influence socially conscious citizens [8]. Research-funding agencies are calling for effective framing and communication of AR. In the words of Wellcome Trust Director, Jeremy Farrar, ‘We can do all the science and innovation we want but if we can't take society with us, then we won't land the science or the challenges, and we won't access the maximum number of people [9]’. Public campaigns for judicious use of antibiotics are often focused on awareness-raising as a behavioural tool. However, such campaigns have seldom been developed from an appraisal of public attitudes towards antibiotics and AR [10–12]. The role that AR should be given in patient–doctor communication and in campaigns is debatable because the concept is difficult, and is a health threat not only for the individual but also (mostly) for the collective. The development of effective communication requires knowledge in the following areas: (i) What characteristics of antibiotic treatment drive antibiotic use by lay people? (ii) Can the behaviour of lay people be influenced by concerns over the rise of AR? As previous studies have mainly focused on characteristics of antibiotics influencing patients' and prescribers' preferences or behaviour, the aim of the present study was to identify the preferences of the general public regarding antibiotic treatment characteristics, and to show the relative weight of AR in their treatment choices.

2. Materials and methods

2.1. Ethics

This study adhered to Swedish research regulations and was approved by Uppsala Regional Ethical Review Board (Dnr 2018/293).

2.2. Discrete choice experiment

A discrete choice experiment (DCE) is a stated preference method, used widely and increasingly in health research [13]. The method provides participants with several hypothetical but realistic choice sets. A DCE is used to elicit individuals' preferences for a medical intervention, such as antibiotic treatment, under the assumption that: (i) the treatment can be described by separate characteristics (‘attributes’), which are further specified by variants called ‘attribute levels'; and (ii) when showed alternative hypothetical treatment options that consist of different combinations of levels (i.e. choice tasks), individuals prefer the combination of attributes and levels that gives them the highest utility [14]. Respondents choose multiple times between the alternatives and, by analysing their choices, the relative importance of the attributes (levels) can be determined and trade-offs can be calculated [15].

2.3. Attributes and levels

Attributes and levels were developed in adherence with methodological standards [16,17]. The process is described below.

2.3.1. Literature review

A literature search was conducted in PubMed (from 1999 to 2019) to identify key concepts in antibiotic use behaviour, and produced 343 hits. An assessment of titles and abstracts was made. The criterion adopted was to include titles and abstracts indicating that the document likely contained a description of characteristics of antibiotics influencing patients' or prescribers' preferences or behaviour. From the resulting 26 documents, 12 potential attributes were identified.

2.3.2. Focus groups

Twenty-three representatives of the general population (13 women and 10 men, mean age 38 years, age range 20–81 years) participated in four focus group discussions. Participants were recruited through an area-based approach and purposive sampling, aiming to create groups as heterogeneous as possible with regard to gender, age and education level. Data were collected until saturation was reached. Nominal group process (NGP) techniques were employed to determine features that would drive participants' decision-making between different antibiotic treatment options. NGP is a method encompassing a number of steps and techniques to explore the qualitative and quantitative elements, patterns and structure of a healthcare issue under preliminary investigation [18]. Each group generated a ranking of the most important antibiotic features. After adopting uniform terminology to eliminate different formulations for the same attribute, seven additional potential attributes were identified.

2.3.3. Attribute features checklist

All 19 potential attributes (12 from the literature review and seven from the focus groups) were tested against a checklist of desirable attribute features, based on the methodological literature on DCEs and the researchers' experience [16,17]. The desirable features of the attributes for inclusion in the final list of attributes were: realistic, plausible, tradable, clear and unambiguous, distinctively different from others, comprehensive, not a proxy for utility, unlikely to dominate, and relevant to respondent's choice.

2.3.4. Stakeholder interviews and refinement

Interviews with stakeholders (two general practitioners, a nurse and a pharmacist) were held to discuss the attributes, levels and the whole questionnaire. The research team discussed the results of the interviews until consensus was reached. The number of attributes was kept as low as possible to increase response accuracy [19]. Table 1 presents the attributes and levels as described in the instruction section of the DCE.

2.4. DCE design

A Bayesian D-efficient design was created using Ngene 1.0 (ChoiceMetrics, Sydney, Australia, 2011) to estimate a standard multi-nomial logit (MNL) model, based on a main-effects utility function. The prior preference information needed for the design was based on best guesses from the literature and expert opinions. Choice tasks consisted of two unlabelled antibiotic alternatives: ‘Antibiotic A’ and ‘Antibiotic B’ (see Fig. 1).

In the pre-testing phase, peer debriefing and think-aloud (n=4) methods were used [20]. Forty-four respondents from the general population took part in a pilot test run in February 2019. The pilot used the same recruitment method and research population as the final survey. In the pilot phase, the whole questionnaire was tested to see whether correct wording was used and if the research population could understand the attributes, levels, information and choice tasks. Data were analysed using MNL models, and estimates were used as priors for the final DCE design. The final Bayesian D-efficient design consisted of 48 unique choice tasks divided over three blocks of 16 choice tasks to which respondents were assigned at random.

2.5. Questionnaire

Light House Studio 9.6.1 (Sawtooth Software, Provo, UT, USA) was used to design the questionnaire and conduct the web-based survey in April 2019. The questionnaire had three sections.

The first section comprised sociodemographic and background questions, including age, gender, highest attained educational level,

Table 1
Attributes (bold) and attribute levels (italic) as described in the survey.

Contribution to AR Bacteria that can withstand an antibiotic treatment are antibiotic-resistant bacteria. The main cause of resistance is treatment with antibiotics. AR is a serious and growing public health problem. It results in longer care times, higher care costs and an increased risk of complications in infection. The contribution to AR of the antibiotic treatments you choose is:
Low 15,000 cases per year: in 10 years, the number of cases in Sweden would remain the same.
Medium 30,000 cases per year: in 10 years, the number of cases in Sweden would double.
High 70,000 cases per year: in 10 years, the number of cases in Sweden would more than quadruple.
Treatment duration You must take three tablets a day throughout the treatment period prescribed by your doctor.
3 days
7 days
14 days
Side effects All medicines have side effects, including antibiotics. As they not only kill harmful but also beneficial bacteria in the body, they can cause mild-to-moderate side effects such as nausea, stomach upset, headache and tiredness. In the choice situations, it is stated how likely the antibiotic treatment is to cause side effects.
1% (1 in 100 people taking this antibiotic get side effects, 99 do not get side effects)
5% (5 in 100 people taking this antibiotic get side effects, 95 do not get side effects)
10% (10 in 100 people taking this antibiotic get side effects, 90 do not get side effects)
20% (20 in 100 people taking this antibiotic get side effects, 80 do not get side effects)
Treatment failure An antibiotic treatment can fail to treat an infection for many reasons. If a treatment fails, it means that you have to be treated with another course of antibiotics.
5% (5 out of 100 people need a further course of antibiotics)
10% (10 out of 100 people need a further course of antibiotics)
15% (15 out of 100 people need a further course of antibiotics)
20% (20 out of 100 people need a further course of antibiotics)
Cost Antibiotic treatments are not reimbursed and you have to pay out-of-pocket.
€10
€25
€40
€100

AR, antibiotic resistance.

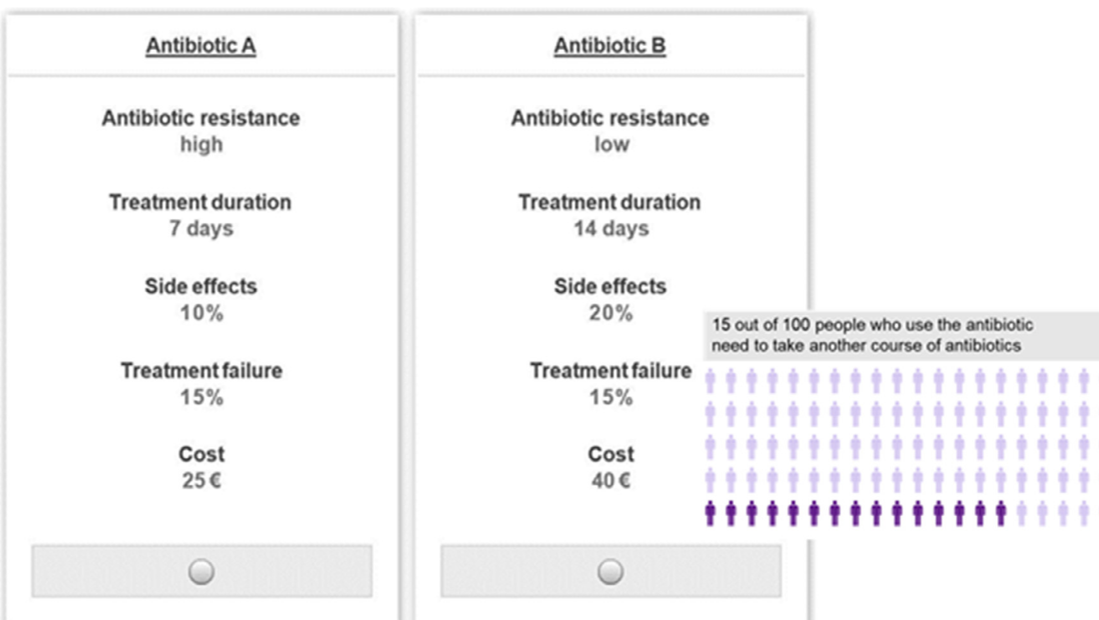

Fig. 1. Example choice task and hover box.

occupation and financial vulnerability. The latter describes the individual's ability to recover from sudden financial shocks. Respondents answered whether they had experienced trouble reaching the end of the month or not in the past year, and if they could afford an unexpected expense. The first section further asked for self-reported health status using a five-point Likert scale from very good to very poor. Finally, experience of and knowledge about antibiotics were tested (two questions on antibiotic use and two related to AR), and two validated subjective rating scales were used to determine the respondent's health literacy (S-CCHL: the Communicative and Critical Health Literacy Scale – Swedish version) and numeracy (SNS-3: the three-item version of the Subjective Numeracy Scale) [21,22]. Health literacy is a measure of the ability to access, understand, appraise and apply health-related information. Numeracy refers to the ability to apply and manipulate numerical concepts. The S-CCHL consists of five items on a five-point Likert scale from 'never (1)' to 'always (5)'. The SNS-3 consists of three items on a six-point Likert scale from 'not good at all/never (1)' to 'extremely good/very often (6)'. In both scales, an overall level was calculated for each respondent. In terms of their level of health literacy and numeracy, respondents who scored 1/2 were classed as 'inadequate'; those who had at least one score of 3 in the S-CCHL and 3/4 in the SNS-3 were classed as 'problematic'; and those who consistently scored 4/5 in the S-CCHL and 5/6 in the SNS-3 were classed as 'sufficient'.

The second section comprised information about the DCE and the set of 16 DCE choice tasks. As individuals' understanding of medical probabilities varies [23], a multi-faceted approach was adopted by integrating words, fractions, percentages and icon arrays to describe attributes and levels wherever applicable. Participants in this study were asked to imagine that they had a bacterial infection and that the doctor prescribed antibiotics to avoid complications. While completing the choice tasks, respondents could place the mouse over the attribute or level and a hover box would appear as a pop-up window (see Fig. 1). In the third section, concluding questions aimed to assess any difficulties experienced and the length of the questionnaire, both on a five-point Likert scale, and an optional comments field was included.

2.6. Study sample

An online sample from the Swedish general population, nationally representative in terms of age, gender and geographical region, was recruited via Dynata, a commercial survey sample provider. Calculating the optimal DCE sample size is complicated by the fact that it depends on the true values of the unknown parameters estimated in the discrete choice models. However, there is a generally accepted rule of thumb for calculating sample size [Eq. (1)]:

$$Sample\,size > \frac{500l}{TA} \tag{1}$$

The sample size required depends on the number of choice situations (T), the number of attributes in a choice task (A), and the highest number of levels (l). This survey included 48 choice tasks with two alternatives, and the overdue level was 4. Therefore, this questionnaire required at least 63 respondents (500*4/16*2=62.5) to estimate the main effects alone. As three blocks were included in the design, there was a need for at least 189 respondents (63 x 3=189). To be able to identify differences in preferences (i.e. preference heterogeneity) and to perform subgroup analysis, there was a need for a larger sample. Based on the DCE design, the pilot test, and using current insights related to optimal sample sizes for DCE studies [13], a sample size of 350 respondents was deemed to be sufficient. The inclusion criteria were 18–65 years of age and proficiency in the Swedish language. Respondents were excluded if they could not take antibiotics (e.g. allergic individuals).

2.7. Statistical analysis

All variables were analysed using descriptive statistics in Statistical Package for the Social Sciences (SPSS) Version 25 (IBM Corp., Armonk, NY, USA). Choice data were analysed using Nlogit 5.0 (Econometric Software Inc., Plainview, NY, USA, 2012).

Latent class analysis (LCA) models were used to analyse choice data. LCA assumes that respondents differ with respect to their preferences. The classes of preferences are latent because who belongs to which class is not determined a priori. Instead, class membership is expressed as class probabilities that may depend on respondents' characteristics. What is determined by the researcher is the number of classes, based on the model fit (Aikake information criterion, Bayesian information criterion, pseudo-R^2) and sound interpretation of classes [15]. The modelling procedure resulted in a three-class model based on the utility function in Eq. (2).

$$\begin{aligned} U_{rta|c} = {} & \beta_{1|c} Contrib\,to\,AR_{medium\,rta|c} + \beta_{2|c} Contrib\,to\,AR_{high\,rta|c} \\ & + \beta_{3|c} Treatment\,durat_{7\,days\,rta|c} \\ & + \beta_{4|c} Treatment\,durat_{14\,days\,rta|c} + \beta_{5|c} Side\,effects_{5\%\,rta|c} \\ & + \beta_{6|c} Side\,effects_{10\%\,rta|c} + \beta_{7|c} Side\,effects_{20\%\,rta|c} \\ & + \beta_{8i|c} Failure\,rate_{rta|c} + \beta_{9i|c} \mathrm{Cost}_{rta|c} + \varepsilon \end{aligned} \tag{2}$$

In Eq. (2), U represents the observable utility that a respondent r belonging to class c selected alternative a in choice question t; and β_1 – β_9 are variable weights (coefficients) associated with each attribute of the DCE. Failure rate and cost were considered as linear attributes, whereas contribution to AR, treatment duration and side effects were categorical and therefore dummy coded. The reference levels for contribution to AR, treatment duration and side effects were low, 3 days and 1%, respectively. A significant coefficient ($P \leq 0.05$) indicates that the attribute or level has a significant impact on antibiotic treatment preferences. A significant attribute estimate within a certain class indicates that this attribute contributes to the decision-making process of respondents who belong to that class. The sign of the coefficient reveals whether this impact has a positive or negative effect on utility.

After fitting the utility function, a class assignment model was estimated. Potential explanatory variables were tested for a significant contribution to the class assignment model. The final class assignment resulted in the utility function in Eq. (3):

$$\begin{aligned} U_{rta|c} = {} & \beta_1 Age_{rta|c} + \beta_2 Financial\,vu\ln erability_{rta|c} \\ & + \beta_3 Health\,literacy_{rta|c} + \beta_4 Numeracy_{rta|c} \end{aligned} \tag{3}$$

Significant estimates in Eq. (3) indicate that the variables contribute to the class assignment. For instance, if health literacy is positive and significant for Class 1, respondents with sufficient health literacy are more likely to belong to Class 1.

The attribute with the highest relative importance score (RIS) in each class is most decisive in the choice of antibiotic treatment. To estimate RIS, the difference between the largest and the smallest attribute level estimate was calculated for each attribute. An importance score of 1 was given to the attribute with the largest difference value. All other RISs was calculated by dividing the difference value by the largest difference value, which gave the relative distance of each attribute to the most important attribute. RIS values were calculated separately for each of the classes in the model.

Marginal willingness to pay (WTP) values were determined for contribution to AR. To calculate respondents' WTP, the estimate of cost attribute was used as a measure of the marginal utility of money. The ratio of the estimates of contribution to AR and cost was calculated to elicit respondents' WTP for contribution to AR.

3. Results

3.1. Study population

In total, 415 individuals completed the survey, 37 (8.9%) of whom were subsequently excluded as they completed the survey in less than 6 min. The time needed was estimated to be 12 min. To enhance quality, a 50% cut-off was chosen and data were cleared accordingly (e.g. the rule of thumb in commercial surveys is 30%). Of the 378 respondents included in the final cohort, 55% were women. The mean age of respondents was 43 years. In total, 51.9% reported a high educational level, and sufficient health literacy and numeracy were reported by 46.6% and 23.3% of respondents, respectively. High financial vulnerability was reported by 33.6% of respondents, and 10.8% of the respondents reported being unemployed. There were four questions to test knowledge, and while approximately 66% of respondents answered the antibiotic use questions correctly, they were less knowledgeable about AR (6.1% and 29.1% answered correctly, respectively). The detailed sociodemographic characteristics are presented in Table 2.

3.2. Preferences for antibiotic treatment

All attributes showed a significant estimate, which indicates that each attribute contributed to the decision process of

Table 2
Sociodemographic characteristics of respondents

		Respondents (n=378)	
		Mean	SD
Age 18–65 years		43.3	13.5
		n	(%)
Women		208	55.0
Health			
	Bad	44	11.6
	Moderate	113	29.9
	Good	221	58.5
Education			
	Low	26	6.9
	Medium	156	41.2
	High	196	51.9
	Tertiary health education	39	10.3
Health literacy			
	Inadequate	41	10.8
	Problematic	161	42.6
	Sufficient	176	46.6
Numeracy			
	Inadequate	108	28.6
	Problematic	182	48.1
	Sufficient	88	23.3
Occupation			
	Employed (permanent, temporary, self-employed)	248	65.6
	Students	36	9.5
	Retired	34	9
	Unemployed	41	10.8
	On disability living allowance, sick leave or other	19	5.0
Financial vulnerability			
	High	127	33.6
	Medium	105	27.8
	Low	146	38.6
Antibiotic use experience			
	Yes	332	87.8
	Never	20	5.3
	Don't know	26	6.9
Knowledge			
	Antibiotics are effective against (multiple responses):		
(correct)	*Bacteria*	257	68.0
	Viruses, All microbes, Don't know	121	32.0
	Antibiotics are effective against influenza (single response):		
(correct)	*Disagree*	244	64.6
	Agree, Don't know	134	35.4
	Human body becomes resistant to antibiotics (single response):		
(correct)	*Disagree*	23	6.1
	Agree, Don't know	355	93.9
	AR spreads through contact with (multiple responses):		
(correct)	*Human carriers, Animal carriers, Infected surfaces*	110	29.1
	Don't know or *only 1 or 2 of the answers above*	268	70.9

SD, standard deviation.

respondents regarding choices about taking antibiotics. The estimates for the attribute levels are presented in Table 3. In general, participants preferred antibiotics with a low contribution to AR compared with antibiotics with a greater contribution to AR. Additionally, participants preferred medium-course treatment durations (7 days) over long-course (14 days) and short-course (3 days) treatment duration. The lowest risk of side effects (1%) was the preferred option. The negative signs for failure rate and cost indicate that participants preferred treatments with a lower failure rate and a lower price.

3.3. *Relative importance of the attributes and willingness to pay*

Considering the preferences of respondents overall, contribution to AR was the most important attribute, closely followed by cost and then side effects, failure rate and treatment duration. However, respondents in the three classes reported different preferences with respect to antibiotic treatment, which indicates preference heterogeneity (see Table 3). Respondents in Class 1 found cost to be the most important attribute, followed by contribution to AR, treatment duration, failure rate and side effects. For respondents in Class 2, contribution to AR was the most important, followed by cost, side effects, treatment duration and failure rate. For respondents in Class 3, side effects was the most important, followed by contribution to AR, cost, failure rate and treatment duration (see Fig. 2).

Respondents with lower numeracy, and higher financial vulnerability and health literacy were more likely to belong to Class 1. Younger respondents had a greater likelihood of belonging to Class 2. Older respondents with lower financial vulnerability and health literacy, and higher numeracy were more likely to belong to Class 3.

Respondents' WTP for an antibiotic contributing the least to AR was: 389 SEK (approximately €36.50) to have low instead of medium contribution to AR, and 940 SEK (approximately €88) to have low instead of high contribution to AR.

Table 3
Preferences for antibiotic treatment based on latent class analysis

	Class 1			Class 2			Class 3		
	Estimate	*SE*	*RI*	*Estimate*	*SE*	*RI*	*Estimate*	*SE*	*RI*
Contribution to AR			2			1			2
Low (ref.)									
Medium	-0.49***	0.11		-1.69***	0.12		-0.10	0.09	
High	-0.81***	0.19		-4.21***	0.24		-0.51***	0.14	
Treatment duration			3			4			5
3 days (ref.)									
7 days	0.15	0.10		0.11	0.11		0.05	0.08	
14 days	-0.39***	0.10		-0.25**	0.11		-0.17**	0.08	
Risk of side effects			5			3			1
1% (ref.)									
5%	-0.13	0.12		-0.24*	0.13		-0.33***	0.10	
10%	-0.01	0.13		-0.20	0.14		-0.77***	0.10	
20%	-0.23	0.16		-0.71***	0.16		-1.59***	0.13	
Failure rate (linear)	-0.17	0.14	4	-0.59***	0.14	5	-0.95***	0.12	4
Cost (linear)	-0.43***	0.03	1	-0.15***	0.02	2	-0.05***	0.02	3
Class probability model									
Constant	1.44*	0.83		1.05	0.76				
Age	-0.01	0.01		-0.03***	0.01				
Financial vulnerability	-0.42**	0.18		0.05	0.17				
Health literacy	0.58**	0.24		0.26	0.23				
Numeracy	-0.62***	0.22		0.08	0.20				
Average class probability	0.33			0.38			0.29		

AR, antibiotic resistance; RI, relative importance.
* $P<0.10$
** $P< 0.05$
*** $P<0.01$.

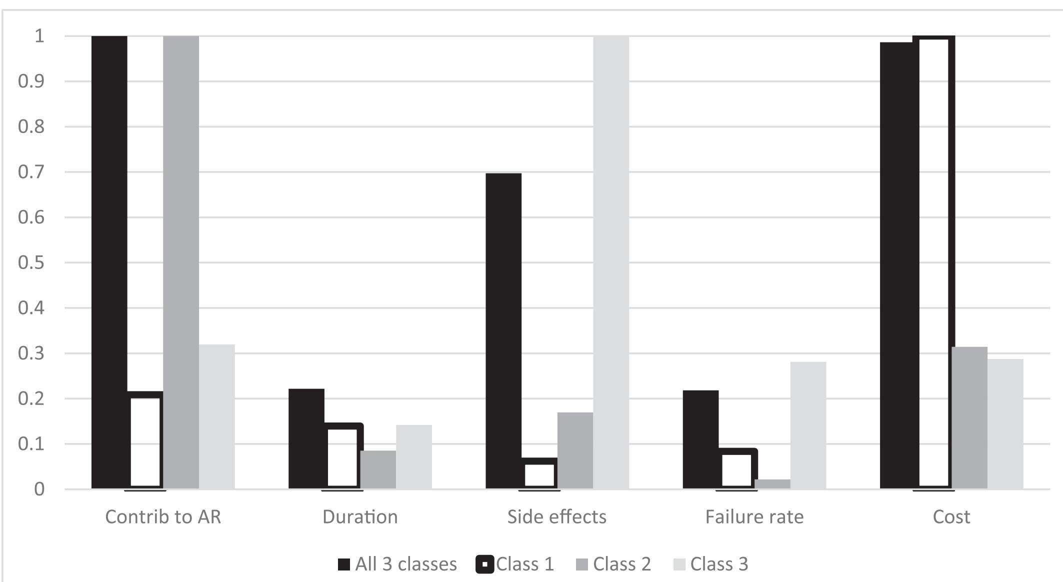

Fig. 2. Relative importance of the attributes stratified by class. Values reflect the relative distance of all attributes to the most important attribute on a scale from 0 to 1. Contrib to AR, contribution to antibiotic resistance.

4. Discussion

To the authors' knowledge, this is the first DCE to investigate the preferences of lay people for antibiotic treatments. Previous DCEs have focused on either prescribers or patients [24–28]. The current study showed that all attributes of antibiotic treatments influenced respondents' preferences, and can therefore be considered as potential drivers of antibiotic use by lay people. The finding that the majority of respondents thought that contribution to AR was the most important attribute suggests that the behaviour of lay people could be influenced by concerns over the rise of AR. It is important to stress that this attribute was explained to people as a collective threat and not as a problem to the individual. These results are consistent with a recent Swedish study in which the majority of participants expressed their willingness to voluntarily abstain from using antibiotics out of concern over AR [29]. The importance of contribution to AR was quantified financially, and respondents were willing to pay €36.50 for switching from an antibiotic treatment with medium contribution to AR to a treatment with low contribution to AR, and €88 to switch from an antibiotic treatment with high contribution to AR to a treatment with low contribution to AR. Considering that the cost attribute (used for calculating WTP) was operationalized and framed as out-of-pocket costs (not covered by health insurance), the numbers are quite high and could be of interest for policy makers considering financial incentives and disincentives as a means of influencing health-related behaviour.

Results showed heterogeneity in preferences, which means that respondents weighed the attributes of antibiotic treatment in different ways. Respondents with low numeracy and high financial vulnerability were more influenced in their decision-making by the cost of the antibiotic (Class 1). Younger respondents were more concerned about their contribution to AR (Class 2), and older respondents were more concerned about side effects (Class 3). These results could facilitate the segmentation and consequent development of tailored messages.

The finding that younger respondents were more concerned about contribution to AR is in line with previous research. A Swedish study on the general population's knowledge and attitudes towards antibiotic use and AR found that younger people were more likely than older people to show an appropriate attitude towards antibiotic accessibility and infection prevention [30]. Research conducted in Italy, however, gave the opposite result, with younger respondents being more inclined to take an antibiotic without a prescription [31]. This suggests that regional and cultural differences need to be acknowledged. Regarding financial vulnerability, results were as expected; namely, that respondents with higher financial vulnerability were more influenced by the cost attribute. Research on socio-economic determinants of outpatient antibiotic use suggest that, from an economic point of view, antibiotics are normal goods. This implies that individual financial health, which typically contributes to greater access to medical care, also influences antibiotic use [32,33]. A study of 17 European countries found that higher antibiotic prices were associated with lower antimicrobial consumption. Purchasing antibiotics out-of-pocket instead of under total or partial reimbursement was also associated with lower antimicrobial consumption [33]. Numeracy is relevant to the present study because respondents needed to interpret and value risk information (risk of side effects and failure rate). Low numeracy is generally associated with biased medical decisions [34]. The fact that respondents with lower numeracy gave the least importance to failure rate and side effects may be a consequence of their difficulties in interpreting and understanding the risk attributes. Previous research highlighted that information which is not well understood is more likely to be neglected or undervalued [35,36]. Although significant, it is difficult to explain the role of health literacy in the class probability model, and further research into this variable would benefit greater understanding of these outcomes.

Seven days was the most preferred level for treatment duration, and this is probably motivated by respondents' familiarity with 7-day treatment courses and/or the idea that 3 days of treatment may not be enough to eradicate the infection. Previous research showed positive attitudes towards short-course treatments among patients, but has also stressed the importance of reassurance that short courses are effective [37,38].

Respondents showed poor knowledge about AR. In particular, only 6.1% of respondents disagreed with the statement, 'The human body can become resistant to antibiotics, giving free space to bacteria'. In a previous study of the Swedish public [30], 12% answered 'no' (correctly) to the statement, 'People can become resistant to antibiotics', which is also a low score. By maintaining the belief that it is one's own body that becomes resistant to antibiotics, and not the bacteria, people may see the problem of AR as being strictly individual and fail to understand the threat posed to public health. This belief is worrying but not very surprising [39].

All results were in line with the expected directions of the estimates and provide support for the theoretical internal validity of the model. Nevertheless, this study was subject to some limitations. To investigate the robustness of the results, lexicographical preference assessment was performed to detect participants with non-compensatory decision-making strategies. Tests were run for left–right bias (always choosing the alternative on the left or the right) and gave negative results. As participants were part of a mixed panel recruited by a commercial survey sample provider, it was not possible to calculate the response rate. With regards to external validity, as for all DCEs, there is a risk of hypothetical bias (i.e. that the results may not reflect actual behaviour). There is no possibility to compare the present results with revealed preference studies. However, studies investigating the predictive value of DCEs in public health have shown accuracy between 80% and 93% [40,41].

5. Conclusion

All antibiotic treatment attributes (contribution to AR, treatment duration, side effects, treatment failure and cost) can be considered as potential drivers of antibiotic use by lay people. The findings suggest that concerns over rising resistance to antibiotics can influence people's behaviour. Therefore, stressing individual responsibility for AR in clinical and societal communication has the potential to impact personal decision-making. However, considering that the concept and mechanisms of AR are still obscure to the majority, communication including AR could be effective only if adequate information is provided. The risk of acquiescing to any kind of AR misconception is that it may induce non-judicious antibiotic use. If patients are informed and feel responsible, they may 'push' less for an antibiotic prescription and, perhaps more importantly, reduce prescribers' perception that patients expect an antibiotic treatment prescription.

The finding that cost was the second most important attribute, together with the rather high WTP for antibiotics that contribute less to AR, suggest that changing the price of antibiotics may influence consumption behaviour. However, caution is warranted because the group whose preferences were mainly influenced by the cost attribute showed financial vulnerablility and low numeracy. Therefore, the risk involved by policy aiming at contrasting excessive use of antibiotics through financial incentives and disincentives is that it may hinder access to treatment and cause health inequalities.

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