



Attitudes of South Korean consumers toward the prudent use of antimicrobials in livestock animals

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ABSTRACT

Antimicrobial resistance (AMR) in livestock is a complicated and multi-sectoral risk that threatens public health in the interactions between humans, animals, and environment. Through their increased awareness of AMR issues, consumers can make a significant impact on regulations and strategies to reduce or eliminate the use of antimicrobials use. This study aims to provide evidence-based data for promoting the prudent use of antimicrobials (PUA) in the livestock industry to reduce the risk of AMR and increase animal welfare by identifying consumers' intentions to support PUA practices in livestock farming. An online survey was conducted on 1000 respondents in South Korea to examine their intention to pay more for PUA practices in livestock farming at state and individual levels against their pro-animal attitude, risk perception of antimicrobial overuse, trust in antimicrobial overuse control, and perceived value of PUA practices. The survey data was analyzed using multiple linear regression to identify the determinants of Korean consumers' support for PUA practices. Approximately 86.3% of the respondents supported government-level spending for PUA in livestock farming, and the same portion of respondents intended to pay more for livestock products that complied with the PUA principle. The four attitudinal variables—pro-animal attitude, consumers' risk perception, trust in antimicrobial resistance control, and perceived value of PUA—positively affected both state- and individual-level support. Overall, our findings highlight the Korean consumers' demand for reducing the risk of AMR and their perceived universal value of PUA for humans and animals.

1. Introduction

Consumers' concerns about food safety and animal welfare can motivate industry stakeholders to implement changes in the livestock industry [1]. One controversial and complex issue that has emerged in recent years as a major concern for consumers is the use of antimicrobials (AMs) in livestock [2]. AMs, which mainly refers to antibiotics (i.e., drugs that target bacteria), are drugs administered to patients to treat and prevent infection, illness, and other health problems resulting from the exposure to microbial organisms such as bacteria, virus, fungi and protozoa [2]. Using AMs for clinical infections in livestock is crucial to ensure health and well-being of livestock animals for human consumption [3]. In fact, half of the world's antibacterial production is used for livestock, and the usage is predicted to increase by two-thirds from 2010 to 2030 [4]. At the same time, AMs have also enabled the crowding of animals (e.g., intensive farming) for profit at the cost of animal welfare [5,6], making animal products much more affordable for consumers

while also creating ethical dilemmas and affecting industry standards [7]. AMs, used as prophylaxes to promote growth rate and feed efficiency, are considered low-cost alternatives to hygiene procedures for disinfecting the livestock [8–10], with sub- and non-therapeutic uses of AMs compensating for the lack of appropriate husbandry, sanitation, ventilation, and stress control. As a result, AMs overuse has been linked to the unsanitary conditions of livestock farms and unhealthy and suffering animals [11,12]. For AMs to be used solely for therapeutic effects and to reduce the unnecessary use of AMs on livestock, it requires the livestock industry to raise the animals in more humane, more sanitary conditions, keeping animals' immunity and health through improved husbandry management for clean and low-stress environment for animals [11].

Meanwhile, AM overuse, resulting from the inadequate prescription of mass medication to promote growth in livestock, can increase the risk of antimicrobial resistance (AMR) [13], where livestock animals become vehicles of bacterial transmission and contribute to the proliferation,

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mixture, and spread of AMR in bacteria and genes [14]. There can be large reservoirs of resistant bacteria and resistance genes wherever AMs are used, in the local communities, livestock farms, and aquaculture environments [15]. AMR is becoming an important public health problem, as illustrated by the complicated interactions involving diverse microbial populations affecting the health of humans, animals and the environment. Once the resistance capacities are developed, AMR can spread easily among these microbial populations [16,17]. In short, the misuse or overuse of AMs in the livestock industry is becoming a “slowly rising disaster” accelerating the emergence of AMR [18].

To combat AMR, the One Health approach takes the complex and ecological nature of AMR into account and addresses it multi-sectorally by involving multiple stakeholders to communicate and work together to achieve better public health outcomes and increase the efficiency and cost-effectiveness of field interventions, surveillance, and health policies for mitigating AMR [15,19,20]. The World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Organization for Animal Health (WOAH) have joined forces to develop a Global Action Plan on AMR that specifies five strategic objectives for tackling AMR: improving awareness and understanding, strengthening knowledge and evidence, reducing the incidence of infection, optimizing the use of antimicrobials, and promoting sustainable investments [21]. Under this global initiative to mitigate AMR and AM residues, governmental agencies have been restricting the use of medically necessary drugs in animal husbandry for growth promotion or requiring the mandatory supervision of veterinarians for the use of AMs at livestock farms in accordance with the regulations for the prudent use of AMs (PUA) [11,22].

Besides governmental agencies, many other stakeholders and authorities are also involved in reducing the use of AMs in livestock, including animal caretakers and veterinarians who actively administer and prescribe AMs. Consumers of livestock products are another critical stakeholder in reducing AM use in livestock, pressuring the livestock industry to accept regulations and strategies for reducing or eliminating AM use through their increased awareness of AMR issues [2,23]. More importantly, consumers express their beliefs and trust through their purchasing power [24,25]. Previous studies have shown that consumers' demand for PUA is based on concerns about antibiotic residues and AMR development mainly in association with human health and animal welfare [2,26]. A scoping review by Barrett et al. evaluating 105 studies on consumers' perception of AMs in meat products in the United States (US), Canada, and the European Union (EU) revealed that 77.1% of the studies were concerned about the use of AMs in meat production mainly in relation to human health and animal welfare, and 32.4% of the studies claimed that consumers' perception of animal welfare was an important factor [2]. Primarily, consumers associated the use of antibiotics with intensive animal production, such as concentrated animal feeding operations (CAFOs) and factory farming, and low animal welfare.

As Rollin [5] notes, people weigh possible risks against actual benefits based on their ethical beliefs, perception, encompassing awareness of their surroundings, and attitude, including their thoughts, feeling, beliefs, and willingness to pay for products [2]. Today, more consumers are choosing products based on their ethical values regarding the environment, animals, and human rights [27,28]. Therefore, it is critical that interventions to promote PUA ensure not only food security, but also ethical practices related to animal welfare [18,29]. In this context, our study analyzes Korean consumers' perceptions of PUA and concerns about the current practice of using AMs in livestock farming, which, to the best of our knowledge, has not been attempted so far. We hypothesized that consumer support for PUA practices in livestock production could be predicted by their demographic characteristics, pro-animal attitude, risk perception, and attitude toward PUA. By investigating the level of demand for livestock products that adhere to PUA principles among Koreans, as well as the factors that influence this demand, this study aims to provide important insights for policymakers and relevant authorities that highlight the need for improved regulations in the

livestock industry to mitigate the risk of AMR and promote the One Health approach.

2. Methods

2.1. Questionnaire

A questionnaire was designed to investigate respondents' intentions to support the increase in governmental budget for PUA practices and pay more to purchase PUA livestock products in relation to their individual attributes and attitudes, which were set as independent variables.

The first section of the questionnaire included items on the respondents' demographic attributes, such as gender, age, educational level, household income, and parental status, which were given as single choice items. The second section included items about the respondents' attitudinal and cognitive attributes. First, the respondents' pro-animal attitude was measured using the Animal Attitude Scale-10 (AAS-10), which is one of the most widely used indices for investigating the ethical and behavioral aspects of human–animal interactions [30]. The AAS-10 contains 10 statements rated on a 5-point Likert scale ranging from 1 (definitely disagree) to 5 (definitely agree). The total AAS-10 score indicates the respondents' pro-animal attitude: the higher the score, the stronger the respondent's ethical stance concerning the use of animals. Next, respondents were asked to rate the degree to which they perceived the risk of AM overuse (five items), trust the government and industry stakeholders' control of AM overuse (five items), and perceived the value of PUA practices for humans, animals, and the environment (three items) based on a 4-point Likert scale (1 = definitely disagree and 4 = definitely agree). The items were set based on studies on the association between consumers' perceived risk and trust in the practices for making products and their willingness to purchase those products [25] as well as the risk and management of AMR and the value of PUA practices from the One Health perspective [1,31,32]. The last section of our questionnaire examined the respondents' support for PUA practices in livestock farming in terms of willingness to pay, that is, their intention to spend more money, either indirectly through supporting government spending or directly out of their pockets. Willingness to pay is a commonly used measure for evaluating consumer demand and preferences for products or production process [33] and denotes the value of goods or services to an individual as the price premium or maximum price to sacrifice to obtain a certain benefit or to avoid undesirable characteristics [34,35]. The respondents were asked to rate their willingness to support the allocation of more governmental budget for PUA (state-level) and to spend more money for the purchase of PUA livestock products (individual-level) on a 4-point Likert scale (1 = definitely will not and 4 = definitely will). Furthermore, they were asked to rate how much more they are willing to pay for PUA livestock products (0, up to 5, 10, 25, 50, 100, or > 100%).

2.2. Data collection and statistical analysis

Ethical approval was received from the Institutional Review Board of Seoul National University (IBR No. 1909/002–023). The respondents ($n = 1000$), all over the age of 19, were collected from panels of an online research company. The survey was conducted from October 24 to November 4, 2019, based on the quota sampling method using age, gender, and region for survey sampling, and the sample showed a sampling error of $\pm 3.1\%$ at a confidence level of 95%. The collected sample was analyzed using multiple linear regression analysis to determine the effect of the independent variables on the respondents' intention to financially support PUA practices in livestock farming.

3. Results

3.1. Demographic characteristics: gender, age, education, household income, and parental status

Table 1 summarizes the respondents' demographic characteristics. Briefly, 50.5% ($n = 505$) were female, and 52.2% ($n = 522$) were under 40 years of age. About half of the respondents had a bachelor's degree (49.4%, $n = 494$), 62.2% ($n = 622$) of them belonged to the \$2000–6000 monthly household income group, and 71.3% ($n = 713$) had children.

3.2. Attitudinal characteristics: pro-animal attitudes, risk perception of AMs overuse, trust in AMs overuse control and perceived value of the PUA

The measures of the four attitudinal variables (pro-animal attitude, perception of the risk in AMs overuse, trust in AMs overuse control, and perceived value of PUA) are presented in Table 2, with each item's mean score, standard deviation (SD), and percentage of responses. The mean of respondents' AAS-10 score was 33.92 (SD = 5.83, Cronbach $\alpha = 0.784$). Female respondents ($M = 35.28$, SD = 5.72) showed higher pro-animal attitudes than males ($M = 32.52$, SD = 5.60) with statistical significance ($t = -7.70$, $p < 0.001$). Meanwhile, older age groups (those in their 50s and over 60s) showed lower AAS-10 scores than younger respondents in analysis of variance (ANOVA) and post hoc comparisons using Tukey-B ($F = 9.371$, $p < 0.001$).

In total, 93.2% ($n = 932$) of the respondents perceived the AMR problem to be serious ("agree" 55.9%, and "definitely agree" 37.3%), and 90.8% ($n = 908$) thought that animal health and welfare might deteriorate due to AMR ("agree" 57.2%, and "definitely agree" 33.6%). The mean scores for the items about the perceived risk of AM overuse ranged from 3.19 (SD = 0.65) to 3.30 (SD = 0.61).

Respondents showed a relatively low trust in AM overuse control, most commonly answering related items with "disagree" and "definitely disagree." The mean scores for these items ranged from 2.17 (SD = 0.68) to 2.52 (SD = 0.66). About two-thirds of the respondents responded negatively to livestock producers' compliance with veterinarians' prescriptions and medication guidance ("disagree" 56.2%, "definitely disagree" 9.5%). With regard to livestock producers' efforts to reduce the types and amounts of unnecessary AMs, 59.5% said that they "disagree," and 13.2% responded as "definitely disagree." Only one-third of the respondents showed trust in governmental AMR control ("agree" 29.2%, "definitely agree" 4%).

The mean scores for the items about the perceived value of PUA ranged from 3.02 (SD = 0.63) to 3.31 (SD = 0.67). More than 80% of the respondents agreed on the importance of PUA in increasing the chances of curing human diseases in the future ("agree" 65.5%, "definitely

agree" 18.8%), protecting the community and the environment ("agree" 59%, "definitely agree" 27%), and improving animals' health and welfare ("agree" 48.9%, "definitely agree" 41.6%).

3.3. Intention to support PUA practices in livestock farming

Respondents' intention to support the allocation of more governmental budget on PUA and pay more to purchase PUA livestock products, measured on a 4-point Likert scale, are shown in Table 3. 86.3% of the respondents supported a higher state-level budget for PUA ("support" 58.4%, "definitely support" 27.9%) with a mean score of 3.13 (SD = 0.66). Furthermore, 86.3% of the respondents ("pay more" 63.4%, "definitely pay more" 22.9%) expressed their intention to pay more for purchasing PUA livestock products ($M = 3.08$, SD = 0.64). Regarding the respondent's willingness to pay for PUA products, 16.7% of the respondents chose "up to 5%" and 44.5% chose "up to 10%." Moreover, 220 respondents (22%) answered that they would be willing to pay 25% more, and 112 respondents (11.2%) indicated they would pay 50% more than the price of non-PUA products. Only 2.2% of the respondents were unwilling to pay more, while 2% of the respondents showed their willingness to pay more than twice the present price (Table 4).

3.4. Multiple linear regression analysis of respondents' intention to support PUA practice in livestock farming

We conducted a multiple linear regression analysis to understand the relationship between the independent variables and the respondents' intention to support PUA practices in livestock farming at state and individual levels. The support for more state-level spending and the intention to pay more personally were analyzed separately, each through two regression models: model 1 including only the demographic characteristics (gender, age, educational level, income, and parental status), and model 2 including demographic characteristics as control variables and the four major attitudinal characteristics (pro-animal attitude, risk perception of AMs, trust in AM overuse control, and perceived value of the PUA) as independent variables. Independence among variables was confirmed through a multicollinearity test.

Model 1 for state-level budget spending revealed no significant predicting variables for demographic characteristics, indicating no demographic effect on respondents' intention to support larger governmental budget spending for PUA products. On the other hand, model 2 including the attitudinal variables identified positive correlations of all attitudinal characteristics with the intention to support a larger governmental budget for PUA. The value of R^2 , known as the coefficient of determination as an indicator of variance explained, for model 2 was 0.19, indicating adequate explanatory power ($R^2 = 0.19$, $F = 14.819$, $p < 0.001$) [36]. Respondents who had stronger pro-animal attitudes ($\beta = 0.095$, $p < 0.01$), who highly perceived the risk of AMR ($\beta = 0.161$, $p < 0.001$), who strongly trusted the government's AM overuse control ($\beta = 0.063$, $p < 0.05$), and who believed more strongly in the importance of PUA practices ($\beta = 0.227$, $p < 0.001$) were more likely to support government policies for greater state-level budget for PUA practices. Also, a comparison of each variable's standardized coefficients (β) showed that the respondents' perceived value of PUA had the largest impact among the variables (see Table 5).

Model 1 for the intention to pay more for PUA products revealed that demographic characteristics have more influence on individual-level support for PUA practices in livestock farming than state-level support. Gender (male, $\beta = -0.065$, $p < 0.05$), older age ($\beta = 0.138$, $p < 0.001$), and higher income ($\beta = 0.098$, $p < 0.05$) were found to be significant predictors for the respondents' intention to pay more for PUA products in model 1 ($R^2 = 0.034$, $F = 7.021$, $p < 0.001$). In model 2 including the attitudinal variables ($R^2 = 0.166$, $F = 21.968$, $p < 0.001$), age and income were still significant, whereas the effect of gender was reduced to an insignificant level; older people ($\beta = 0.106$, $p < 0.05$) and higher-income groups ($\beta = 0.079$, $p < 0.05$) displayed a higher intention

Table 1
Demographic characteristics of respondents ($n = 1000$).

Variable	Category	%	n
Gender	Female	50.5	505
	Male	49.5	495
Age	19–29	17.0	170
	30–39	15.8	158
	40–49	19.4	194
	50–59	21.0	210
	Over 60	26.8	268
Educational level	High school or less	26.8	268
	College degree (2 years)	14.0	140
	Bachelor's degree (4 years)	49.4	494
	Postgraduate	9.8	98
Household income (monthly)	Under \$2000	10.8	108
	\$2000–4000	31.2	312
	\$4000–6000	30.9	309
	\$6000–8000	15.7	157
	Over \$8000	11.4	114
Parental status (children)	Yes	71.3	713
	No	28.7	287

Table 2
Respondents' attitude toward animals, risk perception of AM overuse, trust in AM overuse control, and perceived value of the PUA (n = 1000).

Variables (Scale reliability)	Items	5-point Likert scale (%)					Mean	SD
		1	2	3	4	5		
Animal Attitude Scale-10 ^a (C α = 0.784)	It is morally wrong to hunt wild animals just for sport.	1.9	6.7	15.8	36.9	38.7	4.04	0.99
	I do not think that there is anything wrong with using animals in medical research.*	7.2	14.5	34.3	36.2	7.8	2.77	1.03
	I think it is perfectly acceptable for cattle and hogs to be raised for human consumption.*	1.7	8.1	27.5	42.8	19.9	2.29	0.93
	Basically, humans have the right to use animals as we see fit.*	16.9	26.2	31.8	21.1	4.0	3.31	1.1
	The slaughter of whales and dolphins should be immediately stopped even if it means some people will be put out of work.	1.7	4.5	20.5	37.0	36.3	4.02	0.95
	I sometimes get upset when I see wild animals in cages at zoos.	0.6	5.0	20.6	48.2	25.6	3.93	0.84
	Breeding animals for their skin is a legitimate use of animals.*	33.3	30.9	21.4	11.8	2.6	3.81	1.1
	Some aspects of biology can only be learned through dissecting preserved animals such as cats.*	4.2	15.2	34.7	37.6	8.3	2.69	0.97
	It is unethical to breed purebred dogs for pets when millions of dogs are killed in animal shelters each year.	2.2	8.6	27.1	37.5	24.6	3.74	0.99
	The use of animals such as rabbits for testing the safety of cosmetics and household products is unnecessary and should be stopped.	4.4	16.8	35.8	27.9	15.1	3.32	1.06
Total score						33.92	5.83	
Variables (Scale reliability)	Items	4-point Likert scale (%)				Mean	SD	
		1	2	3	4			
Risk perception of AMs overuse ^b (C α = 0.804)	The risk associated with AMR is serious.	0.5	6.3	55.9	37.7	3.30	0.61	
	Doctors over-prescribe AMs to patients.	0.7	11.4	56.5	31.4	3.19	0.65	
	People over-take AMs.	0.6	8.9	53.9	36.6	3.27	0.64	
	AMs are used far too much in the livestock and aquaculture environment.	0.1	8.6	55.9	35.4	3.27	0.61	
	Animal health and welfare may deteriorate due to AMR.	0.4	8.8	57.2	3.6	3.24	0.62	
Total score					16.26	2.34		
Trust in AMs overuse control ^b (C α = 0.812)	For food safety, veterinarians responsibly prescribe to and manage AMs in livestock and aquaculture.	3.6	46.1	44.6	5.7	2.52	0.66	
	Livestock producers follow the veterinarian's prescription and medication guidance.	9.5	56.2	30.3	4.0	2.29	0.69	
	Livestock producers reduce the types and amounts of unnecessary AMs.	13.2	59.5	24.6	2.7	2.17	0.68	
	Pharmaceutical companies produce and sell AMs for animals considering the impact on human health.	11.2	55.8	29.2	3.8	2.26	0.70	
	The government strongly monitors and regulates AM usages at farms and fisheries.	13.7	52.4	29.9	4.0	2.24	0.73	
Total score					11.48	2.62		
Perceived value of the PUA ^b (C α = 0.737)	Prudently using AMs in the livestock production process can increase the chances of curing human diseases.	1.6	14.1	65.5	18.8	3.02	0.63	
	Prudently using AMs in the livestock production process can protect the community and the environment.	1.1	12.9	59.0	27.0	3.12	0.66	
	Prudently using AMs for treatments to improve livestock animals' health and welfare is indispensable.	1.0	8.5	48.9	41.6	3.31	0.67	
Total score					9.45	1.58		

*reverse scoring item. These items were calculated with reversed score (1 to 5, 2 to 4, 3 to 3, 4 to 1, and 5 to 1) for mean (SD) and total score; C α : Cronbach's α ; ^a 5-point Likert scale (1 = definitely disagree, 5 = definitely agree); ^b 4-point Likert scale (1 = definitely disagree, 4 = definitely agree); AMR: antimicrobial resistance; AMs: antimicrobials; PUA: prudent use of antimicrobials.

Table 3
Respondents' intention toward state- and individual-level support for PUA practices in livestock farming (n = 1000).

Level of intention	Items	4-point Likert scale (%)				Disagree (%)	Agree (%)	Mean	SD
		1	2	3	4				
State-level spending	Are you willing to support more governmental budget for PUA?	1.3	12.4	58.4	27.9	13.7	86.3	3.13	0.66
Individual-level spending	Are you willing to pay more for purchase of PUA livestock products?	1.6	12.1	63.4	22.9	13.7	86.3	3.08	0.64

4-point Likert scale, 1 = definitely disagree, 4 = definitely agree, PUA: prudent use of antimicrobials.

Table 4
Respondents' willingness to pay more for PUA livestock products (n = 1000).

Additional fee for PUA products (%)						
0	Up to 5%	Up to 10%	Up to 25%	Up to 50%	Up to 100%	>100%
2.2	16.7	44.5	22	11.2	1.4	2

PUA: prudent use of antimicrobials.

to pay more for PUA products. Regarding the attitudinal variables, people with a firmer pro-animal attitude ($\beta = 0.124, p < 0.001$), a higher perception of AMR risk ($\beta = 0.152, p < 0.001$), a more profound trust in AM overuse control ($\beta = 0.097, p < 0.01$), and a stronger belief in the value and importance of PUA intervention ($\beta = 0.250, p < 0.001$) exhibited a higher intention to pay more for PUA products. Similar to

state-level support, respondents' perceived value of PUA had the largest impact on individual-level support (see Table 6).

4. Discussion

Consumers' increasing sensitivity to animal welfare, comprising of cognitive and emotional dimensions, have resulted in changes in purchase behavior [37]. Notably, ethical issues surrounding today's highly intensive livestock production techniques have been increasingly affecting consumers' choice of livestock products [26,38,39]. Animals in intensive livestock production systems are likely to suffer from stress and a poor quality of life, which result in their higher susceptibility to diseases [40], thus requiring a greater use of AMs. Today, more consumers are willing to pay a premium for morally defensible agriculture and farming products, such as those produced through better husbandry and animal welfare practices based on proper hygiene and stress control

Table 5

Result of the multiple linear regression analysis on respondents' Support more state-level budget for PUA practice in livestock farming ($n = 1000$).

Variables	Model 1 (Demographic)			Model 2 (Attitudinal)		
	β	CI		β	CI	
		upper	lower		upper	lower
(Constant)	3.035	2.856	3.214	0.932	0.443	1.421
Gender (Female)	-0.015	-0.105	0.065	0.010	-0.069	0.096
Age	0.040	-0.011	0.048	0.002	-0.028	0.030
Education	-0.012	-0.055	0.038	-0.022	-0.059	0.029
Income	0.033	-0.019	0.056	0.014	-0.027	0.044
Parental status (with children)	0.022	-0.061	0.125	0.013	-0.068	0.107
AAS-10				0.095**	0.004	0.018
Risk perception				0.161***	0.026	0.065
Trust in overuse control				0.063*	0.000	0.032
Perceived value of the PUA				0.227***	0.068	0.122
R ²	0.003			0.119		
F	0.696***			14.819***		

PUA: prudent use of antimicrobials; AAS: Animal Attitude Scale; CI: confidence interval ($p < 0.05$); β = standardized coefficient, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6

Result of the multiple linear regression analysis on respondents' intention to pay more for PUA products ($n = 1000$).

Variables	Model 1 (Demographic)			Model 2 (Attitudinal)		
	β	CI		β	CI	
		upper	lower		upper	lower
(Constant)	2.715	2.545	2.885	0.932***	-0.042	0.876
Gender (Female)	-0.065*	-0.165	-0.003	-0.033	-0.119	0.036
Age	0.138***	0.033	0.090	0.106**	0.020	0.075
Education	0.018	-0.032	0.056	0.013	-0.033	0.050
Income	0.098**	0.019	0.090	0.079*	0.011	0.077
Parental status (with children)	0.050	-0.018	0.158	0.041	-0.025	0.140
AAS-10				0.124***	0.007	0.020
Risk perception				0.152***	0.023	0.060
Trust in overuse control				0.097**	0.009	0.039
Perceived value of the PUA				0.250***	0.076	0.126
R ²	0.034			0.166		
F	7.021***			21.968***		

PUA: prudent use of antimicrobials; AAS: Animal Attitude Scale; CI: confidence interval ($p < 0.05$); β = standardized coefficient, * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

[41–43]. Goddard et al. [32] suggested a link between consumers' moral concerns related with animal welfare and their attitudes toward purchasing livestock products, where individuals with higher concerns about the treatment of animals are more likely to purchase antibiotic-free livestock products and reject the misuse of antibiotics in livestock production. Our study on Korean consumers showed that the majority of the respondents were willing to support PUA practices in livestock farming, with 86.3% agreeing with both increasing government budget and additional personal expenditure. This is similar to the percentage of respondents who are willing to pay more for livestock products using less AMs in Canada (85%) but lower than respondents in Germany (91%) in the research by Goddard et al. [32]. We also found that

respondents' attitudinal characteristics (pro-animal attitude, AMs risk perception, trust in AM overuse control, and perceived value of PUA) correlated with their intention to support PUA practices at both state and individual levels, suggesting the critical importance of securing transparency and reliability in the practice of using AMs in livestock. Furthermore, the perceived value of PUA for humans, animals, and the environment, which is in line with the One Health approach, acted as the most significant predictor of the respondents' intention to support PUA practices, implying that public awareness of One Health values strengthens the belief in PUA in livestock.

Some earlier studies have shown that consumers' individual attributes, such as age, educational level, and household income, were significant factors in predicting their willingness to pay more for products from farms engaging in high levels of animal welfare practices [38,44,45] or antibiotic-free products [46]. We also found that demographic characteristics may also be predicting factors of individual-level spending for PUA, particularly that age and household income positively influenced the respondents' intention to pay more for PUA livestock products. Notably, we found that respondents in their 40s to 60s indicated a higher willingness to pay for PUA livestock products than the younger age groups ($F = 5.579$, $p > 0.001$). This is consistent with a survey of US consumers that reported older respondents' higher consumptive intention for livestock products that are safe from the risk of AMs [46]. The association with these demographic variables may reflect that choosing a PUA product is related with not just the concern for the animal welfare per se, but the concern for (or the value placed on) personal health and safety [47]. Generally, consumers consider the quality attributes of animal-based food, such as safety, nutritional value, sustainability, and health for their family [48]. Respondents in the middle age group may have stronger concerns about their family's health and may afford to be selective in their purchasing decisions as they are likely to be more established career-wise and have a higher income [23,46,49]. In this regard, income has been commonly considered as a significant predictor of the willingness to pay more for animal-friendly livestock products, where high-income families were known to prefer antimicrobial-free and organic products compared to low-income families [41,44,45].

Another interesting finding of our study is that most of the respondents agreed AMR negatively affects animal health and well-being (90.8%) and approved the proper use of AMs for animal treatment (90.5%). While alternative practices for hygiene management and environmental improvement in livestock husbandry are believed to reduce the use of AMs [12,44], it has been noted by previous studies that consumers may perceive PUA practices purely as an indicator of safer food, supporting absolutely no use of AMs in animals [44]. In a survey of US consumers ($n = 1030$), only about 60% of the respondents accepted the use of AMs in livestock production for infectious disease treatment [23]. Similarly, Lusk et al. [50] suggested that US respondents place a substantial premium on pork produced without antibiotics, demonstrating their willingness to pay more for antibiotic-free pork. Consumer's confused perception of "raised without antibiotics" in modern product practices may reflect the lack of knowledge in the necessity of using AMs for the prevention and treatment of infectious diseases [3]. However, our study showed that Korean consumers generally recognized the need for using AMs while supporting PUA practices and calling for changes in husbandry practices to improve the health of the animals and reduce their risk of infection. In this context also, respondents' pro-animal attitudes were significant predictors of their willingness to pay more for the livestock production that comply with PUA principles.

Despite our notable findings, a major limitation of this study is that while ethical considerations of consumers may be a forewarning of possible behavioral changes at the consumer level [26,37,51], consumer intention does not necessarily or directly translate into purchase behavior. Further studies and discussions are needed to gain a more comprehensive understanding on how and why consumers to make purchasing decisions based on an ethical approach. There may be more

reasons why people feel compelled to purchase PUA livestock products beyond the individual-level factors accounted for in our regression model. For example, changes in livestock systems and technologies prioritizing animal welfare and antibiotic-free production or nationwide stewardship focusing on AMR and the One Health strategy can also shape consumer behavior. Ultimately, it will be essential to explore more factors to better understand how personal ethics impact purchasing decisions. Notwithstanding these limitations, our research revealed Korean consumers' demand for reducing the risk of AMR and the significant value they place on PUA for humans, animals, and the environment.

5. Conclusion

As the first survey and analysis of Korean consumers' attitudes toward PUA in livestock farming, our study revealed Korean consumers' need for ethical consumption in terms of animal welfare and food safety by identifying their intention to support PUA practices in livestock farming. Ethical considerations have been gaining greater importance in recent years as a component of customer value, codifying both allowed and prohibited behavior [40]. Accordingly, meeting consumer concerns about food safety and animal welfare has become a major task for the livestock industry to re-establish their reputation and consumer trust in meat products [26]. Although achieving this task may come at a cost to both the producer and the consumer, our findings show that consumers are largely willing to internalize these costs, justifying the use of government interventions to force producers to engage in more ethical production processes based on social consensus [5,6]. In this sense, consumers play an important role as a market initiator in promoting PUA practices in the livestock sector. Our study highlights that AMR policies should consider consumers' intention to engage in ethical consumption in relation to PUA practices; a successful response to public concerns over AMR in livestock is not only a scientific or medical undertaking but must also be an ethical undertaking. In other words, greater public and industry engagement and actions are required to formulate a proper ethical response to AMR [18]. The findings of this study may serve as a basis for delineating and charting the course of future policies aimed at promoting sustainable livestock practices adopting the One Health approach.

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Declaration of competing interest

The authors report there are no competing interests to declare.

Data availability

The data that support the findings of this study are available from the corresponding author, Myung-Sun Chun, upon reasonable request.

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