12-2018

Understanding Consumer Attitudes Towards Antimicrobial Risk Reducing Practices

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UNDERSTANDING CONSUMER ATTITUDES TOWARDS ANTIMICROBIAL RISK REDUCING PRACTICES

by

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A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Agricultural Economics

Under the Supervision of

Professors Amalia Yiannaka and Kathleen Brooks

Lincoln, Nebraska

December 2018

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University of Nebraska,2018

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The emergence and spread of antimicrobial resistance is a natural evolutionary reaction to antimicrobial exposure. However, the misuse and overuse of antimicrobial drugs in human medicine and in agriculture are speeding up the process. Antimicrobials have been used in food-producing animals for therapeutic purposes as well as to promote growth by applying low concentrations in animal feed. Antimicrobial resistant pathogens can enter the food chain through food containing residues of antibiotic-resistant bacteria and cause infections in humans. In the United States, millions of people are infected every year with antimicrobial resistant bacterial diseases causing approximately 23,000 deaths (CDC 2013). This study examines the public's objective and subjective (self-assessed) knowledge and perceptions of antibiotic use in the livestock and poultry industries as well as knowledge and perceptions of antibiotic resistance. The study further examines the public's level of acceptance of antibiotic use in food animals for disease prevention, disease control, disease treatment, and as growth promotants, as well as how attitudes towards animal welfare may impact antibiotic use acceptance. A quantitative survey questionnaire was developed to achieve study objectives, and it was administered online by the survey firm IRI between May and June 2018. A random sample of 1,030 individuals across the United States participated in the survey. Data on participants' subjective and objective knowledge of antibiotics and antibiotic resistance, acceptance of antibiotic use in livestock animals, perceptions of antibiotic use and antibiotic resistance, food safety perceptions, attitudes towards animal welfare and demographic variables were collected. An ordered Probit model was used to determine the level of acceptance of different uses of antibiotics in food animal production. Marginal effects in an ordered Probit model were used to estimate the probability change in the level of acceptance of study participants. Results indicate that the level of acceptance for each use of antibiotics is influenced by the participants' subjective and objective knowledge of both antibiotic use and antibiotic resistance. The results further demonstrate that food safety perceptions play a significant role in the level of acceptance of antibiotics in food animal production. Further, results show that attitudes towards animal welfare and demographic variables such as age, sex and race affect the level of acceptance of antibiotic use in food animal production.

ACKNOWLEDGEMENT

The help, mercy and incomparable kindness of almighty God who governs the whole of my being deserve a deep in my measure words of thanks.

I would like to thank my advisor Dr. Amalia Yianaka and Dr. Kate Brooks for everything he has helped me with over the last few years. I really appreciate the guidance and patience They have given me. Your confidence in my abilities has been invaluable. Dr. Yiannaka and Dr. Brooks, I very much appreciate the opportunity to assist you during my time in graduate school. The experience I obtained during my master's program will help me for years to come. Professor Christopher Gustafson thank you for all your assistance and carefully reading my thesis and giving me constructive feedback to my work.

I also want to express my deepest gratitude to the Pakistani Government for their financial support and to give me a chance to learn in a competitive academic environment and to explore another culture other than mine.

To my family, my friends, you are part of this success. I couldn't thank you enough for been incredibly supportive.

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1 Introduction

Antimicrobial resistance (AMR) is considered to be one of the most significant threats to human health worldwide (Walker et al. 2009). The emergence and spreading of new AMR bacteria threatens the effectiveness of the best tools available to treat bacterial infections, leading to an increase in diseases, disability, and death (WHO 2018). In April 2018, the Centers for Disease Control and Prevention (CDC) reported that more than 220 varieties of bacteria with new or rare antibiotic-resistant genes have been found in 27 states in the U.S. Further, the report stated that of all the bacteria tested by the CDC, 25% have special genes that allow them to circulate their genes to other bacteria, and these germs are “virtually untreatable with modern medicine” and can “spread like wildfire” (CDC 2018).

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 antimalarial medicines) to which they were once sensitive – that is, the germs are not killed, and their growth is not stopped (CDC 2013). Recent studies report that due to AMR infections approximately 700,000 people die each year globally and by 2050 the death toll will increase up to 10 million people (O'Neill 2014; de Kraker et al. 2016). According to the CDC (2013), each year at least 2 million people in the United States are infected with AMR bacteria resulting in 23,000 deaths. Moreover, these AMR infections lead to increased costs for consumers and the health care system. O’Neill (2014) reported that continued increases in AMR would result in a two to three and a half percent reduction in Gross Domestic Product by 2050 and would cost the world up to $100 trillion. Currently, the annual cost of AMR infections to the United States health system is estimated to be between $21 billion to $34 billion a year (CDC 2013; Roberts et al. 2009).

Antibiotic resistance (ABR) is a type of AMR, which occurs when bacteria become resistant to antibiotics. The development of ABR occurs because of evolutionary natural selection. However, the misuse and overuse of antimicrobial drugs are speeding up the ABR process. The incorrect use of antibiotic drugs in humans for a short period, incorrect dosing or use for the wrong disease, results in bacteria not being killed, and these bacteria develop resistance and can pass resistant traits to more bacteria (CDC 2013).

Antibiotics and ABR genes are found in the soil around farms, water, in the air, in wild animal populations, and on retail meat and poultry (Smith et al. 2005). Different factors are involved in the spread of these bacteria (Chee-Sanford et al. 2001; Emborg et al. 2003). Poor hygiene, poor sanitation, and inadequate infection control are three interconnected vital factors contributing to the spread of resistant pathogens in health-care facilities as well as in the community (Batterman et al. 2009). ABR bacteria and ABR genes enter the food chain through food containing residues of ABR bacteria and cause infections in humans (Singer et al. 2003). For instance, *Escherichia coli* (*E. coli*) is an ABR strain, which can be transferred from food animals and cause infections in humans (Johnson et al. 2007; Warran et al. 2008; Sheldon 2010). In the United States, each year millions of cases of gastrointestinal bacterial diseases like *Salmonellosis* and *Campylobacteriosis* are caused by consumption of contaminated meat and other cross-contaminated foods because of common unsafe handling practices (Scallan et al. 2011).

In addition to medical antibiotics usage in humans, veterinary use of antibiotics is believed to have a significant impact on the increase of ABR (Mellon et al. 2001).

The widespread use of antimicrobials in livestock production has been linked to the prevalence of AMR in pathogens (McEwen and Fedorka-Cray 2002). Very limited research has been conducted related to dissemination of ABR within agricultural sites and to humans via food-producing animals and plants, as well as risks to humans caused by the release of antimicrobial agents, AMR genes, and AMR bacteria into the environment (Thanner et al. 2016). In food-producing animals antibiotics are used for prophylactic or therapeutic purposes as well as to promote animal growth by mixing low concentrations of antimicrobials into animal feed (Holmes et al. 2016). While most of antimicrobial use in the agri-food industry tends to be for food animal production, it is also used to prevent crop diseases and produce biofuel by-products (FAO 2017).

It is difficult to calculate the use of antimicrobials in the agriculture sector globally due to lack of regulations and inadequate data collection in many countries, but it is estimated to be over 60,000 tons per year (FAO 2017). Hollis and Ahmed (2013) state that the use of antibiotics in the livestock sector is approximately 80 percent of all the antibiotics used in the United States annually. Green et al. (2010) report that producers engaged in intensive farming practices were more likely to use antimicrobials routinely (i.e., for sub-therapeutic purposes in animal feed). Key and McBride (2014) found that the sub-therapeutic use of antibiotics in U.S. hog farms has a positive effect on productivity and production risk, increasing output by 1 to 1.3 percent. However, ABR genes in animal manure can be quickly disseminated to soil and even to plants when manure is used as fertilizer, resulting in higher frequency of ABR in the environment

(Wang et al. 2015). Baguer et al. (2000) claim that land application of antibiotic-laced manure is the dominating pathway for the release of antibiotics in the terrestrial environment. Chee-Sanford et al. (2001) reported that if the land application of antibiotic-laden manure continues, groundwater could become a potential source of antibiotics and genetic resistant determinants in the food chain. The release of these antimicrobials in the environment through land application can create problems for disease treatment in humans and animals (Corpet 1996; Klare et al. 1995). There is also evidence of the transfer of resistant genes from animal to human pathogens (Khachatourians 1998). Moreover, Smith et al. (2002) studied the impact of the emergence of ABR in humans due to the use of antibiotics in animals and found that antibiotic use in livestock hastens the appearance of ABR bacteria in humans. Thus, antimicrobial use in agriculture is an essential factor in the dissemination of AMR. However, food animals are not only vehicles of AMR transmission, but they also help in the propagation, selection, and spread of resistant bacteria and resistant genes (Thanner et al. 2016).

Given the current use of antibiotics in agriculture and its link to ABR, it is essential to assess the economic and social impacts of its continued use. A critical element in this analysis is the understanding of the public's views of and attitudes towards antibiotic use in agriculture. It is well documented that product attributes and production processes influence consumer preferences and choices (Lancaster 1966; Gaskell et al. 1999; Siegrist and Cvetkovich 2000; Tegene et al. 2003; Hu et al. 2006; Schroeder et al. 2007; Roosen et al. 2015). A review of the literature reveals that there are significant gaps in the empirical study of consumer knowledge, perceptions of and attitudes towards antibiotic use in agriculture and ABR.

The primary goals of this study are to examine the U.S. residents' subjective and objective knowledge and perceptions of ABR and antibiotic use in agriculture and how their knowledge and perceptions affect acceptance of the use of antibiotics in various animal production practices. In addition, the study examines the relationship between the publics' attitude towards animal welfare, food safety and antibiotic use in agriculture. To achieve these objectives, a survey was developed and administered to 1030 individuals in the U.S. Understanding public perceptions, knowledge and attitudes towards antibiotic use in general and in agriculture, in particular, is important for the livestock industry and for policymakers who may choose to regulate antibiotic use and AMR risk-reducing practices. The findings of this study can help the livestock and poultry sectors develop livestock production practices that improve consumer confidence in the food production system.

The rest of the thesis is organized as follows. Chapter two presents a review of the literature on AMR, antimicrobial use in agriculture, and consumer perceptions of antimicrobial use. Chapter three describes the survey design and gives summary data, which is followed by the model specification in chapter four. Empirical results are discussed in chapter five. Chapter six summarizes and concludes the thesis.

2 Literature Review

2.1 Antimicrobial resistance

Antimicrobial drugs are essential for the maintenance of human and animal health and welfare. Antimicrobials, particularly antibiotics, have been a very important part of modern medicine for the last eight decades. In 1928, the first antibiotic (penicillin) was discovered by Alexander Fleming. Since then, penicillin has lowered mortality associated with pneumococcal pneumonia from 20 percent to 5 percent and mortality from pneumococcal bacterium from 80 percent to 20 percent (Ho et al. 2001; Podolsky 2006). Moreover, in the past few decades, antibiotics have played a vital role in achieving major advances in medicine and surgery and they have prevented or treated infections during organ transplants and chemotherapy (Gould and Bal 2013). Laxminarayan et al. (2015) found that from 2000 to 2010 there was a 36 percent increase in the consumption of antibiotics, and three quarters of this increase has been contributed by Brazil, Russia, India and South Africa.

There is emergence and spread of resistant microorganisms worldwide, threatening the efficacy of antibiotics, which is seen as one of the leading human health threats (Ashbolt et al. 2013; Carlet et al. 2014; Cecchini et al. 2015; Laxminarayan et al. 2013). This increase in AMR is potentially decreasing child survival rates, as according to a recent study, an estimated 214,500 neonatal sepsis deaths occur each year due to resistant pathogens (WHO 2014).

AMR disseminates via multiple processes, such as genetic material exchange and, more likely, through plasmid transmission[1] (Walsh et al. 2011). This exchange of genetic

[1] Plasmid is a small DNA molecule in the cell of a bacterium which can be transmitted to another bacterium or even to other species through conjugation, this process is called plasmid transmission.

material and plasmid transmission leads to transfer of resistant determinants between microorganisms (Beaber et al. 2004). Moreover, the environment, drinking water and food play an important role in the dissemination of AMR since AMR bacteria are everywhere in natural environments (Walsh et al. 2011). Transmission of these resistant microorganisms can occur by non-food mechanism (e.g., contact with the infected animals) or by food mechanisms (e.g., eating contaminated food).

Recently, a few studies have estimated that the cost of treating infections caused by ABR pathogens doubled from 5.2 percent in 2002 to 11 percent in 2014 in the U.S. (CIDRAP 2018). The annual costs of these ABR infections is between $21 billion to $34 billion a year and more than $8 million due to additional hospital days (Roberts et al. 2009; Filice et al. 2010; Spellberg et al. 2011). Moreover, Thorpe et al. (2018) find that decreasing ABR infections by just 20 percent would save $3.2 to $5.2 billion in health care costs each year and an additional $11.3 million from reduced in-hospital stays for patients with ABR infections.

The use of antimicrobials is not only limited to human medicine; they are widely used in agriculture as well. Use of antimicrobials in agriculture is highly correlated with the evolution and dissemination of AMR and described as a major contributor to the clinical problems of AMR in human medicine (Durso and Cook 2014). Several studies identified that the use of the same antibiotics in both human and animal medicines presents a serious threat to public health (Phillips et al. 2004; Marshall and Levy 2011; Spellberg et al. 2016). Although the misuse of antimicrobials is a problem for both developed and developing countries, it is more common in developing countries due to factors like inappropriate prescription practices, inadequate patient education, limited diagnostic facilities, over the counter sale of antimicrobials, lack of drug sale policies, and non-human use of antimicrobials in livestock production (James et al. 2017). Unsurprisingly, application of antibiotics in food animals, in larger quantities leads to ABR strains, and these resistant microbes and resistant genes can circulate in the food chain (Kluytmans et al. 2013).

2.2 Use of antimicrobials in agriculture

The application of antimicrobial agents to treat infections in farm animals started in the mid-1940s. Since then, these antibiotics have been widely used in commercial feed for pigs, cattle, and poultry. The worldwide consumption of antimicrobials in food animal production was 63,151 tons in 2010 and is projected to rise 67 percent (to 105,596 tons) by 2030 (Van Boeckel et al. 2014).

A number of studies have shown that the excessive application of antibiotics in animal farming is one of the main reasons for the spread of ABR (Economou and Gousia 2015; Ilias Chantziaras et al. 2014; Vieira et al. 2011). Isaacson and Torrence (2002) discuss concerns regarding the use of antibiotics in agriculture, which are increases in ABR genes due to antibiotic use in agriculture and these ABR pathogens are a threat to the public and can impact animal health and production. AMR bacteria have been found everywhere where antimicrobials are heavily applied (Aarestrup 1995; Aarestrup 1998) in associated food products (Bates et al. 1994; Chadwick et al. 1996), in environment contaminated by animal waste (Chee-Sanford et al. 2009; Linton 1988) and on farm workers (Levy et al. 1976; Van den Bogaard et al. 1997).

Although the majority of antimicrobial use is on the agricultural side, research on antimicrobial use in food animals and how it contributes to the spread of AMR is limited (Landers et al. 2012). Swan et al. (1991) first reported the link between AMR and antibiotic use in agriculture. Antibiotics are mainly used in food animals to prevent and control infections and for sub-therapeutic purposes such as growth promotants in cattle (Mellon et al. 2001; McManus et al. 2002; Singer et al. 2003), as well as to treat infections in crops (Stockwell and Duffy 2012).

In developing countries, demand for animal protein has increased significantly due to rising incomes (Tilman et al. 2011). In Asia, the total intake of protein grew from 7 to 25 grams per capita per day between 1960 and 2013 (Van Boeckel et al. 2015). To meet this demand, countries like India, China, Brazil and South Africa have shifted to cost-efficient and vertically integrated livestock farming (Silva et al. 2013). However, these systems demand antimicrobials to maintain a healthy environment for animals in the herd which results in increased AMR (Silva et al. 2013). Also, Usui et al. (2014) in a study about the use of antimicrobials in Vietnam, Thailand and Indonesia found that, in developing countries, a number of antimicrobials are given as feed additives to promote animal growth.

In the United States, an estimated 14,788 tons of antimicrobials were sold for use in animals both for the purpose of treatment and sub-therapeutic use. For instance, in 2013, 4,434 tons of ionophores (class of antimicrobials) were used in animals (FDA 2015). McBride et al. (2008) were the first to study the impacts of sub-therapeutic antibiotics on animal production and found that farm operations with sub-optimal environmental and management practices such as closed and cramped conditions experienced more infections in their animals. Researchers have known since the 1940s that the use of antibiotics at low levels in animal feed and water leads to quicker growth and improved feed efficiency (Gustafson and Bowen 1997). However, MacDonald and Wang (2011) show that 42 percent of broiler growers do not use sub-therapeutic antibiotics in their feed or water, and instead, they depend on different treatment practices like pathogen testing, sanitary protocols, altered feeding regimens, and Hazzard Analysis Critical Control Point plans for production.

Despite the above facts regarding the use of antibiotics in agriculture and its contribution to the evolution and spread of ABR, there is still debate and controversy as to whether agricultural practices are to blame for the emergence of ABR (Kennedy 2013). However, the CDC (2013 p. 37) issued a report that states, “because of the link between antimicrobial use in food-producing animals and the occurrence of antimicrobial-resistant infections in humans, antimicrobials should be used in food-producing animals only under veterinary oversight and only to manage and treat infectious diseases, not to promote growth.” Concerns about increasing AMR have led to a ban on antimicrobials as growth promotants in European countries. Sweden became the first country in 1986, to ban antibiotics as growth promotants due to consumer concerns about AMR (Wierup 2001). In the United States, the Food and Drug Administration has taken a significant step regarding the use of certain drugs in animal feed and banned the use of antibiotics as feed supplements to promote growth (US FDA 2016). Moreover, the animal medicinal drug use clarification act 1994, veterans allows veterinarians to prescribe extra label application of certain approved new animal drugs and approved human drugs for animals under certain condition (US FDA 1994).

2.3 Consumer perceptions of antimicrobial use and animal welfare

Understanding consumer preferences for meat product attributes has been of interest to animal producers, processors and marketers. Studies show that, when selecting food products, consumers consider a number of factors which include the environmental impact, food safety implications and social implications of food production methods (Olynk et al. 2010). Frewer et al. (2005) report that livestock products arouse consumer sentiments regarding livestock treatment and animal welfare. Lusk and Briggeman (2009) studied consumer attitudes towards eleven different food attributes; taste, price, safety, nutrition, tradition, origin, fairness, naturalness, appearance and environmental impact. Their results showed that the most important food attributes for consumers were food safety, price and taste. Consumer responses to food safety risks are affected by their demographic characteristics, such as gender (Kirk et al. 2002), age, (Kirk et al. 2002), income (Grobe et al. 1999), and education (Grobe et al. 1999; Kirk et al. 2002). Kubberød et al. (2002) conducted an experiment on gender-specific preferences and attitudes towards meat and found that dislike for red meat varieties is more prevalent among females than males.

In addition to food price and food safety, several studies show that consumers are concerned about farm animal welfare and strongly focus on high animal welfare standards, through clear and credible labels by trustworthy control and traceability mechanisms (Vanhonacker et al. 2007). It has been suggested that consumers may use animal welfare as an important indicator to value food as safer, healthier and of higher quality (Fallon and Earley 2008). Napolitano et al. (2007a, 2007b) found that information about animal welfare can affect quality perceptions of lamb and beef. Earlier studies show that while consumers often report high concern for food animal welfare, most consumers do not purchase products that are certified as higher welfare products and only 10% of consumers actively look for animal welfare information when they purchase food products (Webster 2001). However, a study by McKendree et al. (2014) found that due to animal welfare concerns, 14% of U.S. consumers reduced their consumption of pork products.

Consumer perceptions of meat and their consumption of meat have been negatively influenced by animal epidemics. The reduction of antibiotic use for treatment of sick animals without increasing animal suffering is a critical issue for those who value food animal welfare because denying sick animals' treatment with antibiotics, if needed, conflicts with animal welfare requirements (D'Angeli et al. 2016). Goddard et al. (2017) found that in both Canada and Germany individuals with higher welfare concerns about the humane treatment of animals more strongly reject the use of antibiotics in livestock production. This finding suggests that consumers do not believe that a reduction in antibiotics use in livestock production would have a negative influence on animal welfare. However, the reduction in antibiotic use in livestock production that does not result in an increase in animal suffering requires adjustments in animal husbandry that result in higher production costs (Jensen and Hayes 2014). (Brewer and Rojas 2008) studied consumer perceptions of food safety and antibiotic use and found that 74 percent of consumers thought that foods from animals treated with antibiotics, which have been scientifically evaluated and found safe by the FDA, are safe to eat however, one third would not purchase products treated with antibiotics, and more than 20 percent stated that they reduced their intake of particular products (meat, poultry, milk) because they feared that they were from antibiotic treated animals. Lusk et al. (2006) conducted a field experiment that examined consumers' willingness to pay for pork raised without the use of antibiotics, and consumers' willingness to contribute to the mitigation of ABR. Their results showed consumer support for a ban on the sub-therapeutic use of antibiotics, and willingness to pay for antibiotic-free pork.

While the above studies shed some light on consumer attitudes towards antibiotic use in animal production, important questions remain unanswered. Specifically, assessment of subjective and objective consumer knowledge of AMR and antibiotic use in agriculture and their influence on consumer perceptions and acceptance of antibiotic use in various production practices are issues that have not been examined. This study will address these issues and explore additional factors that influence perceptions and attitudes towards antibiotic use in agriculture.

3 Materials and Methods

3.1 Study Description

A hypothetical survey was developed to achieve study objectives. The survey included questions that addressed (1) public knowledge of AMR and antimicrobial use both in food animals and in humans; (2) public attitudes towards animal welfare and (3) consumer acceptance of antimicrobial use in food animals. The survey was administered online by the survey firm IRI. A total of 8,528 individuals over 19 years of age across the United States were randomly invited to participate via email between May and June 2018. Subject recruitment closed when 1,030 responses were returned. The survey questions can be found in Appendix A.

3.2 Survey design and measurement scales

The survey was developed following the Likert-type scale assessment model and consisted of four sections. The first section collected information on demographic variables such as the respondents' age, gender, household income, ethnicity, education level, number of children in the family and employment or involvement in the livestock/poultry industry. In the second section, questions were asked about meat consumption habits, attitudes towards various food animal production practices (e.g., use of growth hormones, antibiotics and vaccines), food safety, and animal welfare practices. The third section covered questions related to personal antibiotic use and experience with antibiotic drug effectiveness. Section four covered questions on three topics: (1) subjective and objective knowledge of antibiotic use in food animal production and ABR, (2) attitudes towards antibiotic use and ABR, and (3) attitudes towards food labeling and willingness to pay for meat products produced without antibiotics.

3.3 Data and Descriptive Statistics

Table 1 provides descriptive statistics and a description of demographic characteristics, including age, ethnicity, gender, income, and education, as well as participants' involvement in the livestock or health sectors and meat consumption habits. As shown in Table 1, the average age of survey participants was 51.8 years, 29% male and 73% were white. The average income of participants was $73.68. In addition to demographic characteristics, participants were asked about their involvement in the livestock industry, human health or animal health sectors. This question was asked to see whether involvement in these sectors impacts participants' perceptions and acceptance of antibiotics use in food animals, as those involved in these sectors could have a better understanding of how animals are being kept and raised on farms. Approximately 9.0% of participants reported that they are involved in one of these sectors while 91.0% of participants reported that they are not involved in any of these sectors. Individuals who received a high school degree comprised 34.8% of the participants, 31.3% received an associates or technical degree, 19.5% received a bachelor's degree, and only 14.2% received a graduate or professional degree. The percentage of participants in each category of education in our sample is close enough to the percentage of people in each category of education calculated by US census bureau 2017[2].Which shows that our sample is close enough to be a national representative sample.

Participants were further asked about their meat consumption habits. Consumption habits related to four different types of meat (beef, chicken, pork and fish) were measured

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[2] (The Us population with high school degree are 39.20%, Associate or some college 26.63%, bachelor's degree 21.32%, post graduate or professional degree 12.83%). https://www.census.gov/data/tables/2017/demo/education-attainment/cps-detailed-tables.html

on a five-point scale where 1= never, 2=a few times per year, 3=monthly, 4=weekly, and 5=daily. The average consumption of chicken was 3.80 which shows that respondents consume chicken on a monthly basis which was higher than the other types of meat. The average consumption of beef, pork and fish was 3.50, 3.10 and 3.11, respectively.

Table 1. Descriptive statistics of demographic variables (n=1030)

Variable	Description	Mean (S.D)
Demographics		
Age	Age in years	51.82 (15.47)
Race	1 if subject is white; 0 otherwise	0.73 (0.44)
Male	1 if subject is male; 0 otherwise	0.29 (0.45)
Income	Income 1,000 USD	73.68 (49.32)
Involvement in the Industry	1 if subject is involved in the industry; 0 otherwise	0.09 (0.28)
	Percentage (Freq.)	**Mean (S.D)**
Education		
High School or less	34.8% (359)	0.34 (0.48)
Associate college or some degree	31.3% (323)	0.31 (0.46)
Bachelor’s degree	19.5% (201)	0.18 (0.40)
Post graduate degree	14.2% (147)	0.14 (0.34)
Meat consumption habits		

	Never (Freq.)	**Few times per year (Freq.)**	**Monthly (Freq.)**	**Weekly (Freq.)**	**Daily (Freq.)**	**Mean (S.D)**
Beef	5.72% (59)	8.83% (91)	21.07% (217)	58.47% (602)	5.96% (61)	3.50 (0.94)

	Never (Freq.)	Few times per year (Freq.)	Monthly (Freq.)	Weekly (Freq.)	Daily (Freq.)	Mean (S.D)
Chicken	4.00% (41)	2.81% (29)	11.06% (114)	72.62% (748)	9.51% (98)	3.80 (0.80)
Pork	9.32% (96)	16.80% (173)	30.67% (316)	40.48% (417)	2.71% (28)	3.10 (1.02)
Fish	9.32% (96)	17.08% (176)	29.51% (304)	41.36% (426)	3.00% (31)	3.11 (1.02)

(Values in parentheses under the percentages are number of participants.)

Table 2 presents descriptive statistics for importance of food safety, animal welfare and perception of ABR. Participants were asked questions about how important food safety and animal welfare is for them when purchasing meat. A five-point scale, 1=very unimportant to 5= very important was used to assess the importance level of these attributes for participants. Over 85% of respondents indicated that food safety was very important while 68% answered animal welfare was very important, for them. The percentage of participants who felt neutral about food safety were 5.3% and those who answered neutral about animal welfare were 18.6%. Approximately 9.9% of the respondents indicated that food safety was very unimportant and approximately 14% felt animal welfare was an unimportant factor for them while purchasing meat. The average for importance of food safety was 3.83 and the mean for importance of animal welfare was 4.40 which showed that on average participants considered both food safety and animal welfare as an important factor while purchasing meat.

Further, a question was asked about the participants' perception of ABR. Participants were told to indicate their level of agreement with the statement "ABR is one of the biggest problems the world faces." A five-point scale, 1= strongly disagree to 5=

strongly agree, was used to examine agreement levels of participants. Participants' level of agreement was 3.41 which was higher than neutral, indicating that many participants agree ABR is a big problem that the world faces.

Table 2. Descriptive statistics for importance of food safety, animal welfare and perceptions of ABR.

Variable	Very Unimportant (Freq.)	Unimportant (Freq.)	Neutral (Freq.)	Important (Freq.)	Very Important (Freq.)	Mean (S.D)
Importance of Food Safety	7.86% (81)	1.10% (11)	5.33% (55)	13.99% (144)	71.35% (735)	3.83 (1.22)
Importance of Animal Welfare	7.57% (78)	5.92% (61)	18.64% (192)	26.21% (270)	41.45% (427)	4.40 (1.16)
	Strongly Disagree (Freq.)	**Disagree** (Freq.)	**Neutral** (Freq.)	**Agree** (Freq.)	**Strongly Agree** (Freq.)	**Mean (S.D)**
Perceptions of ABR	4.30% (44)	10.60% (109)	39.32% (405)	30.48% (314)	15.33% (158)	3.41 (1.01)

Values in parentheses under the percentages are number of participants.

Table 3 provides descriptive statistics of consumers' acceptance of antibiotic use for various purposes (treat, control and prevent infection in animals and use as growth promotants) in animal production. A five-point scale 1= totally unacceptable to 5= totally acceptable was developed to examine the level of acceptance of these various practices. Participants on average indicated that use of antibiotics as growth promotants is unacceptable with mean of 2.21 (58% find it unacceptable, 28% neutral and 14% acceptable). Further results show that participants were fairly neutral with respect to the use of antibiotics to prevent infections in food animals with a mean of 3.05 (approximately 29% find it unacceptable, 35% are neutral and 36% find it acceptable).

Finally, participants indicated that antibiotic use to control and to treat infections is acceptable with mean of 3.52 and 3.77, respectively, (For control 15% find it unacceptable, 32% are neutral, and 54% find it acceptable while for treat 11% find it unacceptable, 28% are neutral, and 61% find it acceptable).

Table 3. Level of acceptance of the antibiotics use in food animals

	Totally unacceptable (Freq.)	Somewhat unacceptable (Freq.)	Neutral (Freq.)	Somewhat acceptable (Freq.)	Totally acceptable (Freq.)	Mean (S.D)
Growth promotant	38.16% (393)	19.81% (204)	27.96% (288)	10.10% (104)	3.98% (41)	2.21 (1.17)
Prevent	13.98% (144)	15.34% (158)	34.56% (356)	23.69% (244)	12.43% (128)	3.05 (1.20)
Control	6.21% (64)	8.35% (86)	31.65% (326)	34.17% (352)	19.61% (202)	3.52 (1.08)
Treat	3.70% (38)	7.09% (73)	28.06% (289)	33.40% (344)	27.77% (286)	3.77 (1.05)

Table 4 provides summary statistics for the level of participants' stated concern about the use of antibiotics for various purposes (treat, control, prevent and as growth promotants) in food animal production. A five-point scale was used to examine the level of concern with 1= not at all concerned to 5= extremely concerned. Participants on average showed concern towards the use of antibiotics as growth promotants with a mean of 3.44 (approximately 16% are not concerned, 30% are somewhat concerned and approximately 55% are very concerned). Regarding the use of antibiotics to prevent and control infections participants on average were somewhat concerned with a mean of 3.18 and 3.05, respectively (for prevent 25% are not concerned, 38.64% are neutral and 35.77% are concerned, while for control 28.57% are not concerned, 39.22% are neutral and 32.14% are concerned). However, participants on average indicated that they are slightly concerned towards the use of antibiotics to treat infection in food animals with a mean of 2.89 (34.28%

are not concerned, 38% are neutral and 27.86% are concerned). Results from Table 3 and Table 4 show that participants are more concerned towards antibiotic use as growth promotants, and slightly concerned to use antibiotics to treat infections. Moreover, they are unaccepting antibiotics to promote growth and accepting antibiotics to treat infections.

Table 4. Level of concern about use of antibiotics in food animal production.

	Not at all concerned (Freq.)	Slightly concerned (Freq.)	Somewhat concerned (Freq.)	Very concerned (Freq.)	Extremely concerned (Freq.)	Mean (S.D)
Growth promotant	5.00% (47)	10.87% (112)	30.00% (308)	23.88% (246)	30.77% (317)	3.44 (1.15)
Prevent	9.22% (95)	15.92% (162)	38.64% (398)	19.07% (203)	16.70% (172)	3.18 (1.16)
Control	11.20% (116)	17.37% (179)	39.22% (404)	18.64% (192)	13.50% (139)	3.05 (1.16)
Treat	17.00% (174)	17.28% (178)	38.00% (391)	15.63% (161)	12.23% (126)	2.89 (1.21)

Scale: 1= not all concerned to 5 = extremely concerned

Table 5 presents the descriptive statistics concerning participants' beliefs about the policies governing the use of antibiotics in food animals. Half of the participants, 50%, responded that they do not know whether the use of antibiotics to treat illness in animals is prohibited, allowed but regulated or allowed and unregulated, 36.3% answered that it is allowed and regulated, 9.8% responded that it is allowed and unregulated, while 3.8% responded that it is prohibited. Similarly, participants were asked about their beliefs regarding the use of antibiotics to prevent illness in food animals. More than half of the participants, 52.8%, reported that they do not know whether the use of antibiotics to prevent illness in animals is prohibited, allowed but regulated or allowed and unregulated, 30.0% believed that it is allowed and regulated, 11.3% believed that it is allowed and unregulated, while, 6.0% believed that it is prohibited. Moreover, participants were further asked about the current use of antibiotics as growth promotants.

More than half of participants, 55.0%, answered they do not know, 20.0% believed it is allowed and regulated, 13.2% reported using antibiotics as growth promotants is allowed and unregulated, and 11.4% answered that it is prohibited.

Participants were further asked to answer questions regarding the percentage of food animals given antibiotics for any purpose, to treat an illness, to prevent infections or to promote growth. As shown in Table 6, a significant number of participants answered that they did not know what percentage of food animals were treated with antibiotics for any purpose (42.2%), to treat an illness (43.8%), to prevent infections (46.7%) or to promote growth (50.8%).

Table 5. Participants' beliefs about policies governing the use of antibiotics in food animals

	Prohibited (Freq.)	Allowed and Regulated (Freq.)	Allowed and unregulated (Freq.)	I do not know (Freq.)
The use of antibiotics to treat illness in food animals	3.78% (39)	36.31% (374)	9.80% (101)	50.00% (516)
The use of antibiotics to prevent illness in food animals	6.00% (62)	30.00% (309)	11.26% (116)	52.78% (543)
The use of antibiotics as growth promotants in food animals	11.45% (118)	20.00% (204)	13.20% (136)	55.00% (516)

Values in parentheses under the percentages are number of participants.

Table 6. Participants' beliefs about antibiotic used in food animals

	More than 80% (Freq.)	61-80% (Freq.)	41-60% (Freq.)	21-40% (Freq.)	Less than 21% but greater than zero (Freq.)	Zero (Freq.)	I do not know (Freq.)
Percentage of food animals that are given antibiotics	13.50% (139)	16.40% (169)	14.66% (151)	7.52% (78)	5.14% (53)	0.19% (2)	42.2% (438)
Percentage of food animals that are given antibiotics to treat an illness	11.84% (122)	10.38% (107)	13.30% (137)	11.74% (121)	8.34% (86)	0.48% (5)	43.8% (452)
Percentage of food animals that are given antibiotics to prevent infection	12.62% (130)	10.58% (109)	12.52% (129)	8.35% (86)	7.37% (76)	1.84% (19)	46.7% (481)
	More than 80% (Freq.)	**61-80%** (Freq.)	**41-60%** (Freq.)	**21-40%** (Freq.)	**Less than 21% but greater than zero** (Freq.)	**Zero** (Freq.)	**I do not know**
Percentage of food animals that are given antibiotics to promote growth	12.13% (125)	10.67% (110)	8.44% (87)	7.44% (77)	6.50% (67)	3.88% (40)	50.86% (524)

Values in parentheses under the percentages are number of participants.

3.4 Scale conversion for importance of food safety, importance of animal welfare and meat consumption habits variables

The scales for the variables importance of food safety and animal welfare were converted from a five-point to a three-point scale due to a low number of responses in the extreme two categories “very unimportant”, “unimportant” (see table 2). The categories very unimportant and unimportant were combined together and renamed not important. The neither unimportant nor important category was kept as it is and renamed neutral while the important and very important categories were combined together and renamed important.

For the regression analysis, the scale for meat consumption habits of participants was also converted from a five-point scale to a three-point scale due to lack of data in the categories never, few times per year and daily. The categories “never and few times a year were grouped together and renamed less than monthly. The categories weekly and daily were grouped together and named weekly or more while the category monthly was kept the same.

3.5 Using scores and Factor Analysis to analyze subjective and objective knowledge questions

In the survey, multiple questions were asked related to participants’ subjective and objective knowledge of antibiotic use and ABR. Two approaches were used to analyze the subjective and objective knowledge questions: scoring and factor analysis. The factor loadings for subjective and objective knowledge questions and regression results using factor analysis scores are presented in Appendix B. For the remainder of the thesis, the scoring approach will be used.

Respondents were asked to rate their subjective knowledge on a scale of knowing 0= Nothing at all to 3= A great deal, while objective knowledge questions were examined through 1= True, 2= False and 3= I do not know. There was a single question regarding participants' subjective knowledge of antibiotics, while five questions were asked regarding their subjective knowledge of ABR. The subjective and objective knowledge questions of antibiotics and ABR are presented in tables 7 and 8, respectively. The descriptive statistics results show that participants answered that they have little knowledge of the use of antibiotics in livestock production, with a mean of 0.95 (36.40% reported knowing nothing at all, 37.86% knowing a little, 19.61% having moderate knowledge and 6.11% reported knowing a great deal). Further results regarding subjective knowledge of ABR show that participants have little knowledge of ABR in humans with a mean of 1.33 (21.84% reported knowing nothing at all, 34.70% having a little knowledge, 31.16% moderate knowledge and 12.2% knowing a great deal). Similarly, participants average for knowledge of drug resistance was low with a mean of 1.16 (29.61% reported knowing nothing at all, 34.61% having a little knowledge, 26.21% having moderate knowledge and 9.8% knowing a great deal). The results further demonstrate that half of the participants reported knowing nothing about ABR in animals. The average was very low with a mean of 0.75 (50.58% reported knowing nothing at all, 28.00% having a little knowledge, 16.60% having moderate knowledge and 4.85% knowing a great deal). Further, results indicate that average knowledge of ABR bacteria was low among participants with a mean of 1.16 (29.61% reported knowing nothing at all, 33.49% having a little knowledge, 27.37% having moderate knowledge and 9.51% knowing a great deal). Finally, the average subjective knowledge of participants regarding super bugs was very low with a mean of 0.99 (37.66% report knowing nothing at all, 32.42% having a little knowledge, 22.62% having moderate knowledge and 7.28% knowing a great deal).

Table 7. Subjective knowledge questions of antibiotics and ABR

	Nothing at all (Freq.)	A little Knowledge (Freq.)	Moderate (Freq.)	A great deal (Freq.)	Mean (S.D)
Subjective knowledge of antibiotics					
Use of antibiotics in livestock production	36.40% (375)	37.86% (390)	19.61% (202)	6.11% (63)	0.95 (0.89)
Subjective knowledge of ABR					
ABR in humans	21.84% (225)	34.70% (358)	31.16% (321)	12.20% (126)	1.33 (0.95)
Drug resistance	29.61% (305)	34.36% (354)	26.21% (270)	9.80% (101)	1.16 (0.96)
ABR in animals	50.58% (521)	28.00% (288)	16.60% (171)	4.85% (50)	0.75 (0.89)
ABR bacteria	29.61% (305)	33.49% (345)	27.37% (282)	9.51% (98)	1.16 (0.96)
Superbugs	37.66% (388)	32.42% (334)	22.62% (233)	7.28% (75)	0.99 (0.94)

Results from the objective knowledge questions of antibiotics and ABR show that approximately 75% of the participants correctly answered that antibiotics are common drugs useful in treating bacterial infections in humans, 40.77% answered correctly that antibiotics are not used for viral infections in humans, 53.49% correctly answered it is false that antibiotics can be used to treat any kind of pain and inflammation. All Participants correctly answered that antibiotics can be used to treat bacterial infections in food animals, while 45.14% of the participants answered ‘I do not know’ for antibiotic use to treat viral infections in animals. The low self-reported knowledge of ABR was further confirmed by follow up-testing questions regarding ABR. Only two questions were answered correctly by most of the participants. Almost 69% of the participants answered correctly that ABR occurs when bacteria become resistant to antibiotics and antibiotics no longer work as well. Similarly, 70.38% of the participants answered correctly that overuse and misuse of antibiotics accelerates ABR. In contrast, most of the participants answered I do not know for the remaining questions in table 8, showing that participants have low knowledge of ABR.

Table 8. Objective knowledge questions of antibiotics and ABR

	Correct answer	True (Freq.)	False (Freq.)	I do not know (Freq.)	Mean (S.D)
Objective Knowledge of antibiotics					
Antibiotics are common drugs useful in treating bacterial infection	true	74.75% (770)	6.99% (72)	18.25% (188)	1.43 (0.78)
Antibiotic are common drugs used to treat viral infections in humans	false	37.66% (388)	40.77% (420)	21.55% (222)	1.83 (0.75)
Antibiotics are common drugs useful in treating any kind of pain or inflammation.	false	21.26% (219)	53.49% (551)	25.24% (260)	2.03 (0.68)
Antibiotics are common drugs useful in treating bacterial infections in food animals.	true	48.83% (503)	7.18% (74)	43.98% (453)	1.95 (0.96)
Antibiotics are common drugs useful in treating viral infections in food animals	false	24.07% (248)	30.77% (317)	45.14% (465)	2.21 (0.80)
Objective Knowledge of ABR					
Antibiotic resistance occurs when bacteria become resistant to antibiotics and antibiotics no longer work as well	true	68.93% (710)	6.69% (69)	24.36% (251)	1.55 (0.80)
Overuse and misuse of antibiotics accelerates antibiotic resistance	true	70.38% (725)	5.92% (61)	23.68% (244)	1.53 (0.85)

	Correct answer	True (Freq.)	False (Freq.)	I do not know (Freq.)	Mean (S.D)
The overuse and misuse of antibiotics in animals does not cause antibiotic resistance in humans because the antibiotics that are used to treat animals are different than those used to treat humans	false	14.36% (148)	29.22% (301)	56.40% (581)	2.24 (0.72)
Antibiotic resistance existed before human development of antibiotics.	true	19.32% (199)	22.62% (233)	58.05% (598)	2.38 (0.79)
Not all forms of antibiotic resistance impact human health	false	31.84% (328)	16.60% (171)	51.55% (531)	2.19 (0.89)

Subjective knowledge of ABR was analyzed using scores after the data collection. The index was created to examine the level of subjective knowledge each respondent has regarding ABR and was constructed as follows. A score of 0 was given for ‘know nothing at all’ answers, a score of 1 for ‘know a little’ answers, a score of 2 for answers stating moderate levels of knowledge and a score of 3 for ‘know a great deal’ answers. After scoring, the average score of each participant was calculated based on five questions regarding participants’ subjective knowledge of ABR. Finally, the average score of each participant was used in regression analysis.

The objective knowledge questions regarding antibiotic use and ABR were examined using the scale 1=True, 0=False/I do not know. Five questions were asked to assess objective knowledge of antibiotics and six questions were asked to assess objective knowledge of ABR. Since the intent of these questions was to capture objective knowledge, to limit guessing participants were told that not everyone knows about these issues and they should feel free to choose “I do not know” if they were uncertain. After the data collection, each statement of antibiotic use and ABR was scored. If the respondent answered the statement correctly (true or false) the statement was scored with 1 and if they answered incorrectly or I do not know the statement was scored with a 0. Finally, an average score for each participant was calculated based on the five questions regarding the participants' objective knowledge of antibiotics and an average score was calculated based on the six objective knowledge questions regarding ABR. These average scores for objective knowledge of antibiotics and ABR were used in the regression analysis.

Table 9 provides the descriptive statistics for the subjective and objective knowledge of participants analyzed after scoring. The average for subjective knowledge of antibiotics is 0.95 and the average for subjective knowledge of ABR is 1.08. The average for objective knowledge of antibiotics and ABR is 0.49 and 0.39, respectively, showing that only 49% of the objective knowledge of antibiotics questions were answered correctly and only 39% of the objective knowledge of ABR questions were correctly answered. Which show that there is little knowledge of antibiotics use and ABR among participants.

Table 9. Descriptive statistics for subjective and objective knowledge after scoring

Variable	Mean (S.D)
Subjective Knowledge	
Knowledge of antibiotics	0.95 (0.89)
Knowledge of ABR	1.08 (0.80)
Objective Knowledge	

Variable	**Mean (S.D)**
Knowledge of antibiotics	0.49 (0.32)
Knowledge of ABR	0.39 (0.25)

4 Model specification

4.1 Probit Model

Based on the descriptive statistics, there is a difference in participants' level of acceptance for the use of antibiotics to treat, prevent, and control infections and as a growth promotant in food animal production. We found that a larger share of participants were neutral in regard to use of antibiotics to prevent and control infections compared to those that found them either acceptable or unacceptable, the majority of participants found their use as growth promotants unacceptable, while the majority of participants found their use to treat infection in food animals acceptable. Four ordered probit models were analyzed to determine the impact of subjective and objective knowledge, importance of animal welfare and food safety, concerns about AMR, and demographic characteristics on the acceptance of antibiotics for treatment of infections, prevention of infections, control of infections, and as growth promotants.

The specification of the ordered Probit model follows Cameron and Trivedi (2010) and Wooldridge (2010), who defined y_i as individual $i's$ response for integer values $1,2,3, \dots .J$. The ordered probit model for y given x is modeled from an unobserved latent variable y^*. The vector x_i is assumed to be relevant individual characteristics. For individual $i,$ the latent variable is specified such that:

$$y_i^* = x_i'\beta + u_i, \qquad i = 1, 2, \dots, , n \qquad (4.1)$$

$$u_i \sim N(0,1)$$

Where β is a $k \times 1$ column vector. Assuming unknown threshold values of $\alpha_1 < \alpha_2 < \cdots \alpha_{J-1}$ the relationship between the latent variable $y_i{}^*$ and the observed variable y_i, can be defined as:

$y_i = 1 \quad if - \infty < y_i^* \leq \alpha_1$

$y_i = 2 \quad if\ \alpha_1 < y_i^* \leq \alpha_2$ (4.2)

$y_i = 3 \quad if\ \alpha_3 < y_i^* \leq \alpha_3$

$\vdots$

$y_i = J \quad if\ \alpha_{j-1} < y_i^* \leq \infty$

The threshold values are assumed to be unknown because the actual index that changes an individual from one threshold to another is not known and is different for each individual. Since u_i is distributed standard normal, the conditional distribution of y given x is derived from probabilities as:

$$P(\alpha_{J-1} = J) = P(\alpha_{J-1} < y_i^* \leq \alpha_J$$

$$= P(\alpha_{J-1} < x_i'\beta + u_i \leq \alpha_J)$$

$$= P\left(\alpha_{J-1} < x_i'\beta + u_i \leq \alpha_J - x_i'\beta\right) \qquad (4.3)$$

$$\vdots$$

$$= F\left(\alpha_J - x_i'\beta\right) - F(\alpha_{J-1} - x_i'\beta)$$

Where *F* is the standard normal cumulative distribution function (CDF) of u_i.

The sign of the parameters β in the ordered probit regression gives an indication of the direction of the latent variable y_i^*, and whether it increases or decreases with a regressor. The value of the coefficient in the ordered probit model does not truly tell us the change in probability of choosing an alternative when the independent variable changes, therefore we estimate the marginal outcome in the ordered probit model to examine the change in the latent variable. The marginal effects indicate the change in probability of choosing an alternative when the predictor variable changes by one unit. The marginal effect of the probability that option j is chosen when a predictor variable (continuous predictor) x_r changes is expressed as:

$$\frac{\partial \Pr[y_i = j]}{\partial X_i} = \{F'(\alpha_{j-1} - X'\beta) - F'(\alpha_j - X'\beta)\}\beta, \qquad 0<j<J \qquad (4.4)$$

The marginal effects for all regressions are reported and are evaluated at the mean of the predictor variables for the last response category using the margins argument in Stata 13. We report results for the last response category, totally acceptable, which is level 5 on the five-point scale used in the analysis.

Given the general description of the ordered probit model above, the variables used in this study include the level of acceptance for each use of antibiotic as a dependent variable and the independent variables that affect the level of acceptance are demographics, subjective and objective knowledge of antibiotics and ABR, perceptions of ABR, meat consumption habits, involvement in the industry or human/animal health sector, importance of food safety and importance of animal welfare.

5 Results

Table 10 shows coefficients for the ordered probit regression. Unlike the coefficients of the OLS model, the coefficients of the ordered probit model do not give the change in the dependent variable with the change in the independent variable, but rather the direction of change in the latent variable. To find the probability change in the dependent variable marginal effects are estimated. Marginal effects show the change in probability when the predictor or independent variable increases by one unit. For example, with each additional year of age the probability of total acceptance of antibiotics is more (or less) likely. For continuous variables this represents the instantaneous change given that the 'unit' may be very small. For binary variables, the change is from 0 to 1, for example, if a category is coded as male "0" and female "1" we can interpret the marginal effect as the probability that total acceptance towards antibiotics being more (or less) likely in males as compared to females (Wooldridge 2015). While, the sign of the marginal effect shows the direction of change, the sign of the marginal effect in the lowest category is the opposite of the sign of the marginal effect in the highest category. For instance, in our study marginal effect values with the negative sign show that people are less likely to totally accept antibiotics and a positive sign implies participants are more likely to totally accept antibiotics. Furthermore, in the highest category "totally accept" (level 5) people are less likely to accept antibiotics to promote growth in food animals, but in the first category "totally unacceptable" (level 1) participants are more likely to not accept antibiotics as growth promotants.

Table 11 reports the marginal effects at level 5 (totally acceptable) that are used to analyze the level of acceptance of the use of antibiotics to treat, prevent, control and promote growth. The marginal effects for levels 1, 2, 3, and 4 are presented in Appendix C.

Table 10. Ordered probit results: Coefficients for accepting antibiotics as growth promotants, prevent, control, and treat infection

Variables	Growth promotant	Prevent	Control	Treat
Subjective knowledge of antibiotics	0.08 (0.06)	0.09 (0.06)	-0.07 (0.06)	-0.05 (0.06)
Subjective knowledge of ABR	0.06 (0.06)	-0.09 (0.06)	0.15** (0.06)	0.10 (0.07)
Objective knowledge of antibiotics	-1.09*** (0.13)	-0.80*** (1.12)	-0.07 (0.13)	0.55*** (0.13)
Objective knowledge of ABR	-0.17 (0.18)	-0.61 (0.17)	0.15 (0.17)	0.19 (0.17)
Perceptions of ABR *(*Strongly disagree*)*				
Somewhat disagree	-0.00 (0.20)	0.00 (0.19)	-0.20 (0.19)	-0.01 (0.19)
Neutral	-0.03 (0.17)	-0.29 (0.17)	-0.44** (0.17)	-0.20 (0.17)
Somewhat agree	-0.05 (0.17)	-0.25 (0.17)	-0.38** (0.17)	-0.05 (0.17)
Strongly agree	-0.17 (0.19)	-0.31* (0.18)	-0.40** (0.19)	0.04 (0.19)
Beef Consumption (Less than monthly)				
Monthly	-0.05 (0.13)	0.07 (0.13)	0.30 (0.12)	-0.01 (0.13)
Weekly or more	0.22* (0.13)	0.21* (0.12)	0.93 (0.12)	0.62 (0.13)
Chicken Consumption (Less than monthly)				
Monthly	0.51** (0.19)	0.64** (0.18)	0.33* (0.18)	0.30* (0.10)
Weekly or more	0.26* (0.18)	0.47** (0.16)	0.27* (0.16)	0.30* (0.16)
Pork consumption (Less than monthly)				

	Growth promotant	Prevent	Control	Treat
Monthly	0.05 (0.10)	0.08 (0.10)	-0.00 (0.09)	0.03 (0.10)
Weekly or more	0.15 (0.10)	0.08 (0.10)	0.97 (0.10)	0.04 (0.10)
Fish consumption (Less than monthly)				
Monthly	-0.04 (0.10)	-0.00 (0.09)	0.04 (0.09)	0.07 (0.09)
Weekly or more	-0.03 (0.09)	0.12 (0.09)	0.12 (0.09)	0.04 (0.09)
Importance of food safety (Not important)				
Neutral	0.31 (0.21)	-0.06 (0.20)	-0.06 (0.20)	0.10 (0.20)
Important	0.35** (0.15)	0.23 (0.15)	0.24 (0.15)	0.39** (0.15)
Importance of animal welfare (Not Important)				
Neutral	-0.10 (-0.13)	-0.03 (0.13)	-0.08 (0.13)	-0.11 (0.13)
Important	0.30** (0.14)	-0.04 (0.13)	-0.04 (0.13)	-0.06 (0.14)
Age	-0.00 (0.00)	-0.01*** (0.00)	0.00 (0.00)	-0.00 (0.00)
Male	0.33*** (0.08)	0.27** (0.08)	0.18** (0.08)	-0.02 (0.08)
Race	-0.16* (0.08)	-0.10 (0.08)	0.01 (0.08)	0.20** (0.08)
Income	-0.01 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Involvement	0.20 (0.12)	-0.01 (0.12)	0.06 (0.12)	- 0.02 (0.01)
Education (High school or less)				
Associates degree or less	-0.02 (0.08)	0.02 (0.08)	0.01 (0.08)	-0.06 (0.08)
Bachelors	0.04 (0.10)	0.01 (0.10)	-0.02 (0.10	0.14 (0.10)
Post graduate	-0.09 (0.12)	-0.08 (0.12)	0.07 (0.12)	0.17 (0.12)

* ** *** *represent significance level at p=0.10, p= 0.05, and p=0.01, respectively*.
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable

Table 11. Marginal effects of ordered probit regressions for level 5 (totally acceptable)

Variables	Growth promotant	Prevent	Control	Treat
Subjective knowledge of antibiotics	0.00 (0.00)	0.01 (0.01)	-0.02 (0.01)	-0.02 (0.02)
Subjective knowledge of ABR	0.00 (0.00)	-0.02 (0.01)	0.04** (0.01)	0.03 (0.02)
Objective knowledge of antibiotics	-0.06*** (0.01)	-0.14*** (0.02)	-0.02 (0.03)	0.18*** (0.04)
Objective knowledge of ABR	-0.01 (0.01)	0.01 (0.03)	0.04 (0.05)	0.06 (0.06)
Perceptions of ABR (Strongly disagree)				
Somewhat disagree	0.00 (0.01)	0.00 (0.04)	-0.67 (0.07)	-0.00 (0.07)
Neutral	-0.00 (0.01)	-0.06 (0.04)	-0.13** (0.05)	-0.06 (0.05)
Somewhat agree	-0.00 (0.01)	-0.05 (0.04)	-0.12** (0.06)	-0.01 (0.06)
Strongly agree	-0.00 (0.01)	-0.06* (0.04)	-0.12** (0.06)	0.01 (0.06)
Beef Consumption (Less than monthly)				
Monthly	-0.00 (0.00)	0.01 (0.02)	0.10 (0.03)	-0.00 (0.04)
Weekly or more	0.01* (0.00)	0.04* (0.02)	0.02 (0.03)	0.03 (0.03)
Chicken Consumption (Less than monthly)				
Monthly	0.03** (0.01)	0.10*** (0.02)	0.08* (0.04)	0.09* 0.05
Weekly or more	0.01* (0.00)	0.07*** (0.01)	0.06* (0.03)	0.09* (0.04)
Pork consumption (Less than monthly)				
Monthly	0.00 (0.00)	0.01 (0.01)	-0.00 (0.02)	0.01 (0.03)
Weekly or more	0.01 (0.01)	0.01 (0.02)	0.03 (0.03)	0.01 (0.03)
Fish consumption (Less than monthly)				

	Growth promotant	Prevent	Control	Treat
Monthly	-0.00 (0.00)	-0.00 (0.01)	0.01 (0.02)	0.02 (0.03)
Weekly or more	-0.00 (0.00)	0.02 (0.02)	0.03 (0.02)	0.01 (0.03)
Importance of food safety (Not important)				
Neutral	0.01 (0.01)	-0.00 (0.02)	-0.01 (0.03)	0.02 (0.05)
Important	0.02** (0.00)	0.03 (0.02)	0.01 (0.03)	0.11** (0.04)
Importance of animal welfare (Not Important)				
Neutral	-0.00 (0.01)	-0.00 (0.02)	-0.02 (0.03)	-0.03) (0.04)
Important	0.02* (0.01)	-0.00 (0.02)	-0.01 (0.03)	-0.02 (0.04)
Age	-0.00 (0.00)	-0.00*** (0.00)	0.00 (0.00)	-0.00 (0.00)
Male	0.02*** (0.00)	0.05** (0.01)	0.05** (0.02)	-0.01 (0.02)
Race	-0.01* (0.00)	-0.02 (0.01)	0.00 (0.02)	0.07** (0.03)
Income	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Involvement	0.01 (0.01)	0.00 (0.02)	0.02 (0.03)	-0.00 (0.04)
Education (High school or less)				
Associates degree or less	-0.00 (0.00)	0.00 (0.01)	0.00 (0.03)	-0.02 (0.03)
Bachelors	0.00 (0.01)	0.00 (0.02)	-0.00 (0.02)	0.04 (0.03)
Post graduate	-0.00 (0.01)	-0.01 (0.02)	0.02 (0.03)	0.06 (0.04)

* ** *** *represent significance level at p=0.10, p= 0.05, and p=0.01, respectively.*
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable

5.1 Subjective knowledge of antibiotics and ABR

Based on our results, subjective knowledge of antibiotics does not significantly impact survey participants' level of total acceptance of the use of antibiotics in any of the food animal production practices. The significant variable subjective knowledge of ABR shows that with an increase in each unit of subjective knowledge of ABR, participants are 4 percentage points more likely to totally accept antibiotics to control infections in food animals.

5.2 Objective knowledge of antibiotics and ABR

The regression results demonstrate that there is no significant link between objective knowledge of ABR and the level of total acceptance (category 5) of the use of antibiotics in any of the food animal production practices. A participants' objective knowledge of antibiotics, on the other hand, significantly impacted a participants' level of total acceptance (category 5) of the use of antibiotics as growth promotants, to prevent illness and to treat illness. For each unit increase in a participants' objective knowledge of antibiotics, the participant is 6 percentage points less likely to totally accept antibiotics to promote growth and 14 percentage points less likely to totally accept antibiotics to prevent infections in food animals. However, participants are 18 percentage points more likely to totally accept antibiotics to treat food animals as the participants' objective knowledge of antibiotics increases.

5.3 Perceptions of ABR

In the survey, participants were asked to state their level of agreement with the statement that ABR is the biggest threat to the world. Participants who showed neutral behavior to this statement were 13 percentage points less likely to totally accept antibiotics to control infection in food animals than those participants who strongly disagreed with the statement. Participants who answered somewhat agree or strongly agree with the statement were 12 percentage points less likely to totally accept antibiotics to control animal infections. Participants who strongly agreed with the statement were also 6 percentage points less likely to totally accept antibiotics to prevent infections respectively, in food animals than those who strongly disagreed with the statement.

5.4 Meat Consumption habits

The results from the ordered probit model show that beef and chicken consumption have a significant link with the level of acceptance of antibiotic use in various food animal production practices, while pork and fish consumption have no significant effect on the level of acceptance of antibiotic use in food animal production. Participants who consume beef on a weekly basis or more are 1 percentage points and 4 percentage points, more likely to totally accept antibiotics to promote growth and to prevent infection, respectively, in food animals than those participants who consume beef on less than a monthly basis. Similarly, participants who consume chicken on a monthly basis are 3 percentage points, 10 percentage points, 8 percentage points and 9 percentage points more likely to accept antibiotics as growth promotants, to prevent, control and treat infections in food animals, respectively, than those participants who consume chicken on less than a monthly basis. Likewise, we found a statistically significant relationship between the category “weekly or more” and the total acceptance of antibiotics in food animal production practices. Participants consuming chicken on a weekly basis or more were 1 percentage points, 7 percentage points, 6 percentage points and 9 percentage points more likely to accept antibiotics to promote growth, to prevent, to control and to treat infections, respectively, in food animals as compared to those participants who consume chicken on less than monthly basis.

5.5 Importance of food safety and animal welfare

The significance of the variable ‘importance of food safety’ shows that participants who considered food safety as an important factor while purchasing meat were 2 percentage points and 11 percentage points more likely to totally accept antibiotics as growth promotants and to treat infections in food animals than those participants for whom food safety was not important. There was no difference between those that were neutral or that stated that food safety was important compared to not important for the level of acceptance of antibiotic use to prevent or control illness.

We found that the variable importance of animal welfare was significant at 10% level for growth promotants. It shows that participant who consider animal welfare as an important factor while purchasing meat were 1 percentage point more likely to totally accept antibiotics to promote growth in food animals than those who reported animal welfare as not important. However, we didn’t find any significance for animal welfare in the other three regression models (prevent, control and treat infection).

5.6 Demographics

The statistical significance of the age variable shows that with increase in participants’ age participants were 0 percentage points less likely to accept antibiotics to prevent animal infections. While, the significance of the male variable shows that male respondents were more likely to totally accept antibiotics to promote growth, to prevent, and control animal infections, by 2 percentage points, 5 percentage points and 5 percentage points, respectively, than female respondents. Results further showed that white people were 7 percentage points more likely to totally accept antibiotics to treat animals and 1 percentage points less likely to totally accept antibiotics to promote growth in food animals than non-white people. Our results did not reveal any significant relationship between income, education and involvement in the industry and total acceptance of antibiotics in any of the four regression models.

6 Conclusions

This study examined the impact of consumer perceptions of antibiotics and subjective and objective knowledge of antibiotics and ABR on the level of acceptance of antibiotic use in the livestock and poultry industry. Moreover, demographics, involvement in the industry, meat consumption habits, and perceptions of ABR were analyzed as to their impact on survey participants' level of acceptance of antibiotic use in food animals to treat, prevent, and control infections or as growth promotants. Study objectives were achieved with a survey instrument. A random, representative sample of 1,030 U.S. consumers was targeted and the survey firm IRI fielded the survey and collected the data.

Descriptive statistics revealed that participants' level of acceptance of the use of antibiotics to treat infections in food animals is higher than their level of acceptance of the use of antibiotics to promote growth in food animals. Moreover, participants were more concerned about the use of antibiotics as growth promotants than the use of antibiotics to treat infections in food animals. Further, results indicated that approximately half of the participants had no knowledge of the current regulations for antibiotic use in food animals or the percentage of antibiotics used in food animals.

Ordered probit regression models were used to determine factors that impact participants' level of acceptance of the use of antibiotics in food animal production practices. Using the Stata software, four regression models were used varying the dependent variable. The models analyzed the acceptance of the use of antibiotics as growth promotants, to prevent infections in food animals, to control infections in food animals, and to treat infections in food animals.

The results show that participants' subjective and objective knowledge of antibiotics and ABR impact consumers' level of total acceptance of antibiotics differently for each production practice. Our empirical results presented in this study suggest that participants with greater subjective (self-assessed) knowledge of ABR were more likely to accept antibiotics to control infection in food animals. Moreover, results show that with increases in objective knowledge of antibiotics, participants were less likely to totally accept antibiotics to promote growth and to prevent infection in food animals but more likely to totally accept antibiotics to treat infections. Participants who agreed with the statement that ABR is one of the biggest threats the world faces indicated less acceptance of the use of antibiotics to prevent and to control infections, compared to those who disagreed with the statement. Moreover, the descriptive statistics table for the level of concern towards the use of antibiotics show that participants were concerned about the use of antibiotics as growth promotants, to prevent and to control infection in animals and slightly concerned about their use to treat infection in food animals.

Our results did not show any similarity to results from Goddard et al. (2017) which reveal that there is a link between concerns about food animal treatment and respondent's belief that antibiotics should not be given for growth promotant. Participants who considered food safety and animal welfare an important factor while purchasing meat were more likely to totally accept antibiotic to promote growth as compared to those participants who answered unimportant. Our results show that age, race, and gender impact participants' level of acceptance of the use of antibiotics in food animals. As participants' increase in age they are less likely to totally accept antibiotics to prevent infection in food animals, while white people are more likely to totally accept antibiotics to treat infection and less likely to accept antibiotics to promote growth in food animals. Male participants were found to more likely totally accept antibiotics to control and prevent infections in food animals and more likely to accept antibiotic use as growth promotants in food animals compared to females. In our research, we did not find any significant relationship between subjective knowledge of antibiotics, objective knowledge of ABR, education, or involvement in the industry with participants' level of acceptance of the use of antibiotics in food animal production practices. Further results also show that there is a low level of understanding among the public in regard to the use of antibiotics to control and prevent infections in food animals.

Our study contributes to the increasing strand of literature that highlights consumer preferences and concerns about meat production. Our results suggest that educating the public about the use of antibiotics in food animals and dissemination of ABR between animals and human could be beneficial. Further analysis will be necessary for the livestock and poultry industry to find out how much consumers are willing to pay for meat that is produced without the use of antibiotics. It will be useful also to examine the impact of information on consumers' willingness to accept antibiotics for production purposes. Meat labelling plays a vital role in providing information to consumers; it would be beneficial to explore how information related to antibiotics use can be provided through meat labels, and how consumers would perceive such labels on meat. Moreover, it would be interesting to investigate whether providing information influences consumers' purchasing behavior for meat and their attitude towards antibiotics use in livestock and poultry industry. These questions could be the focus of future research.

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APPENDIX A

We appreciate your participation in this survey. The survey is being conducted by researchers at a Public University to understand consumer views towards animal production methods and meat consumption preferences. Your response is extremely valuable for our study.

Section 1: Background Questions

First, we would like you to tell about yourself

1. What is your gender?

- Male
- Female
- Other

2. What is your age?

- 19-25yrs
- 26-34yrs
- 35-54yrs
- 55-64yrs
- 65+

3. What is your household annual income?

- Under $10,000
- $10,000 to $24,999

- $25,000 to $39,999
- $40,000 to $54,999
- $55,000 to $69,999
- $70,000 to $84,999
- $85,000 to $99,999
- $100,000 to $149,999
- $150,000 and above
- Prefer not to say

4. Which of the following categories best describe you? [Select all that apply]

- White
- Hispanic, Latino or Spanish origin
- Black or African American
- American Indian or Alaska native
- Middle Eastern or North African
- Asian
- Native Hawaiian or other Pacific Islander
- Other

5. What is your education level?

- Less than high school
- High school diploma or equivalent
- Some college, no degree
- Associate degree
- Bachelor's degree
- Master's degree
- Doctorate or professional degree

6. How many people live with you?

- 0
- 1
- 2
- 3
- 4
- 5
- 6 or more

7. How many children (ages 0-18) live with you?

- 0
- 1
- 2
- 3
- 4
- 5
- 6 or more

8. Which of the following best describes you? [Select all that apply]

- I am employed by/involved in the livestock or poultry sector.
- Someone in my family is employed by/involved in the livestock or poultry sector.
- I am employed by/involved in the human health sector.
- Someone in my family is employed by/involved in the human health sector.
- I am employed by/involved in the animal health sector.
- Someone in my family is employed by/involved in the animal health sector.
- None of the above.

Section 2 Animal Food production questions

Now we would like to ask you a few questions regarding your meat consumption habits and views about food animal production practices.

9. How often do you consume the following types of meat?

Never	A few times per year	Monthly	Weekly	Daily
1	2	3	4	5

9.1. Beef
9.2. Chicken
9.3. Pork
9.4. Fish

10. How important are the following factors to you when you purchase meat?

	Very unimportant	Somewhat unimportant	Neither unimportant nor important	Somewhat important	Very important
Use of organic production practices					

Animal welfare (well-being of farm animals used in food production)					
Animals raised without the use of antibiotics					
Nutritional value of the meat					
Food safety					
Animals raised without the use of growth hormones					

Section 4: Subjective and Objective Knowledge Questions

Now we are going to ask you questions related to your knowledge of animal production practices and antibiotic use. Not everyone knows about these issues so feel free to choose "I do not know" if you are uncertain.

11. How much do you know about the following?

Nothing at all	A little	A moderate amount	A great deal
1	2	3	4

11.1. Use of growth hormones in livestock production.
11.2. Use of vaccines in livestock production.
11.3. Use of antibiotics in livestock production.
11.4. Antibiotic resistance in humans.
11.5. Drug resistance.
11.6. Antibiotic resistance in animals.
11.7. Antibiotic-resistant bacteria.
11.8. Superbugs.

12. The following statements refer to antibiotics, antibiotic use and antibiotic resistance. Please choose whether each statement is True, Not True, or that you do not know. Not everyone knows about these issues so feel free to choose "I do not know" if you are uncertain.

True	Not True	I do not know
1	2	3

12.1. Antibiotics are common drugs useful in treating bacterial infections in humans.
12.2. Antibiotics are common drugs useful in treating viral infections in humans.
12.3. Antibiotics are common drugs useful in treating any kind of pain or inflammation.
12.4. Antibiotics are common drugs useful in treating bacterial infections in food animals.
12.5. Antibiotics are common drugs useful in treating viral infections in food animals.

12.6. Antibiotic resistance occurs when bacteria become resistant to antibiotics and antibiotics no longer work as well.

12.7. Overuse and misuse of antibiotics accelerates antibiotic resistance.

12.8. The overuse and misuse of antibiotics in animals does not cause antibiotic resistance in humans because the antibiotics that are used to treat animals are different than those used to treat humans.

12.9. Antibiotic resistance existed before human development of antibiotics.

12.10. Not all forms of antibiotic resistance impact human health.

12.11. Antibiotic resistance has been found in every environment studied, including many not impacted by food animal or human antibiotic use.

13. Please state your level of agreement or disagreement with the following statements.

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

13.1. Antibiotic resistance is one of the biggest problems the world faces.

13.2. Antibiotic resistance is an issue that could affect me or my family.

13.3. Antibiotic resistance is only a problem for people who take antibiotics regularly.

13.4. Fewer antibiotics should be given to food animals to minimize antibiotic resistance.

13.5. Use of antibiotics in food animals does not cause antibiotic resistance that could affect humans.

13.6. Fewer antibiotics should be given to humans to minimize antibiotic resistance.

APPENDIX B

Factor Analysis

The factor analysis (FA) procedure was to reduce the number of variables related to subjective knowledge of antibiotic resistance and objective knowledge of antibiotic and antibiotic resistance.

The FA model is specified as (Britwum K 2017)

$$x = \Lambda f + \eta$$

Where x is $p \times 1$ vector of observed variables, f is an $m \times 1$ vector of factors which is a random component to all original variables, η is a vector of $p \times 1$ specific factors and $p \times m$ is matrix of factor loadings. The covariance matrix of x is given as:

$$\Sigma = \Lambda\Lambda' + \Psi$$

Λ and Ψ are estimated using the covariance matrix. And achieved with the maximum likelihood procedure. In choosing the optimum number of factors, the Eigen value greater than 1rule was followed (Kaiser 1960).

Factor loadings for subjective and objective knowledge are presented in tables below.

Table 12. Factor loadings for subjective knowledge of ABR

	Factor 1
ABR in human being	0.85
Drug resistance	0.85
ABR in animals	0.70
ABR in bacteria	0.86
Superbugs	0.79

Table 13. Factor loadings for objective knowledge of antibiotics

	Factor 1	Factor 2
Antibiotics are common drugs useful in treating bacterial infections in humans.	0.99	-0.04
Antibiotics are common drugs useful in treating viral infections in humans.	0.99	-0.04
Antibiotics are common drugs useful in treating any kind of pain or inflammation.	0.99	-0.04
Antibiotics are common drugs useful in treating bacterial infections in food animals.	0.92	-0.11
Antibiotics are common drugs useful in treating viral infections in food animals	0.99	-0.02

Table 14. Factor loadings for objective knowledge of ABR

	Factor 1	Factor 2
Antibiotic resistance occurs when bacteria become resistant to antibiotics and antibiotics no longer work as well.	0.18	0.68
Overuse and misuse of antibiotics accelerates antibiotic resistance.	0.19	0.68
The overuse and misuse of antibiotics in animals does not cause antibiotic resistance	0.57	0.22
Antibiotic resistance existed before human development of antibiotics.	0.58	0.22
Not all forms of antibiotic resistance impact human health.	0.54	0.23
Antibiotic resistance has been found in every environment studied, including many not impacted by food animal or human antibiotic use.	0.59	0.24

Table 15. Ordered probit results using factor analysis

	Growth Promotant	Prevent	Control	Treat
Subjective Knowledge of antibiotics	0.03 (0.07)	0.052 (0.06)	-0.10 (0.06)	-0.07 (0.06)
Subjective Knowledge of ABR	-0.04 (0.05)	-0.14** (0.05)	0.11* (0.05)	0.11** (0.05)
F1 Objective knowledge of antibiotics	-0.16** (0.06)	-0.22*** (0.06)	-0.09 (0.06)	-0.04 (0.06)
F2 Objective knowledge of antibiotics	0.03 (0.07)	0.03 (0.06)	-0.18** (0.06)	-0.28*** (0.06)
F1 Objective knowledge of ABR	-0.34*** (0.06)	-0.20*** (0.05)	-0.04 (0.05)	0.11** (0.05)
F2 Objective knowledge of ABR	0.58*** (0.06)	0.32*** (0.06)	0.05 (0.05)	-0.15*** (0.05)
Importance of food safety (Not important)				
Neutral	0.26 (0.21)	-0.05 (0.20)	-0.08 (0.20)	0.20 (0.20)
Important	0.30* (0.15)	0.19 (0.15)	0.22 (0.15)	0.40*** (0.15)
Importance of Animal welfare (Not important)				
Neutral	-0.09 (0.13)	0.02 (0.13)	-0.07 (0.13)	-0.11 (0.13)
Important	-0.22 (0.13)	0.02 (0.12)	-0.03 (0.13)	-0.08 (0.13)
Beef (Less than monthly)				
Monthly	-0.20 (0.13)	-0.03 (0.12)	-0.00 (0.13)	0.01 (0.13)
Weekly or more	0.09 (0.13)	0.12 (0.12)	0.05 (0.12)	0.12 (0.13)
Chicken **(**Less than monthly)				
Monthly	0.55** (0.19)	0.66*** (0.18)	0.34* (0.18)	0.29 (0.18)
Weekly or more	0.33** (0.18)	0.54*** (0.17)	0.31* (0.16)	0. 29* (0.17)
Pork (Less than monthly)				

	Growth Promotant	Prevent	Control	Treat
Monthly	-0.06 (0.01)	0.08 (0.09)	0.01 (0.00)	0. 01 (0.10)
Weekly or more	0.14 (0.10)	0.07 (0.10)	0.11 (0.10)	0. 02 (0.10)
Fish (Less than monthly)				
Monthly	-0.11 (0.09)	-0.06 (0.09)	0.02 (0.09)	0. 07 (0.09)
Weekly or more	-0.01 (0.09)	0.08 (0.09)	0.08 (0.09)	0. 00 (0.09)
Perceptions of antibiotics				
Somewhat disagree	-0.02 (0.19)	-0.02 (0.19)	-0.23 (0.19)	-0.03 (0.19)
Neutral	-0.03 (0.20)	-0.27 (0.17)	-0.41** (0.17)	-0.15 (0.17)
Somewhat agree	-0.11 (0.17)	-0.29* (0.17)	-0.40** (0.18)	-0.03 (0.17)
Strongly agree	-0.19 (0.19)	-0.40** (0.18)	-0.43** (0.19)	0.07 (0.19)
Education (High school or less)				
Associate or some college	0.02 (0.08)	0.03 (0.08)	0.00 (0.08)	-0.06 (0.08)
Bachelors	0.11 (0.10)	0.01 (0.10)	-0.02 0.10	0.12 (0.10)
Postgraduate	-0.17 (0.12)	-0.15 (0.11)	0.06 (0.12)	0.23* (0.12)
Age	-0.00 (0.00)	-0.01** (0.00)	0.00 (0.00)	-0.00 (0.00)
Male	0.32*** (0.08)	0.28*** (0.07)	0.18** (0.07)	-0.03 (0.07)
Race	-0.16** (0.08)	-0.10 (0.08)	0.01 (0.08)	0. 23*** (0.08)
Income	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Involvement	0.06 (0.12)	-0.07 (0.11)	0.03 (0.12)	0.01 (0.12)

Table 16. Marginal effects of ordered probit regression for level 5

	Growth Promotant	Prevent	Control	Treat
Subjective Knowledge of antibiotics	0.00 (0.00)	0.00 (0.01)	0.02 (0.01)	-0.02 (0.01)
Subjective Knowledge of ABR	-0.00 (0.00)	-0.03** (0.01)	0.03** (0.01)	0.03** (0.01)
F1Objective knowledge of antibiotics	-0.00** (0.00)	-0.04*** (0.01)	-0.02 (0.01)	-0.01 (0.02)
F2 Objective knowledge of antibiotics	0.00 (0.00)	0.00 (0.01)	-0.05*** (0.01)	-0.09*** (0.02)
F1 Objective knowledge of ABR	-0.02*** (0.00)	-0.04*** (0.01)	-0.01 (0.01)	0.04** (0.01)
F2 Objective knowledge of ABR	0.03*** (0.00)	0.06*** (0.01)	0.01 (0.01)	-0.05*** (0.01)
Importance of food safety (Not important)				
Neutral	0.01 (0.01)	-0.00 (0.02)	-0.00 (0.04)	0.05 (0.05)
Important	0.01* (0.00)	0.03 (0.02)	0.05 (0.03)	0.11*** (0.03)
Importance of Animal welfare (Not important)				
Neutral	-0.00 (0.01)	-0.00 (0.02)	-0.01 (0.03)	-0.03 (0.04)
Important	-0.01 (0.00)	0.00 (0.02)	-0.00 (0.05)	-0.02 (0.04)
Beef (Less than monthly)				
Monthly	-0.00 (0.00)	-0.00 (0.02)	-0.00 (0.03)	0.00 (0.04)
Weekly or more	0.00 (0.00)	0.02 (0.02)	0.01 (0.03)	0.03 (0.03)
Chicken **(**Less than monthly)				
Monthly	0.03*** (0.01)	0.09*** (0.02)	0.08** (0.02)	0.08 (0.05)
Weekly or more	0.01** (0.00)	0.07*** (0.01)	0.30** (0.02)	0.08* (0.04)
Pork (Less than monthly)				
Monthly	0.00 (0.00)	0.01 (0.01)	0.00 (0.02)	0. 00 (0.03)

	Growth Promotants	Prevent	Control	Treat
Weekly or more	0.00 (0.00	0.01 (0.01)	0.023 (0.02)	0. 00 (0.03)
Fish (Less than monthly)				
Monthly	-0.00 (0.00)	-0.01 (0.01)	0.00 (0.02)	0. 02 (0.03)
Weekly or more	-0.00 (0.00)	0.01 (0.01)	0.02 (0.02)	0. 00 (0.02)
Perceptions of antibiotics (Strongly disagree)				
Somewhat disagree	-0.00 (0.13)	-0.00 (0.04)	-0.07 (0.06)	-0.01 (0.06)
Neutral	-0.00 (0.01)	-0.57 (0.04)	-0.12** (0.05)	-0.05 (0.05)
Somewhat agree	-0.00 (0.01)	-0.06* (0.04)	-0.12** (0.06)	-0.01 (0.05)
Strongly agree	-0.01 (0.01)	-0.08** (0.04)	-0.13** (0.06)	0.02 (0.06)
Education (High school or less)				
Associate or less	0.00 (0.00)	0.00 (0.01)	0.00 (0.02)	-0.02 (0.02)
Bachelors	0.00 (0.00)	0.00 (0.01)	-0.00 (0.02)	0.04 (0.10)
Postgraduate	-0.00 (0.00)	-0.02 (0.01)	0.01 (0.03)	0.08* (0.04)
Age	-0.00 (0.00)	-0.00*** (0.00)	0.00 (0.00)	-0.00 (0.00)
Male	0.02*** (0.00)	0.05*** (0.02)	0.05** (0.02)	-0.01 (0.02)
Race	-0.01** (0.00)	-0.02 (0.01)	0.00 (0.021)	0. 07*** (0.02)
Income	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Involvement	0.00 (0.00)	-0.01 (0.02)	0.01 (0.03)	0.00 (0.03)

APPENDIX C

Table 17. Marginal effects of ordered probit regressions on level 4 (somewhat acceptable)

	Growth Promotants	Prevent	Control	Treat
Subjective knowledge of antibiotics	0.01 (0.00)	0.01 (0.01)	-0.00 (0.00)	-0.00 (0.00)
Subjective knowledge of ABR	0.00 (0.00)	-0.01 (0.01)	0.02** (0.00)	0.00 (0.00)
Objective knowledge of antibiotic	-0.14*** (0.02)	-0.14*** (0.02)	-0.00 (0.01)	0.03** (0.01)
Objective knowledge of ABR	-0.02*** (0.02)	0.01*** (0.03)	0.01 (0.02)	0.03 (0.01)
Perceptions of ABR (Strongly disagree)				
Somewhat disagree	-0.00 (0.02)	0.00 (0.03)	-0.00 (0.00)	-0.00 (0.00)
Neutral	0.00 (0.02)	-0.04 (0.02)	-0.03*** (0.00)	-0.01** (0.00)
Somewhat agree	-0.00 (0.02)	-0.04 (0.02)	-0.03*** (0.00)	-0.00 (0.00)
Strongly agree	-0.02 (0.02)	-0.05* 0.03	-0.023** (0.01)	0.00 (0.00)
Beef Consumption (Less than monthly)				
Monthly	-0.00 (0.01)	0.01 0.02	0.00 (0.01)	-0.00 (0.01)
Weekly or more	0.02 (0.01)	0.03 (0.02)	0.01 (0.01)	0.00 (0.00)
Chicken Consumption (Less than monthly)				
Monthly	0.06** (0.02)	0.12*** (0.03)	0.05* (0.03)	0.02 (0.02)
Weekly or more	0.03 (0.01)*	0.09*** (0.03)	0.04* (0.03)	0.02 (0.02)
Pork Consumption (Less than monthly)				
Monthly	-0.06 (0.01)	0.01 (0.01)	0.00 (0.01)	0.00 (0.00)

	Growth Promotants	Prevent	Control	Treat
Weekly or more	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.00)
Fish Consumption (Less than monthly)				
Monthly	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.01)	0.00 (0.00)
Weekly or more	0.00 (0.01)	0.02 (0.01)	0.01 (0.01)	0.00 (0.00)
Importance of food safety (Not important)				
Neutral	0.03 (0.02)	-0.01 (0.03)	-0.01 (0.03)	0.01 (0.02)
important	0.04** (0.01)	0.04 0.03	0.03 (0.02)	0.04* (0.02)
Importance of animal welfare (Not Important)				
Neutral	-0.01 (0.02)	-0.00 (0.02)	-0.01 (0.01)	-0.00 (0.00)
Important	-0.04** (0.01)	-0.00 0.02	-0.00 (0.01)	-0.00 (0.00)
Age	-0.00 (0.00)	-0.00*** (0.00)	0.00 (0.00)	-0.00 (0.00)
Male	0.04*** (0.01)	0.04 (0.01)	0.02*** (0.01)	-0.00 (0.00)
Race	-0.0 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.01** (0.00)
Income	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)
Involvement	0.02 (0.01)	-0.02 (0.02)	0.00 (0.01)	0.00 (0.00)
Education (High school or less)				
(Associate or some college	-0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.00)
Bachelors	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.00)
Post graduate	-0.01 (0.01)	-0.01 (0.02)	0.00 (0.01)	0.00 (0.00)

** ** *** represent significance level at p=0.10, p= 0.05, and p=0.01, respectively.*
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable

Table 18. Marginal effects of ordered probit regressions on level 3 (neither unacceptable nor acceptable)

Variables	Growth Promotant	Prevent	Control	Treat
Subjective knowledge of antibiotics	0.01 (0.01)	-0.00 (0.00)	0.01 (0.01)	0.01 (0.01)
Subjective knowledge of ABR	0.01 (0.01)	-0.00 (0.00)	-0.03** 0.01	-0.02 (0.01)
Objective knowledge of antibiotic	-0.21*** (0.03)	0.02 ** (0.01)	0.01* (0.02)	0.12*** (0.02)
Objective knowledge of ABR	-0.03*** (0.03)	-0.00 (0.00)	-0.02 (0.03)	-0.04 (0.03)
Perceptions of ABR (Strongly disagree)				
Somewhat disagree	0.00 (0.03)	-0.00 (0.02)	0.04 (0.04)	-0.00 (0.04)
Neutral	0.00 (0.03)	0.018 (0.01)	0.09** (0.03)	0.04 (0.03)
Somewhat agree	-0.01 (0.03)	0.01 (0.01)	0.078* (0.03)	0.01 (0.03)
Strongly agree	-0.03 (0.03)	0.01 (0.01)	0.08** (0.04)	-0.00 (0.04)
Beef Consumption (Less than monthly)				
Monthly	-(0.01) (0.03)	0.00 (0.00)	-0.00 (0.02)	-0.00 (0.02)
Weekly or more	0.04 (0.02)	-0.00 (0.00)	-0.01 (0.21)	-0.02 (0.02)
Chicken Consumption (Less than monthly)				
Monthly	0.10** (0.04)	0.01 (0.22)	-0.05** (0.02)	-0.06* (0.03)
Weekly or more	0.06* (0.04)	0.022 (0.02)	-0.41 (0.01)	-0.06** (0.03)
Pork Consumption (Less than monthly)				
Monthly	0.01 (0.02)	-0.00 (0.00)	-0.00 (0.01)	-0.00 (0.02)

	Growth Promotants	Prevent	Control	Treat
Weekly or more	0.02 (0.02)	-0.00 (0.00)	-0.01 (0.01)	-0.00 (0.02)
Fish Consumption (Less than monthly)				
Monthly	-0.00 (0.02)	0.00 (0.00)	-0.00 (0.01)	-0.01 (0.02)
Weekly or more	0.00 (0.01)	-0.00 (0.00)	-0.02 (0.01)	-0.00 (0.01)
Importance of food safety (Not important)				
Neutral	0.06* (0.04)	-0.00 (0.01)	0.00 (0.02)	-0.01 (0.03)
Important	0.08** (0.03)	-0.00 (0.00)	-0.03* (0.02)	-0.07** (0.02)
Importance of animal welfare (Not Important)				
Neutral	-0.01 (0.02)	0.00 (0.00)	0.014 (0.02)	0.02 (0.03)
Important	-0.05** (0.02)	0.00 (0.00)	0.008 (0.02)	0.01 (0.02)
Age	-0.00 (0.00)	0.00** (0.00)	-0.00 (0.00)	0.00 (0.00)
Male	0.06*** (0.01)	-0.01** (0.00)	-0.03** (0.01)	0.00 (0.01)
Race	-0.03 (0.01)	0.00 (0.00)	-0.00 (0.01)	-0.04 ** (0.01)
Income	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)
Involvement	0.04 0.02	-0.00 (0.00)	-0.01 (0.02)	0.00 (0.02)
Education (High school or less)				
Associate or some college	0.00 (0.01)	-0.00 (0.00)	-0.00 (0.01)	0.01 (0.01)
Bachelors	0.00 (0.02)	-0.00 (0.00)	-0.00 (0.01)	-0.03 (0.02)
Post graduate	0.01 (0.02)	-0.00 (0.00)	-0.01 (0.02)	-0.03 (0.02)

** ** *** represent significance level at p=0.10, p= 0.05, and p=0.01, respectively.*
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable

Table 19. Marginal effects of ordered probit regressions on level 2 (somewhat unacceptable)

	Growth Promotant	Prevent	Control	Treat
Subjective knowledge of antibiotics	-0.00 (0.00)	-0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Subjective knowledge of ABR	-0.00 (0.00)	0.01 (0.00)	-0.01** (0.00)	-0.00 (0.00)
Objective knowledge of antibiotic	0.01 (0.00)	0.11*** (0.01)	0.01* (0.01)	-0.05*** (0.01)
Objective knowledge of ABR	0.01 (0.00)	-0.00** (0.02)	-0.01 (0.01)	-0.01 (0.02)
Perceptions of ABR (Strongly disagree)				
Somewhat disagree	-0.00 (0.00)	-0.00 (0.02)	0.01 (0.01)	-0.00 (0.01)
Neither disagree nor agree	0.00 (0.00)	0.03 (0.02)	0.04** (0.01)	0.02 (0.01)
Somewhat agree	0.00 (0.00)	0.03 (0.02)	0.03** (0.01)	-0.00 (0.01)
Strongly agree	0.00 (0.00)	0.04 (0.02)	0.04** (0.01)	-0.00 (0.01)
Beef Consumption (Never)				
Monthly	-0.00 (0.00)	-0.00 (0.01)	-0.00 (0.00)	-0.00 (0.01)
Daily	-0.00 (0.00)	-0.02 (0.01)	-0.00 (0.01)	-0.01 (0.01)
Chicken Consumption (Never)				
Monthly	0.00 (0.01)	-0.08*** (0.02)	-0.03 (0.02)	-0.03 (0.02)
Daily	0.00 (0.00)	-0.06*** (0.01)	-0.03 (0.01)	-0.03 (0.01)
Pork consumption (Never)				
Monthly	0.00 (0.00)	-0.01 (0.01)	0.00 (0.01)	-0.00 (0.01)
Daily	-0.01 (0.00)	-0.01 (0.01)	-0.01 (0.01)	-0.00 (0.01)

	Growth Promotants	Prevent	Control	Treat
Fish consumption (Never)				
Monthly	0.00 (0.00)	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.00)
Daily	-0.00 (0.00)	-0.01 (0.01)	-0.01 (0.00)	-0.00 (0.00)
Importance of food safety Not important				
Neutral	0.00 (0.00)	0.00 (0.02)	0.00 (0.02)	-0.01 (0.02)
Important	0.00 (0.00)	-0.03 (0.01)	-0.02 (0.01)	-0.04 (0.01)
Importance of animal welfare Not Important				
Neutral	0.00 (0.00)	0.00 (0.01)	0.00 (0.01)	-0.01 (0.01)
Important	0.00 (0.00)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.01)
Age	0.00 (0.00)	0.01** (0.00)	-0.00 (0.00)	0.00 (0.00)
Male	-0.00 (0.00)	-0.03** (0.01)	-0.02** (0.00)	0.00 (0.00)
Race	0.00 (0.00)	0.01 (0.01)	-0.00 (0.00)	-0.02** (0.00)
Income	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)
Involvement	-0.00 (0.00)	-0.00 (0.01)	-0.00 (0.01)	-0.00 (0.01)
Education High school or less				
Associate or less	-0.00 (0.00)	-0.00 (0.01)	-0.00 (0.09)	-0.00 (0.00)
Bachelors	-0.00 (0.00)	0.001 (0.01)	-0.00 (0.01)	-0.01 (0.00)
Post graduate	-0.00 (0.00)	0.01 (0.01)	-0.00 (0.01)	-0.01 (0.01)

** ** *** represent significance level at p=0.10, p= 0.05, and p=0.01, respectively.*
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable

Table 20. Marginal effects of ordered probit regressions on level 1 (totally unacceptable)

	Growth Promotant	Prevent	Control	Treat
Subjective knowledge of antibiotics	-0.02 (0.02)	-0.01 (0.01)	0.008 (0.00)	0.00 (0.00)
Subjective knowledge of ABR	-0.02 (0.02)	0.01 (0.01)	-0.02** (0.00)	-0.00 (0.00)
Objective knowledge of antibiotic	0.41*** (0.05)	0.16*** (0.02)	0.01* (0.01)	-0.04*** (0.00)
Objective knowledge of ABR	0.06*** (0.06)	0.01 (0.03)	-0.01 (0.01)	-0.01 (0.01)
Perceptions of ABR (Strongly disagree)				
Somewhat disagree	-0.00 (0.07)	-0.00 (0.02)	0.01 (0.01)	-0.00 (0.01)
Neither disagree nor agree	-0.01 (0.06)	0.05 (0.02)	0.04** (0.01)	0.01 (0.01)
Somewhat agree	0.02 (0.06)	0.04* (0.02)	0.03** (0.01)	0.00 (0.01)
Strongly agree	0.06 (0.07)	0.06** (0.03)	0.03** (0.01)	-0.00 (0.01)
Beef Consumption (Less than monthly r)				
Monthly	0.01 (0.05)	-0.01 (0.02)	-0.00 (0.01)	-0.00 (0.01)
Weekly or more	-0.08 (0.05)	-0.04 (0.02)	-0.00 (0.01)	-0.00 (0.00)
Chicken Consumption (Less than monthly)				
Monthly	-0.21** (0.07)	-0.15** (0.05)	-0.00 (0.01)	-0.02 (0.01)
Weekly or more	-0.10 (0.07)	-0.12** (0.05)	-0.01 (0.01)	-0.02 (0.01)
Pork consumption Less than monthly				
Monthly	-0.01 (0.04)	-0.01 (0.02)	-0.04 (0.02)	-0.00 (0.06)
Weekly or more	-0.05 (0.04)	-0.01 (0.02)	-0.03 (0.02)	-0.00 (0.00)
	Growth Promotants	**Prevent**	**Control**	**Treat**
Fish consumption Less than monthly				

Monthly	0.01 (0.03)	0.00 (0.01)	-0.00 (0.01)	-0.00 (0.00)
Weekly or more	-0.01 (0.03)	-0.01 (0.02)	-0.01 (0.01)	-0.00 (0.00)
Importance of food safety **Not important**				
Neutral	-0.12 (0.08)	0.01 (0.05)	0.00 (0.03)	-0.00 (0.02)
Important	-0.13** (0.06)	-0.05 (0.03)	-0.03 (0.02)	-0.03 (0.01)
Importance of animal welfare Not Important				
Neutral	0.03 (0.04)	0.00 (0.02)	0.00 (0.01)	-0.00 (0.01)
Important	0.11** (0.04)	0.00 (0.02)	0.00 (0.01)	-0.01 (0.01)
Age	0.00 (0.00)	0.00*** (0.00)	-0.00 (0.00)	0.00 (0.00)
Male	-0.12*** (0.03)	-0.05*** (0.01)	-0.02** (0.00)	0.00 (0.00)
Race	0.06 (0.03)	0.02 (0.01)	-0.00 (0.00)	0.01** (0.00)
Income	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
Involvement	-0.07 (0.04)	-0.00 (0.02)	- 0.00 (0.01)	-0.00 (0.00)
Education High school or less				
Associate or less	0.01 (0.03)	-0.00 (0.01)	-0.00 (0.01)	0.00 (0.00)
Bachelors	-0.01 (0.03)	0.00 (0.01)	-0.01 (0.01)	-0.00 (0.00)
Post graduate	-0.03 (0.04)	-0.01 (0.02)	-0.01 (0.01)	0.01 (0.00)

* ** *** *represent significance level at p=0.10, p= 0.05, and p=0.01, respectively.*
Values in parentheses are standard errors.
The dependent variables are on a 5- point scale from 1=totally unacceptable to 5=totally acceptable