Information Avoidance Behavior: Does Ignorance Keep Us Uninformed About Antimicrobial Resistance?

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Abstract: The study examines the role of subjective and objective knowledge of antimicrobial resistance (AMR) and antibiotic use in livestock production on information avoidance behavior. The study also assesses the effects of AMR information on public perceptions and understanding of AMR. A survey instrument was developed to achieve study objectives and data from 1,030 individuals across the U.S. was collected and analyzed. Results show that 39 percent of participants avoided AMR information and those with little or no knowledge of AMR were more likely to avoid information than more knowledgeable individuals. Among the participants who chose to access AMR information, however, those with little or no knowledge of AMR improved their understanding of AMR the most, raising important questions about how to encourage willfully uninformed individuals to access information about critical issues.

Keywords: antimicrobial resistance, information avoidance, subjective and objective knowledge.

1. Introduction

Antimicrobial resistance (AMR) is one of the greatest threats to healthcare systems worldwide and the global economy. According to the World Health Organization (WHO) (2014), AMR is the ability of microorganisms (such as bacteria, fungi, viruses, and parasites) to resist the effects of antimicrobial drugs (such as antibiotics, antifungals, antivirals, and antimalarials). One of the main causes of the spread of AMR is antibiotic overuse and misuse in humans and animals.[1]

[1] Examples of misuse include the use of antibiotics to treat viral infections. Also, overuse of antibiotics in food-producing animals is thought to lead to the proliferation of AMR bacteria, which can enter the food chain through residues in meat, milk, or eggs (World Health Organization 2017).

AMR infections cannot be successfully treated with common antibiotics, increasing threats to the health of infected individuals and the risk of infections spreading to others. In the United States, around 2 million people are infected with AMR bacteria each year, of whom approximately 23,000 die; globally there are currently 700,000 deaths attributed to AMR per year, a number that is predicted to rise to 10 million annual deaths by 2050 (CDC 2013).

The estimated annual direct cost of AMR to the U.S. healthcare system is approximately $20 billion, with additional indirect costs as high as $35 billion per year (CDC 2013). According to recent projections by the World Bank (2017), the world will lose 1.1 percent of annual gross domestic product by 2050 under a low AMR-impact scenario, while under a high AMR-impact scenario, annual global gross domestic product will likely fall by 3.8 percent. By 2050, annual health care expenditures (both public and private) are projected to increase by 25 percent, 15 percent, and 6 percent in low-income, middle-income, and high-income countries, respectively, due to increases in AMR (World Bank 2017).

Given the serious threat AMR poses for global public health, raising public awareness of AMR and promoting the responsible use of antimicrobials in humans and animals is of critical importance. One of the main objectives of the WHO Global Action Plan on antimicrobial resistance that was launched in 2015 is to raise awareness and improve understanding of AMR through educational and communication campaigns that target both healthcare personnel and the general public (WHO 2015). However, communicating critical health issues to the general public is an ongoing challenge for stakeholders and policymakers (Barnett et al. 2011). Although one would expect that individuals would be motivated to seek information about health risks in order to minimize adverse outcomes, a number of studies (see Case et al. 2005, Kuttschreuter 2006, Narayan et al. 2011, Gaspar et al. 2016 and Golman et al. 2017) suggest that individuals may avoid health risk information when they believe that the information may make them uncomfortable, rendering health risk communication campaigns less successful.

A growing literature in economics, psychology, and neuroscience identifies situations in which people avoid information even when it is free and could improve decision-making (for a review, see Golman et al. 2017).[2] Information avoidance is defined as any behavior an individual engages in to avoid acquiring available and free but potentially unwanted information (Sweeny et al. 2010). Individuals avoid information strategically to promote materialistic outcomes, to prevent themselves from reconsidering decisions in the future, or when they believe that information would make them feel bad (Carillo and Mariotti 2000; Golman et al. 2017). For example, investors monitor their financial portfolios frequently when the market is up but avoid looking at them in falling markets (Karlsson et al. 2009). In a survey of individuals who were at a high risk of contracting HIV, Sullivan et al. (2004) found that 18 percent of the respondents avoided learning their HIV test results. Of those, around 23 percent chose to avoid information because they were scared of knowing the results. McCloud et al. (2013) examined social factors that may influence information avoidance among cancer survivors. They found that subjects who were female, younger, had lower income and greater financial debt were more likely to avoid cancer information. Bell et al. (2017) examined information avoidance behavior in the context of animal welfare by questioning consumers on whether or not they want to know how farm animals are raised. They found that about one-third of their respondents chose to remain willfully ignorant about farm animal production methods, with a large majority of respondents stating that

[2] In contrast, a number of studies confirm the standard economic theory assumption that economic agents value information, showing that individuals seek information and are even willing to pay for useless information (Kübler and Weizsäcker. 2004; Eliaz and Schotter 2007; Goeree and Yariv 2015).

they trust farmers and have more important issues to worry about. The authors suggest that the main motivational factor for information avoidance behavior in their study was guilt avoidance.

The current study presents one of the first explorations of information avoidance behavior in the context of AMR. Given that a key priority of the WHO is to educate the public about the relationship between antimicrobial use and AMR, we investigate whether the public accepts or avoids AMR related information and seek to identify key factors that contribute to AMR information avoidance behavior. Specifically, we explore whether individuals respond differently to the provision of AMR information depending on their level of subjective (self-assessed), and objective (measured) knowledge of AMR and antibiotic use in livestock production. Our study also seeks to assess the effects of AMR information on the individuals' perceptions and understanding of AMR.

The study contributes to the existing literature in a number of ways. First, it assesses public knowledge of and attitudes towards AMR and antibiotic use in livestock production in the U.S. Second, it is the first study to examine the role of subjective and objective knowledge in information avoidance behavior. Finally, it sheds light on whether providing information on critical topics to individuals with different levels of knowledge improves their understanding of these topics. The examination of these issues is important as our research findings can contribute to the development of effective health risk communication campaigns (e.g., campaigns to raise awareness and promote the rational use of antimicrobials in the human healthcare system and livestock production).

The rest of the paper is organized as follows. Section two describes the survey design, and section three discusses the sample data, variables and descriptive statistics. Section four presents the empirical models and section five discusses the empirical results. The last section discusses the policy implications, summarizes and concludes the paper.

2. Survey Design

An online survey was developed to achieve study objectives. The survey was administered by IRi, a leading online survey firm, between May and June of 2018.[3] IRi invited a total of 8,528 individuals (who were 19 or older) across the United States to participate in this online survey and closed the survey when they received 1,030 completed responses.[4]

The online survey was divided into two sections. The first section asked questions about participants' demographic characteristics, meat consumption habits, personal history of antibiotic use, and perceptions of and attitudes towards animal welfare, AMR, and antibiotic use in livestock production. Participants were also asked to rate their subjective knowledge of AMR and antibiotic use in livestock production. Participants' objective knowledge of these issues was measured by their answers to 10 true or false questions.

The second section of the online survey was used to identify information avoidance behavior. Participants selected one of two videos to watch, which were labeled as: (i) antimicrobial resistance: the role of food and agriculture, or (ii) nature white noise: rain and thunderstorm sounds for relaxation. The first video was an animated video produced by the Food and Agriculture Organization of the United Nations and presented a definition as well as causes and consequences of AMR in lay terms.[5] The second video contained a black screen with rain and thunderstorm sounds and had no information content. Before selecting a video link,

[3] More information about IRi can be found at: https://www.iriworldwide.com/en-US.
[4] IRi excludes 'speeders' and responses with missing observations.
[5] The FAO video on AMR can be found at: https://www.youtube.com/watch?v=d3YXW_gWNz4.

participants were informed that the length of each video was the same (3 minutes and 35 seconds) and there was no option to skip the video. Since participants were taking a survey on AMR, watching the AMR video could provide them with useful information while choosing to watch the white noise video instead indicates information avoidance. Participants who chose to watch the AMR video took a short quiz after the video, which was included to capture how much detail of the AMR video participants remembered. Moreover, to determine the effects of AMR information on participants' perceptions of AMR, these participants re-answered a set of questions related to their perceptions of AMR. Participants who chose to watch the white noise video were asked about their reasons for not choosing the AMR video and were also asked to re-answer the same set of questions related to their perceptions of AMR as those who chose the AMR video.

3. Data, Variables and Descriptive Statistics

3.1 Subjective and objective knowledge

To assess participants' subjective knowledge, respondents were asked to report how much they knew about six topics related to AMR and antibiotic use in livestock production on a 4-point scale anchored by "no knowledge" and "a great deal of knowledge."[6] Table 1 presents measures of participants' subjective knowledge. As shown in Table 1, participants, on average, reported the lowest levels of self-assessed knowledge for antibiotic resistance in animals and use of antibiotics in livestock production. We averaged responses to these six topics to measure the level of their subjective knowledge of AMR and antibiotic use in livestock production. Survey

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[6] Topics include antibiotic resistance in humans and animals, use of antibiotics in livestock production, drug resistance, antibiotic-resistant bacteria and superbugs.
4-point scale: no knowledge (1); little knowledge (2); moderate knowledge (3); and a great deal of knowledge (4)

results show that around 25 percent of the respondents assessed that they have no knowledge of AMR and antibiotic use in livestock production, 42 percent reported little knowledge, 27 percent moderate knowledge while only 6 percent reported having a great deal of knowledgeable. Thus, a large majority of our respondents (67 percent) self-identified as having little or no knowledge of AMR and antibiotic use in livestock production.

Table 1. Subjective knowledge of AMR and antibiotic use in livestock production

Subjective knowledge	**Percentage of participants**				**Mean (S.D.)**
	(1) No knowledge	**(2) Little knowledge**	**(3) Moderate knowledge**	**(4) A great deal of knowledge**	
Antibiotic use in livestock production:					
Use of antibiotics in livestock production	36%	38%	20%	6%	1.95 (0.90)
AMR:					
Antibiotic resistance in humans	22%	35%	31%	12%	2.34 (0.95)
Drug resistance	30%	34%	26%	10%	2.16 (0.96)
Antibiotic resistance in animals	51%	28%	17%	5%	1.76 (0.90)
Antibiotic-resistant bacteria	30%	33%	27%	10%	2.17 (0.96)
Superbugs	38%	32%	23%	7%	2.00 (0.95)

Notes: Responses were categorical, but were coded as numerals. The categories included No knowledge (1); little knowledge (2); moderate knowledge (3); and a great deal of knowledge (4).

We measured participants' objective knowledge by their answers to 10 true-false questions related to AMR and antibiotic use in livestock production. 5 questions were related to antibiotic use in livestock production, while 5 questions were about AMR (see Table 2). To construct the objective knowledge index, we divided the total number of correct answers by the total number of questions. For example, if a participant answered 7 questions correctly out of 10 true-false questions, the objective knowledge score for that participant would be 0.70. Therefore, the objective knowledge score ranges from 0 to 1, and the higher the objective knowledge score, the greater the knowledge of AMR and antibiotic use in livestock production. The average number of correct answers was 4, indicating respondents answered, on average, less than half of the 10 questions correctly. Randomly guessing would yield a 50 percent success rate on average. Out of 1030 respondents, about 13 percent answered all 10 questions incorrectly while no participants answered all questions correctly.

Table 2. Objective knowledge of AMR and antibiotic use in livestock production

Objective Knowledge	**Correct Answer**	**% of participants answering correctly**
Antibiotic use in livestock production:		
Antibiotics are common drugs useful in treating bacterial infections in humans	True	75%
Antibiotics are common drugs useful in treating viral infections in humans.	False	41%
Antibiotics are common drugs useful in treating any kind of pain or inflammation.	False	53%
Antibiotics are common drugs useful in treating bacterial infections in food animals.	True	49%
Antibiotics are common drugs useful in treating viral infections in food animals.	False	31%
AMR:		
Antibiotic resistance occurs when bacteria become resistant to antibiotics and antibiotics no longer work as well.	True	69%
Overuse and misuse of antibiotics accelerate antibiotic resistance.	True	70%
The overuse and misuse of antibiotics in animals do not cause antibiotic resistance in humans because the antibiotics that are used to treat animals are different than those used to treat humans.	False	29%
Antibiotic resistance existed before human development of antibiotics.	True	19%
Antibiotic resistance has been found in every environment studied, including many not impacted by food animal or human antibiotic use.	True	31%

3.2 Control variables

The survey also gathered data on a number of relevant variables including: meat consumption habits, personal history of antibiotic use, willingness to pay a premium for food safety and animal welfare attributes, perceptions of and attitudes towards animal welfare, AMR, and antibiotic use in livestock production and level of concern about AMR and antibiotic use in livestock production. Since this study investigates information avoidance behavior in the context of AMR, it is important to include the above variables as control variables in regression analysis. We also collected participants' demographic characteristics. As mentioned earlier, participants' demographic characteristics may affect their information avoidance behavior (McCloud et al. 2013). Our hypothesis is that the above-mentioned variables along with subjective and objective knowledge may influence AMR information avoidance behavior. Descriptive statistics and a description of each variable are displayed in Table 3.

Table 3. Descriptive statistics of control variables

Variables	Description	Mean (S.D.)
Meat and fish consumption habits		
Beef	Frequency of meat or fish consumption, 1= never to 5= daily	3.5 (0.94)
Chicken		3.81 (0.80)
Fish		3.11 (1.03)
Pork		3.10 (1.02)
Willingness to pay a premium for		
Products that are produced under strict animal welfare standards	Willingness to pay a premium for product attributes, 1= strongly disagree to 5= strongly agree	3.55 (1.07)
Meat from animals that are never given antibiotics		3.38 (1.01)
Perceptions of AMR		
AMR is one of the biggest problems the world faces	Level of agreement with the statement, 1= strongly disagree to 5= strongly agree	3.42 (1.01)
Antibiotic resistance is an issue that could affect me or my family		3.91 (0.92)

Table 3. Descriptive statistics of control variables (continued)

Variables	Description	Mean (S.D.)
Perceptions of AMR		
Widespread use of antibiotics in animal feed can lead to antibiotics polluting the environment through agricultural runoff	Level of agreement with the statement, 1= strongly disagree to 5= strongly agree	3.55 (0.88)
Widespread use of antibiotics creates new resistant bacteria that cause illness that antibiotics cannot cure		3.77 (0.89)
Use of antibiotics in food animals does not cause AMR that could affect humans		2.77 (0.99)
History of antibiotics use		
Treated with antibiotics in previous year	1= yes; 0= no	0.42 (0.49)
Antibiotic treatment didn't work-own	Treated with an antibiotic that didn't work, 1= yes; 0= no	0.27 (0.44)
Antibiotic treatment didn't work-family	Family member treated with an antibiotic that didn't work, 1= yes; 0= no	0.23 (0.42)
Animal welfare		
Use of antibiotics to treat improves animal welfare	Level of agreement with the statement, 1= strongly disagree to 5= strongly agree	3.39 (0.96)
Use of antibiotics in food animals reduces animal welfare		3.23 (0.98)
Food safety is strongly dependent on the care provided to food animals		4.00 (0.87)
Level of concern		
Use of antibiotics to treat infections in food animals	Level of concern about AMR and antibiotic use in livestock production, 1= not at all concerned to 5= extremely concerned	2.89 (1.22)
Use of antibiotics to prevent infections in food animals		3.19 (1.16)
Use of antibiotics to control the spread of an illness among food animals		3.06 (1.16)
Use of antibiotics to promote animal growth in food animals		3.65 (1.16)
Use of antibiotics in food animal production contributing to antibiotic resistance		3.45 (1.19)
Use of the same antibiotics in humans and food animals contributing to antibiotic resistance in humans		3.46 (1.14)
Use of any antibiotics to treat humans contributing to antibiotic resistance in humans		3.38 (1.17)

Table 3. Descriptive statistics of control variables (continued)

Variables	Description	Mean (S.D.)
Demographic characteristics		
Age	Age in years	51.75 (15.38)
Gender	1 if subject is female; 0 otherwise	0.71 (0.45)
Race	1 if subject's ethnicity is white; 0 if non-white	0.74 (0.44)
College education	1 if subject has some college education or higher; 0 otherwise	0.44 (0.50)
Family size	Number of family members including respondent	1.77 (1.51)
No involvement in health sector	Respondent and his/her family members are not involved in the health sector, 1= True; 0= False	0.91 (0.29)

Table 3 shows that participants' frequency of meat consumption was between weekly and monthly, with chicken being the meat category consumed most often. Participants, on average, expressed the highest level of agreement with the statements "Antibiotic resistance is an issue that could affect me or my family" and "widespread use of antibiotics creates new resistant bacteria that cause illness that antibiotics cannot cure". On average, participants were somewhat concerned about AMR and antibiotic use in livestock production, expressing the greatest level of concern for the use of antibiotics to promote growth in food animals. Approximately 42 percent of participants were treated with antibiotics in the previous year, while 27 percent reported that their antibiotic treatment was not successful.

3.3 Information avoidance behavior

We define AMR information avoidance behavior as participants choosing to watch the video labeled as 'nature white noise: rain and thunderstorm sounds for relaxation' rather than the video labeled as 'antimicrobial resistance: the role of food and agriculture' that provided AMR related information. Survey results show that 39 percent of respondents avoided AMR information by choosing to view the white noise video. Participants who chose to watch the white noise video were asked about their reasons for not choosing the AMR video. Participants could choose multiple reasons and/or provide their own reasons. Figure 1 depicts respondents reasons for avoiding AMR information. The top three reasons for avoiding AMR information were: (1) watching a video is not going to change my existing view, (2) scared of knowing about AMR, and (3) there is nothing I can do to solve the AMR issue. 'Other' refers to additional reasons participants provided for avoiding AMR information.

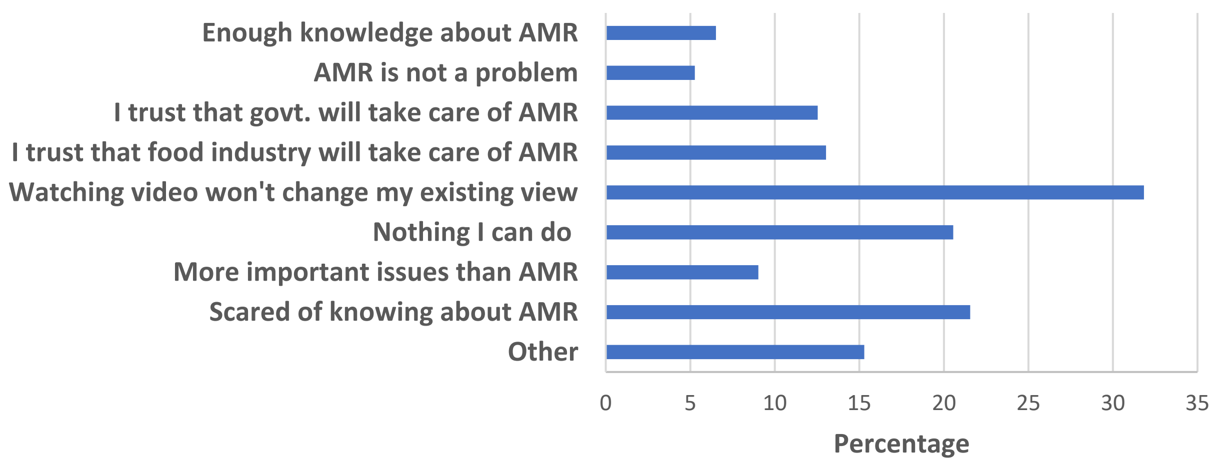
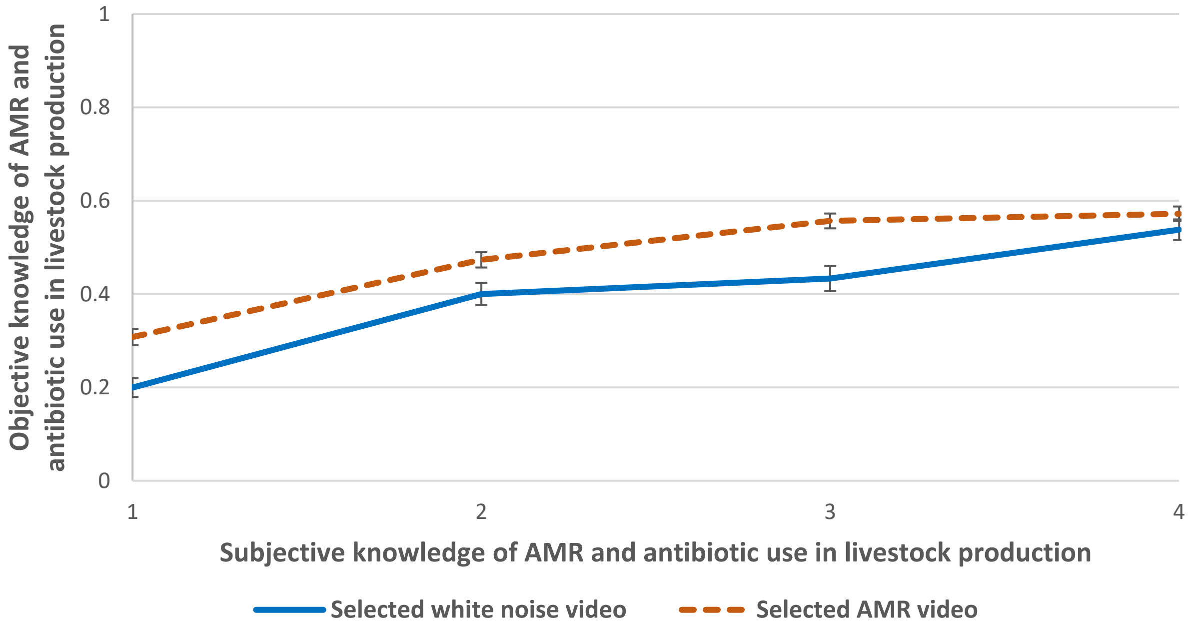


Figure 1. Reasons for avoiding AMR information

Figure 2 depicts the average self-assessed and objective knowledge of AMR and antibiotic use in livestock production by video choice (i.e., acceptance or avoidance of AMR information). Figure 2 shows a positive relationship between participants' subjective and objective knowledge of AMR and antibiotic use in livestock production irrespective of the video link they selected. On average, participants with little or no subjective knowledge had very low levels of objective knowledge of AMR and antibiotic use in livestock production. Moreover, the objective knowledge of participants who avoided the AMR information was, on average, lower than that of participants who did not avoid AMR information, regardless of participants' subjective knowledge.



Note: Error bars represent 95% confidence interval. Participants assessed their subjective knowledge of AMR on 4-point scale: no knowledge (1); little knowledge (2); moderate knowledge (3); and a great deal of knowledge (4). The objective knowledge index ranges from 0 to 1. The higher is the objective knowledge index, the greater is the knowledge.

Figure 2. Relationship between subjective and objective knowledge of AMR by information choice.

4. Empirical Estimation Strategies

4.1 Logit Model

A binomial (binary) logistic model was employed to determine the role of knowledge in information avoidance behavior. The dummy variable Y_i takes the value of one if participant i watches the nature white noise video (avoiding AMR information) and zero otherwise.

(1) $$Y_i = \begin{cases} 1, & if\ 'white\ noise'\ video\ is\ selected \\ 0, & if\ 'antimicrobial\ resistance'\ video\ is\ selected \end{cases}$$

Following McFadden (1974), the probability that participant i avoids the AMR information can be modelled as:

$$(2) \qquad Prob\ (Y_i = 1|X_i) = \frac{e^{x_i'\beta_j}}{1 + e^{x_i'\beta_j}}$$

The binomial logistic model that captures information avoidance behavior can be represented as:

$$(3) \qquad log\left(\frac{p_i}{1 - p_i}\right) = \beta_0 + \sum_{j=1}^{k} \beta_{ij} x_{ij}$$

where $p_i = prob\ (Y_i = 1|X_i)$ and the term $log\left(\frac{p_i}{1-p_i}\right)$ indicates the log of the odds ratio. While β_{ij} are coefficients to be estimated, x_{ij} is a set of independent variables representing participants' subjective and objective knowledge of AMR and antibiotic use in livestock production, demographic characteristics, meat consumption habits, willingness to pay a premium for food safety and animal welfare attributes, personal history of antibiotic use, and perceptions of and attitudes towards animal welfare, AMR and antibiotic use in livestock production. Recall that to assess participants' level of concern about AMR and antibiotic use in livestock production, we used their scores to 7 statements as shown in Table 3. To reduce the dimensionality of the 'concern' variable, factor analysis (FA) was used. The application of the FA procedure yielded one factor and was termed as "*level of concern about AMR and antibiotic use in livestock production*."[7] Then, following the varimax method, the factor scores were predicted (see Appendix).

[7] In choosing the optimum number of factors, we followed the eigenvalue greater than one rule (Kaiser 1960). Using the *factor* command in STATA, the factor analysis procedure was applied. The initial analysis gave a set of seven estimated factors, and only one factor with eigenvalue that exceeded the threshold eigenvalue of one.

4.2 Panel Regression

Panel regression techniques are used to estimate the effects of AMR information on participants' understanding and perceived importance of AMR based on participants' subjective and objective knowledge of AMR and antibiotic use in livestock production. Participants who chose to watch the AMR video re-answered four questions related to their perceptions of AMR (on a scale of 1= strongly disagree to 5= strongly agree) after watching the AMR video. We regress the difference in average scores on the four questions related to AMR before and after information on the dummy variables (that capture differences in information and subjective knowledge), objective knowledge index, and their interactions while taking into account individual characteristics (such as participants' demographic characteristics, meat consumption habits, willingness to pay a premium for food safety and welfare attributes, personal history of antibiotic use, and perceptions of and attitudes towards animal welfare, level of concern about AMR and antibiotic use in livestock production):

(4) $$Perceptions\ of\ AMR_{it} =$$

$$= \beta_0 + \beta_1\ Inf_{it} + \beta_2\ Sub\_know_{it} + \beta_3\ Sub\_know_{it} * Inf_{it} + \beta_4\ Obj\_know_{it}$$

$$+ \beta_5\ Obj\_know_{it} * Inf_{it} + \beta_6 \boldsymbol{X_{it}} + \varepsilon_{it}$$

where the β's are coefficients to be estimated and $Perceptions\ of\ AMR_{it}$ denotes participant i's understanding and perceived importance of AMR observed at time t. Inf_{it} is a dummy variable taking a value of one if participant i watched the AMR video at time *t* and zero otherwise. Sub_know_{it} is another dummy variable taking a value of one if participant i rated his/her subjective knowledge of AMR and antibiotic use in livestock production as little or no knowledge; zero otherwise. Finally Obj_know_{it} denotes participants' objective knowledge of

AMR and antibiotic use in livestock production, $\boldsymbol{X_{it}}$ is a vector of control variables (individual characteristics), and ε_{it} is an i.i.d. standard normal error term.

The panel regression model in equation (4) can be estimated either with fixed effects (FE) or random effects (RE) panel specifications. However, since the online survey is designed in such a way that respondents participated in both sections of the survey (before and after they chose the AMR information video), and the values of the variables related to participants' characteristics are time-invariant (i.e., do not change across time), the RE panel specification is appropriate. The Hausman test for all panel regression models indicates that the RE specification is preferred (Hausman, 1978).

5. Results

5.1 Role of knowledge in information avoidance behavior

Table 4 shows the results of the binomial logit model analyzing the role of knowledge in information avoidance behavior. For the estimation, we combined the first two (1= no knowledge and 2= little knowledge) and last two (3= moderate knowledge and 4= a great deal of knowledge) subjective knowledge categories to form two groups of respondents in terms of subjective knowledge, i.e., little or no knowledge and moderate or high knowledge. Therefore, in the logit regression, subjective knowledge is a dummy variable which takes a value of one if participants claimed to have little or no knowledge of AMR and antibiotic use in livestock production and zero otherwise. For robustness, we replicated all analyses without aggregating categories.[8] Recall that the dependent variable is AMR information avoidance behavior (a

[8] The qualitative nature of the results remains the same without making the subjective knowledge scale binary. Results are available upon request.

dummy variable that takes the value of one if a participant selects the nature white noise video link and zero otherwise).

Table 4. Role of knowledge in information avoidance behavior

Independent variables	Marginal Effects
Participants' knowledge	
Little or no subjective knowledge of AMR and antibiotic use in livestock production (1,0)	0.080** (0.035)
Objective knowledge of AMR and antibiotic use in livestock production	-0.300*** (0.068)
Meat and fish consumption habits	
Beef	-0.028 (0.025)
Chicken	-0.058* (0.031)
Fish	-0.016 (0.019)
Pork	0.036 (0.022)
Willingness to pay a premium for	
Products that are produced under strict animal welfare standards	-0.049*** (0.018)
Meat from animals that are never given antibiotics	0.022 (0.020)
Perceptions of AMR	
AMR is one of the biggest problems the world faces	-0.036** (0.017)
Antibiotic resistance is an issue that could affect me or my family	-0.026 (0.019)
Widespread use of antibiotics in animal feed can lead to antibiotics polluting the environment through agricultural runoff	-0.023 (0.021)
Widespread use of antibiotics creates new resistant bacteria that cause illness that antibiotics cannot cure	-0.001 (0.021)
Use of antibiotics in food animals does not cause AMR that could affect humans	0.043*** (0.017)
History of antibiotics use	
Treated with antibiotics last year (1,0)	-0.031 (0.030)
Antibiotic treatment didn't work-own (1,0)	0.006 (0.038)
Antibiotic treatment didn't work-family (1,0)	-0.019 (0.041)
Level of concern	
Level of concern about AMR and antibiotic use in livestock production	0.002 (0.019)

Table 4. Role of knowledge in information avoidance behavior (continued)

Independent variables	Marginal Effects
Animal welfare	
Use of antibiotics to treat improves animal welfare	-0.018 (0.017)
Use of antibiotics in food animals reduces animal welfare	0.053***(0.017)
Food safety is strongly dependent on the care provided to food animals	0.031 (0.019)
Demographic characteristics	
Age	0.001 (0.001)
Gender (1,0)	0.045 (0.033)
Race (1,0)	0.046 (0.036)
College education (1,0)	0.011 (0.030)
Family Size	0.006 (0.010)
No involvement in health sector (1,0)	0.003 (0.052)
Log-likelihood	-623. 869
No. of observations	1030

Note: Reported values are the estimated marginal effects and, in parentheses, standard errors. *** significant at 1%, ** significant at 5%, * significant at 10%.

Regression results show that participants with low subjective knowledge of AMR and antibiotic use in livestock production were around 8 percent more likely to avoid AMR information than more knowledgeable respondents. Results also reveal a negative relationship between information avoidance behavior and objective knowledge of AMR and antibiotic use in livestock production. Participants with more objective knowledge of AMR and antibiotic use in livestock production were around 30 percent less likely to avoid AMR information than less knowledgeable respondents. Estimates of the effect of subjective and objective knowledge of AMR and antibiotic use in livestock production on information avoidance behavior are statistically significant at the 1 percent level. Therefore, empirical results suggest that those with little or no knowledge (both subjective and objective) of AMR and antibiotic use in livestock production were more likely to avoid information about AMR than more knowledgeable individuals.

Respondents who agreed with the statement that they were willing to pay a premium for strict animal welfare standards were 5 percent less likely to avoid AMR information, which is statistically significant at the 1 percent level. Notably, participants who believe that AMR is one of the biggest problems in the world were about 4 percent less likely to avoid AMR information, while respondents who believe that the use of antibiotics in livestock production does not cause AMR were around 4 percent more likely to avoid AMR information. Participants who believe that the use of antibiotic reduces animal welfare were about 5 percent more likely to avoid information about AMR.

The logit model used above assumes a linear relationship between dependent and independent variables. To check the robustness of the key result of this study, that knowledge plays an important role in explaining information avoidance behavior, we also used the random forest (RF) method, relaxing the linearity assumption. The RF method accounts for the non-linear characteristics and complex interactions among the predictor variables. Moreover, when the relationship between response and predictor variables is truly linear, the RF method approximates the logistic regression method (Muchlinski et al. 2015). Results of the RF method also confirm that consumers' knowledge of AMR and antibiotic use in livestock production is a key predictor of AMR information avoidance behavior (for details see Appendix).

5.2 Effects of information on perceptions and understanding of AMR

While the previous section highlights the role of knowledge in information avoidance behavior, this section identifies the effects of AMR information on participants' perceptions of AMR.

Specifically, this section focuses on participants who did not avoid AMR information (a total of 631 out of 1030 respondents chose to watch the AMR video) and explores the effects of AMR information on their perceptions of AMR based on subjective and objective knowledge of AMR and antibiotic use in livestock production.

Table 5 reports simple univariate analyses of AMR information effects on participants' perceptions and understanding of AMR. Recall, respondents who watched the AMR video re-answered four questions related to their perceptions of AMR. According to table 5, the first three statements support that excessive use of antibiotics creates resistant bacteria that could affect human health and consider AMR as one of the greatest challenges to healthcare systems worldwide. The last statement supports that use of antibiotics in food animals does not cause resistant bacteria that could affect human health.

Table 5: Perceptions of AMR before and after watching the AMR video

H_0: Perceptions of AMR before information = Perceptions of AMR after information
Scale from 1 to 5, where 1 means strongly disagree and 5 means strongly agree

Statements	**Stage 1 Level of agreement before AMR information**	**Stage 2 Level of agreement after AMR information**	**Change in the level of agreement**	**Prob (|T| > |t|)**
AMR is one of the biggest problems of the world	3.54	3.92	↑	<0.001
Widespread use of antibiotics in animal feed can lead to antibiotics polluting the environment through agricultural runoff	3.65	4.00	↑	<0.001
Widespread use of antibiotics creates new resistant bacteria that cause illness that antibiotics cannot cure	3.89	4.18	↑	<0.001
Use of antibiotics in food animals does not cause AMR that could affect humans	2.66	2.26	↓	<0.001

Note: The reported *p*-values test equivalency using a pair-wise *t* test. A total of 631 out of 1030 respondents selected the AMR video link.

The univariate tests in table 5 reveal that the average level of agreement with the first three statements increases (3.54 vs. 3.92, 3.65 vs. 4.00, 3.89 vs. 4.18; *p* <0.001) after watching the AMR video. In contrast, the average level of agreement with the last statement decreases (2.66 vs. 2.26; *p* <0.001) after watching the AMR video. Therefore, comparing the level of understanding of AMR before and after watching the AMR video, our analyses indicate that participants' understanding of AMR, on average, improved significantly after watching the AMR video.

Table 6 presents results of the panel regression with random effect specification analyzing the effects of information on participants' understanding and perceived importance of AMR based on participants' subjective and objective knowledge of AMR and antibiotic use in livestock production.[9] Regression results show that participants' understanding and perceived importance of AMR, on average, increased by 0.32 points after watching the AMR video, confirming the results in table 5. This result is statistically significant at the 1 percent level. As expected, before watching the AMR video, respondents with little or no subjective knowledge of AMR and antibiotic use in livestock production, on average, have less understanding of AMR than more subjective knowledge respondents. While, after exposure to AMR information, the perceived importance of AMR increased for both groups, the increase is greater for participants with little or no subjective knowledge by about 0.20 points compared to more knowledgeable individuals, which is statistically significant at the 1 percent level.

[9] Since the last question supports that use of antibiotics in food animals does not cause AMR (negative statement), we calculated the average score on the four questions about AMR after rescaling the last question. For example, when participants chose 5= strongly agree for the last question, they received 1= strongly agree in rescaling.

Table 6. Effects of information on perceptions and understanding of AMR based on knowledge

Independent variables	Level of agreement about AMR
Information (1,0)	0.322*** (0.092)
Participants' knowledge	
Little or no subjective knowledge of AMR and antibiotic use in livestock (1,0)	-0.162*** (0.050)
Little or no subjective knowledge of AMR and antibiotic use in livestock × information	0.198*** (0.068)
Objective knowledge of AMR and antibiotic use in livestock	0.848*** (0.095)
Objective knowledge of AMR and antibiotic use in livestock × information	-0.234* (0.134)
Meat and fish consumption habits	
Beef	-0.084*** (0.034)
Chicken	-0.031 (0.042)
Fish	0.004 (0.029)
Pork	0.035 (0.036)
Willingness to pay premium for	
Products that are produced under strict animal welfare standards	-0.042 (0.027)
Meat from animals that are never given antibiotics	0.075*** (0.027)
History of antibiotics use	
Treated with antibiotics last year (1,0)	-0.068 (0.043)
Antibiotic treatment didn't work-own (1,0)	-0.048 (0.053)
Antibiotic treatment didn't work-family (1,0)	0.022 (0.067)
Level of concern	
Level of concern about AMR and antibiotic use in livestock production	0.221*** (0.027)
Animal welfare	
Use of antibiotics to treat improves animal welfare	-0.044* (0.027)
Use of antibiotics in food animals reduces animal welfare	-0.010 (0.024)
Food safety is strongly dependent on the care provided to food animals	0.111*** (0.029)
Demographic characteristics	
Age	0.004*** (0.001)
Gender (1,0)	-0.036 (0.045)
Race (1,0)	0.012 (0.051)

Table 6. Effects of information on perceptions of AMR based on knowledge

Independent variables	Level of agreement about AMR
Demographic characteristics	
College education (1,0)	-0.057 (0.042)
Family Size	-0.018 (0.017)
No involvement in health sector (1,0)	0.100 (0.084)
Constant	2.954*** (0.230)
R^2	0.29
Wald χ^2	742.61
No. of observations	1262

Note: A total of 631 respondents out of 1030 selected the AMR video link. Reported values are the estimated coefficients and, in parentheses, cluster robust standard errors.
*** significant at 1%, ** significant at 5%, * significant at 10%.

Results reveal a statistically significant positive relationship between the objective knowledge score and perceived importance of AMR before watching the AMR video. The higher the objective knowledge score, the greater the perceived importance of AMR. However, after exposed to information about AMR, participants with greater objective knowledge increased their perceived importance of AMR less, which is statistically significant at the 10 percent level. Regression results indicate that, regardless of their level of subjective and objective knowledge, participants benefited from accessing AMR information, and less knowledgeable individuals benefited the most.

6. Policy Implications and Conclusions

AMR is considered one of the most serious threats to both animal and human healthcare systems and the global economy. International donor agencies, governments, NGOs, and industry groups are launching local and global campaigns to raise awareness among communities about AMR and promote the rational use of antimicrobials in the human healthcare system and livestock industries. However, studies show that people avoid information when they believe that information would make them feel bad, jeopartizing the effectiveness of health risk communication campaigns. Information avoidance behavior is an initial barrier to effective health risk communication (Gaspar et al. 2016).

This study investigates information avoidance behavior by focusing on AMR and explores whether individuals make different decisions about accessing AMR information based on their subjective and objective knowledge of AMR and antibiotic use in livestock production, perceptions of, and attitudes towards, these issues and individual characteristics. Further, our study determines the effects of AMR information on respondents' understanding of AMR.

Survey results reveal that nearly 39 percent of participants avoided AMR information. The top three reasons for avoiding AMR information were: (1) watching a video is not going to change my existing view, (2) scared of knowing about AMR, and (3) there is nothing I can do to solve the AMR issue. An important finding of our study is that individuals with little or no (subjective or objective) knowledge of AMR and antibiotic use in livestock production were more likely to avoid AMR information than more knowledgeable participants. Our results also show that participants who chose to watch the AMR video improved their understanding and perceived importance of AMR with respondents with little or knowledge benefiting .

The results of this study suggest that individuals who are less knowledgeable about AMR are more likely to avoid AMR information. Although these individuals can correctly assess that they have little or no knowledge of AMR and antibiotic use in livestock production, they choose to remain uninformed, indicating willfully uninformed behavior. However, our results show that these individuals could benefit the most from accessing AMR information. Our findings raise important questions about how to encourage willfully uninformed individuals to access information about critical topics. Given the importance of raising awareness among communities of the devastating effects of AMR, international donor agencies, governments, NGOs, and industry groups may chose to apply different information framing strategies to appeal to willfully uninformed individuals. In particular, our results on the top reasons individuals avoid AMR information suggest that appealing to this group of individuals to access health risk information might require a variety of information sources and mediums and a tactful framing of information; one that presents information in less frightening ways and highlights the role of each individual in combating AMR.

Future research may explore the effect of different information framings on information avoidance behavior and identify the types of health risk information framings that could encourage willfully uninformed individuals to access information about important issues.

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Appendix

I. Factor Analysis Results

Factor loading: Level of concern about AMR and antibiotic use in livestock production

Level of Concern	**Factor 1**
Use of antibiotics to **treat** infections in food animals	0.6981
Use of antibiotics to **prevent** infections in food animals	0.8305
Use of antibiotics to **contro**l the spread of an illness among food animals	0.8075
Use of antibiotics to **promote** animal growth in food animals	0.7481
Use of antibiotics in food animal production contributing to antibiotic resistance	0.8386
Use of the same antibiotics in humans and food animals contributing to antibiotic resistance in humans	0.8301
Use of any antibiotics to treat humans contributing to antibiotic resistance in humans	0.7199
Eigenvalue	*4.299*
Variance explained	*0.9784*
Cumulative variance explained	*0.9784*

II. Random Forest (RF) Method

While the binomial logistic regression generally works well as a classifier when the relationship between dependent and independent variables is linear and the data are relatively balanced between classes (Muchlinski et al. 2015), the random forest (RF), a machine learning method, outperforms the logistic regression when the non-linear characteristics and complex interactions among predictor variables exist (Cutler et al. 2007). In this study, we also use the RF method to determine the role of knowledge in information avoidance behavior, relaxing the assumption of linear relationship between information avoidance behavior and the set of independent variables mentioned earlier in the logit model. Although there are several machine learning methods, we choose the RF method for the following two reasons: (i) its superior performance relative to other statistical learning methods, and (ii) this algorithm can be used to classify discrete variables.

Following Zhang and Ma (2012), suppose x is the set of predictor variables (all participants' characteristics included in the logit model as independent variables) and y represents participants' information avoidance behavior. To predict y the RF method finds a prediction function $f(x)$ which is determined by a loss function $L(y, f(x))$. The prediction function minimizes the expected loss function $E_{xy}\ (L(y,\ f(x)))$. A loss function for a binary response variable (information avoidance) can be written as:

$$(A1) \qquad \left(L\big(y, f(x)\big)\right) = I\big(y \neq f(x)\big) \ = \begin{cases} 0, & if\ y = f(x) \\ 1, & otherwise \end{cases}$$

The RF method uses j number of trees, $h_1(x), \dots \dots, h_j(x)$ as base learners. The prediction function $f(x)$ is the average of all base learners (j trees) for continuous response variable while it is determined by the most frequently predicted category for classification, such as a binary response variable. The RF method randomly divides data into training and validation subsets and takes a bootstrap sample D_j (with replacement of the training dataset) of size N. Then this method typically performs following steps:

1. Randomly select m number of predictors out of p available predictors
2. Identify the best binary split out of all available binary splits
3. Split the node into decedent nodes and build a tree
4. Repeat steps 1 and 2 j number of times to create j number of trees

To make out-of-bag prediction at x_i,[10]

[10] When a bootstrap sample is drawn of size N, some observations do not include in the bootstrap sample. These observations are known as "out-of-bag data". The prediction of response variable using the out-of-bag data is known as out-of-bag prediction.

$$(A2) \qquad \widehat{f_{oob}}(\,x_i) = \arg max_y \sum_{j \in Z_i} I(= I(\widehat{h_j}(x_i) = y)$$

where $Z_i = \{j : (x_i, y_i) \notin D_j\}$ and $\widehat{h_j}(x_i)$ presents the prediction of the response variable y_i at x_i using the jth tree.

Table A1 reports the prediction of information avoidance behavior using the RF method. Columns 1-3 present accuracy, sensitivity, and specificity for information avoidance behavior as the response variable. The accuracy shows the overall performance of predicting information avoidance behavior while the sensitivity and specificity present the percentage of information avoidance incidents correctly identified and the percentage of no information avoidance occurrences correctly predicted, respectively. Like the logit model, our response variable is information avoidance behavior, taking a value of one if the participant avoids the AMR video and zero otherwise. According to table A1, model 1 includes only participants' subjective and objective knowledge as predictor variables. The overall accuracy of the knowledge variables (i.e., subjective and objective knowledge of AMR) in predicting information avoidance behavior is 61 percent. In this context, the sensitivity and specificity indicators are 57 percent and 63 percent, respectively. Inclusion of participants' attitudes towards animal welfare, AMR and antibiotic use in livestock production (i.e., indicators related to perceptions of AMR, history of antibiotic use, level of concern of AMR, animal welfare and WTP for food safety attributes) do not change the overall accuracy drastically (see model 2 in table A1). However, inclusion of participants' demographic characteristics and meat and fish consumption habits reduces the overall accuracy from 61 percent to 58 percent (see models 3 and 4 in table A1). Results of table A1 suggest that consumers' knowledge of AMR and antibiotic use in livestock production is the key to explain the AMR information avoidance behavior.

Table A1. Prediction of information avoidance behavior

Model	**Accuracy**	**Sensitivity**	**Specificity**
Response variable: Avoiding AMR video (yes=1)			
(1) Knowledge	61%	57%	65%
(2) Knowledge + Attitudes towards animal welfare and AMR	62%	61%	63%
(3) Knowledge + Demography + Consumption habits	58%	49%	67%
(4) All	59%	55%	63%

Note: We used the out-of-bag prediction technique. Total observation was 1030, of which 70% was used to train the model while the rest 30% was used for data validation.