


Construction and validation of questionnaires to assess the risk of veterinary antibiotics in egg consumption and their impact on food safety



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Abstract:

Poultry production is one of the most important agricultural sectors worldwide due to the high nutritional value of its products, such as meat and eggs, for human consumption. In this regard, veterinary antibiotics are used to treat or prevent disease-causing pathogens in order to ensure and maintain production. The objective of the study was to design and validate two questionnaires for assessing the risk of veterinary antibiotics used in egg-laying hens and their perceived impact in relation to food safety. Its logic and the validity of its content were determined by expert evaluation. Its construct validity was assessed by exploratory factor analysis, and its reliability, with Cronbach's Alpha coefficient. The survey was applied to 44 establishments or egg producers in the Espaillat province and to 385 consumers in the Santo Domingo province. A Cronbach's alpha coefficient of 0.799 was obtained for egg producers and veterinarians, and of 0.771, for consumers. The principal component analysis identified a KMO sample size adequacy measure of 0.558 for egg producers and veterinarians, and 0.797 for consumers. The questionnaire for egg producers and veterinarians consists of 8 factors and 22 items, and the questionnaire for consumers, of 3 factors and 8 items. The

results confirm that the scale found is reliable and valid for the construct the risks associated with the potential consumption of food containing veterinary antibiotic residues.

Keywords: Egg, Food Safety, Risks, Reliability, Antibiotic, Factor Analysis.

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Introduction

Safe animal feeding is important for animal health, animal food consumer safety, and the environment. There is a close link between the safety of animal feed and derived foods such as eggs. However, additives are deliberately added to animal feed or to the animal directly⁽¹⁾. While eggs are a high-demand product that has promoted the growth of the poultry industry and intensive agriculture, they have also increased the morbidity and mortality of farm poultry, which in turn can lead to diseases in the population such as fowl cholera, avian flu, spotted liver disease, avian salmonellosis, infectious bronchitis, Marek's disease, Gumboro disease, and parasitic diseases⁽²⁾ due to bacteria, viruses, fungi, internal and external parasites, and other handling-related diseases⁽³⁾. Veterinary antibiotics are one of the most viable solutions to combat them.

There is evidence that some poultry producers administer human antibiotics or antibiotics prescribed for other animal species⁽⁴⁾; this may be legal, but their residues may be present in eggs, egg byproducts, and biowaste, including eggshells⁽⁵⁾, leading to the development of antimicrobial resistance⁽⁶⁾. Thus, the presence of antibiotics in egg yolk and albumin is related to the active ingredient or to the pharmacokinetic properties of the antibiotic in question, which will follow different distribution routes within the organism or in the animal tissues, leaving residues that depend on the type of antimicrobial⁽⁷⁾. Consequently, this instills a suspicion of unsafety in egg consumers due to the potential risks involved, mainly because of the constant health crises and alarms, such as the avian flu virus and others that attack poultry.

Food safety is highly compromised when the Maximum Residue Limits, the withdrawal periods for the antibiotics administered, the effects of antibiotics on animals, and the regulatory standards for the use of veterinary antibiotics are not respected. At the international level, the norm CX/MRL 2-2021 of the Codex Alimentarius of the United

Nations' World Health Organization and Food and Agriculture Organization (FAO), which deals with Maximum Residue Limits (MRLs) and Risk Management Recommendations (RMR) for veterinary antibiotic residues in food, is taken as a reference⁽⁸⁾. In the case of the Dominican Republic, it is regulated by Decree No. 354-10, which establishes the technical regulation of the MRLs of veterinary antibiotics and related substances in food of animal origin⁽⁹⁾. This implies that consumers are constantly exposed to this type of antibiotics and any other additives used in animal feed and disease control that can put their health at risk.

Therefore, it is of great interest to have instruments to determine the reliability and validity of the use of veterinary antibiotics in poultry, in addition to the consumer's knowledge, attitude, and practice (KAP) for the consumption of food of animal origin, as all these play a role in ensuring food safety.

The objective of this research was to design and validate a questionnaire to assess the risk of veterinary antibiotics used in poultry production in egg-laying hens and their perceived impact on the consumers in terms of food safety in the Dominican Republic.

Material and methods

Design

A study was conducted with a quantitative and qualitative approach and an analytical cross-sectional design for the construction and validation of an instrument (questionnaire) to assess the risk of veterinary antibiotics in egg consumption and their impact on food safety. Study participants received written information on the purpose and procedures of the study, as well as the right to withdraw at any time. They were assured that the data would be treated confidentially. Prior to the data collection, informed consent was obtained from each participant. Participation was on a voluntary basis.

Study population

The study population included the 2010 national census conducted by the National Statistics Office (Oficina Nacional de Estadística, ONE) of the Dominican Republic. A 95 % confidence level and a 5 % error were estimated for a total of 385 people in the Santo Domingo province and 44 farms or veterinaries in the Espaillat province, both in the

Dominican Republic. The selected poultry farms had the characteristics of being managed under an intensive production system (birds confined in cages or covered all the time) and were managed within the category of small and medium-sized enterprises.

Research instrument

An online questionnaire was designed to be filled out by two groups —1) Poultry producers in the selected sample and veterinary-antibiotics sales managers of veterinary and agrochemical centers, and 2) Table egg consumers— in order to obtain information on the perception of the use of veterinary antibiotics, their residual nature and the relationship with food safety and the risk they may pose to human health (Annex 1). In addition, there were collected general data and other data related to the characteristics of the veterinary antibiotics used in this species (commercial presentation, active ingredient, pharmaceutical form, concentration), the management of veterinary antibiotics (dosage used, route, and frequency of administration, duration of treatment, withdrawal time, indications, precautions-warnings-recommendations) and to who prescribes the antibiotics⁽¹⁰⁻¹¹⁾.

Questions were developed based on the researchers' previous experience, literature reviews, or expert opinions⁽¹⁰⁻¹¹⁾. The questionnaires were structured considering 15 domains or dimensions. The first questionnaire consists of 29 items, divided into ten sections: 1) General characteristics of egg producers, according to factors such as age, sex, name of the commercial establishment or poultry farm, sector, and province; 2) Technical characteristics of the control and prescription of veterinary antibiotics, knowledge and compliance with regulations for their use in poultry production; 3) Characteristics of the veterinary antibiotics used in poultry production; 4) Technical factors of poultry health management and use of veterinary antibiotics; 5) Duration of veterinary treatments applied to the birds; 6) Frequent application of veterinary antibiotics to laying hens; 7) Regular use of veterinary antibiotics in egg production and food safety; 8) Farm and/or veterinary administrative management; 9) Withdrawal time of veterinary antibiotics prior to use of poultry products; 10) Management of poultry by route of administration of veterinary antibiotics. The second questionnaire applied to consumers consisted of 17 items, divided into five sections: 1) General consumer characteristics; 2) Characteristics of egg consumption such as quantity and frequency; 3) Consumer perception of the presence of veterinary antibiotic residues in eggs and regulatory compliance by poultry producers; 4) Relationship between egg consumption and egg poisoning, and 5) Purchase and verification of the quality and hygiene conditions of eggs at the point of sale (supermarket, market, etc.). Responses to the items were generally four- or five-point Likert scales. A version of the questionnaire was developed using the Google Forms platform.

Validation of the instrument

Validation of the specific contents was carried out based on expert review. Five experts were recruited from various agricultural science disciplines. They were asked to evaluate the questionnaire, using a scale of 1 to 5 points to assess the basic dimensions. They also had the option of adding open comments. Construct validity was assessed using Principal Component Exploratory Factor Analysis (PCA); while reliability was determined by Cronbach's alpha coefficient both overall and for each of the questionnaire's dimensions.

Data analysis

Internal consistency was evaluated by focusing on the correlations between the questionnaire items, which indicates their degree of theoretical adequacy. Cronbach's alpha was used for this purpose. An alpha between 0.70 and 0.95 was considered acceptable⁽¹²⁾. All data were analyzed using IBM SPSS Statistics version 25, and the significance level was set at 0.05 for the confirmatory factor analysis.

Results

A total of 429 people responded to the questionnaire. The sample of this research was made up of 93.2 % men and 6.8 % women in the case of farms and veterinarians. For consumers, it consisted of 50.9 % women and 49.1 % men.

Cronbach's alpha score measuring the internal consistency of the questions was satisfactory ($\alpha= 0.799$ and 0.771). Tables 1a and 1b show their values for each questionnaire. Internal consistency was satisfactory in all the domains. However, 7 items were eliminated from the initial 29 items of the first questionnaire (Table 1a), and 9 items, from the original 17 items of the second questionnaire (Table 1b), considering the analysis of the corrected item total, whose correction was deemed necessary because it exhibited a negative correlation and very low representativeness among the questions, which affected the subsequent analysis.

Table 1a: Item-total statistics of the reliability test for egg producers and veterinarians

Items	Scaling average if the item has been suppressed	Scale variance if the item has been suppressed	Total correlation of the corrected items	Squared multiple correlation	Cronbach's alpha if the item has been suppressed
P1. Commercial establishment/Poultry farm.	72.5	121.605	0.672	0.751	0.788
P2. Professional veterinary prescription.	69.93	108.53	0.771	0.849	0.768
P3. Antibiotic control or management program for poultry production.	70.32	109.989	0.507	0.517	0.781
P6. Knowledge of the regulations on veterinary antibiotics in poultry production and of the recommended maximum limits for harmful residues in food.	70.55	102.672	0.628	0.708	0.771
P18. Whether or not to vaccinate poultry regularly with antibiotics.	69.23	127.482	0.121	0.617	0.8
P8. Knowledge of the antibiotics banned by the Dominican government for use in egg production.	70.39	108.847	0.538	0.636	0.779
P9. Most commonly used veterinary antibiotics in poultry egg production.	69.61	116.243	0.499	0.584	0.784
P28. To what age class of animals are veterinary treatments applied?	69.43	119.646	0.375	0.617	0.791
P29. Route of application of veterinary antibiotics.	72.64	127.493	0.144	0.495	0.8
P17. What is the frequency of antibiotic administration?	72.52	123.465	0.179	0.558	0.8
P14. For what types of treatments are veterinary antibiotics indicated?	69.32	127.385	0.013	0.572	0.809
P16. Keeps records of veterinary antibiotic applications.	69.41	126.387	0.057	0.521	0.806
P17. Compliance with label warnings for veterinary antibiotics administered to animals.	69.82	128.059	0.003	0.662	0.807
P24. Often reads the labels of veterinary products before applying them to animals.	69.39	119.266	0.414	0.401	0.789
P15. Have you applied any veterinary antibiotics to animals for which they are not meant?	71.91	120.457	0.291	0.492	0.795
P25. Know the withdrawal periods of veterinary antibiotics before they are applied.	69.91	122.364	0.188	0.53	0.801
P26. Meeting veterinary antibiotic withdrawal deadlines is crucial for consumer safety.	69.48	125.046	0.193	0.415	0.798
P27. What is the withdrawal period for the veterinary antibiotics applied to the birds?	71.59	113.41	0.551	0.655	0.78
P19. Compliance with national regulations on the use of veterinary antibiotics in poultry farming.	70.16	113.16	0.399	0.451	0.789
P20. Veterinary antibiotics can harm if proper withdrawal measures are not followed.	69.68	120.594	0.264	0.409	0.796

P10. Are you familiar with the following veterinary antibiotics: chloramphenicol, diethylstilbestrol (DES), and nitrofurans?	71.57	114.344	0.416	0.679	0.788
P11. Have you treated the birds with, or sold one of these veterinary antibiotics (chloramphenicol, diethylstilbestrol (DES), and nitrofurans)?	71.8	115.143	0.462	0.77	0.785

Table 1b: Total item statistics for the reliability test for the consumer questionnaire

Items	Scaling average if the item has been suppressed	Scale variance if the item has been suppressed	Total correlation of corrected items	Squared multiple correlation	Cronbach's alpha if the item has been suppressed
Q3. Do you consume hen's eggs (table eggs) as food?	20.86	60.538	0.803	0.810	0.689
Q4. How often do you consume eggs?	22.12	58.531	0.602	0.544	0.720
Q5. Amount of egg consumed, when eaten according to frequency.	22.31	60.086	0.775	0.762	0.691
Q6. When you consume eggs, how do you eat them?	21.85	54.696	0.710	0.652	0.694
Q16. When you buy egg products, do you take notice of the packing date, the expiration date, and the brand name?	22.40	77.912	0.136	0.050	0.798
Q7. Do you consider that it is safer to consume eggs than other foods?	21.18	73.561	0.313	0.138	0.770
Q9. Do you understand that egg producers comply with the Dominican animal health legislation to treat diseases in laying hens?	20.90	77.233	0.190	0.320	0.787
Q10. Egg producers comply with the withdrawal period for veterinary antibiotics in laying hens as specified on the label when placing egg products on the market for consumption.	21.54	77.676	0.272	0.344	0.773

The normality test for both questionnaires showed that there is no significant correlation ($\alpha=0.05$) for the Kolmogorov-Smirnow and Shapiro-Wilk methods, as all variables show significance results of $P<0.000$, i.e., below alpha.

The exploratory factor analysis identified a Kaiser - Meyer - Olkin sampling adequacy measure for egg producers and veterinarians of 0.558, while for consumers it was 0.79. Bartlett's test of sphericity is significant at $P=0.000 < \alpha < 0.0$. The degree of significance has a value of 0.000, i.e., the hypothesis of the identity matrix is rejected, and there is a correlation between the variables (Tables 2 and 3).

The total variance explained test for egg producers and veterinarians found that the first 8 components were able to account for 72.035 % of the cumulative variance representativeness of the selected items (Table 2). For consumers, the amount of total variance that is explained by each extracted factor is 3 factors, with a cumulative variance representativeness of 74.807 % (Table 3).

Table 2: Results of total variance explained for the questionnaire applied to egg producers and veterinarians

Component	Baseline eigenvalues			Sums of squared extraction charges			Sums of loads squared by rotation		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	5.122	23.283	23.283	5.122	23.283	23.283	3.424	15.565	15.565
2	2.296	10.435	33.718	2.296	10.435	33.718	2.458	11.171	26.736
3	2.011	9.140	42.858	2.011	9.140	42.858	2.001	9.097	35.833
4	1.709	7.769	50.627	1.709	7.769	50.627	1.775	8.068	43.901
5	1.309	5.948	56.575	1.309	5.948	56.575	1.634	7.425	51.326
6	1.198	5.444	62.019	1.198	5.444	62.019	1.535	6.978	58.304
7	1.113	5.060	67.080	1.113	5.060	67.080	1.521	6.913	65.217
8	1.090	4.955	72.035	1.090	4.955	72.035	1.500	6.818	72.035
9	.906	4.120	76.154						
10	.843	3.831	79.985						
11	.755	3.430	83.416						
12	.625	2.840	86.256						
13	.600	2.728	88.983						
14	.540	2.454	91.437						
15	.430	1.955	93.392						
16	.346	1.573	94.965						
17	.305	1.389	96.354						
18	.235	1.068	97.421						
19	.216	.982	98.404						
20	.163	.741	99.144						
21	.112	.511	99.655						
22	.076	.345	100.000						
Extraction method: principal component analysis.									
Kaiser-Meyer-Olkin measure of sampling adequacy						0,558			
Bartlett's test for sphericity						Approx. chi-square			
						364.243			
						gl			
						231			
						Sig.			
						0,000			

Table 3: Total variance explained results for consumers

Component	Baseline eigenvalues			Sums of squared extraction charges			Sums of loads squared by rotation		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.431	42.884	42.884	3.431	42.884	42.884	3.190	39.876	39.876
2	1.532	19.151	62.035	1.532	19.151	62.035	1.627	20.338	60.213
3	1.022	12.772	74.807	1.022	12.772	74.807	1.167	14.594	74.807
4	.808	10.096	84.902						
5	.443	5.537	90.439						
6	.395	4.934	95.373						
7	.238	2.980	98.352						
8	.132	1.648	100.000						

Extraction method: principal component analysis.

Kaiser-Meyer-Olkin measure of sampling adequacy	0,797
Bartlett's test for sphericity	Approx. chi-square
	1421.936
	gl
	28
	Sig.
	0,000

In the test of unidimensionality of the construct, as established by Kaiser's rule in the sedimentation graph, 8 factors were obtained according to the line drawn at the eigenvalue level for egg producers and veterinarians and 3 for consumers, which explain most of the total variability (Figures 1 and 2).

Figure 1: Questionnaire survey from egg producers and veterinarians

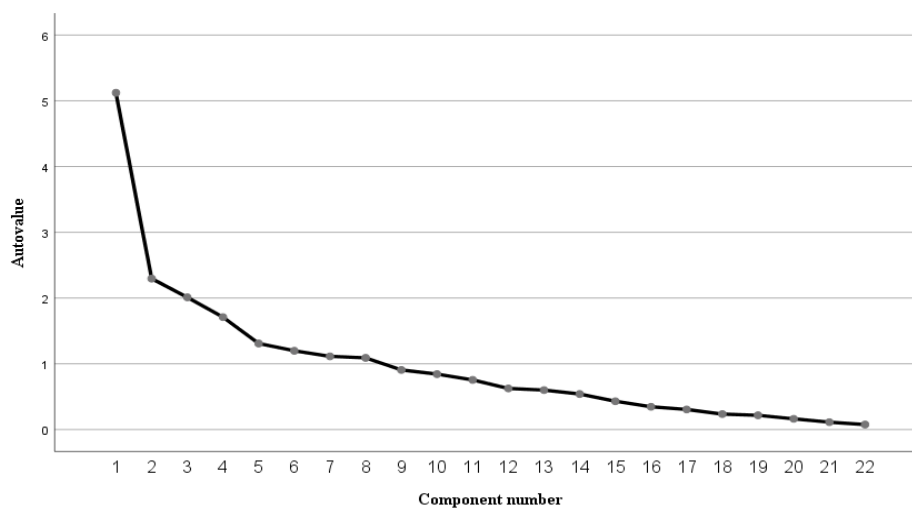
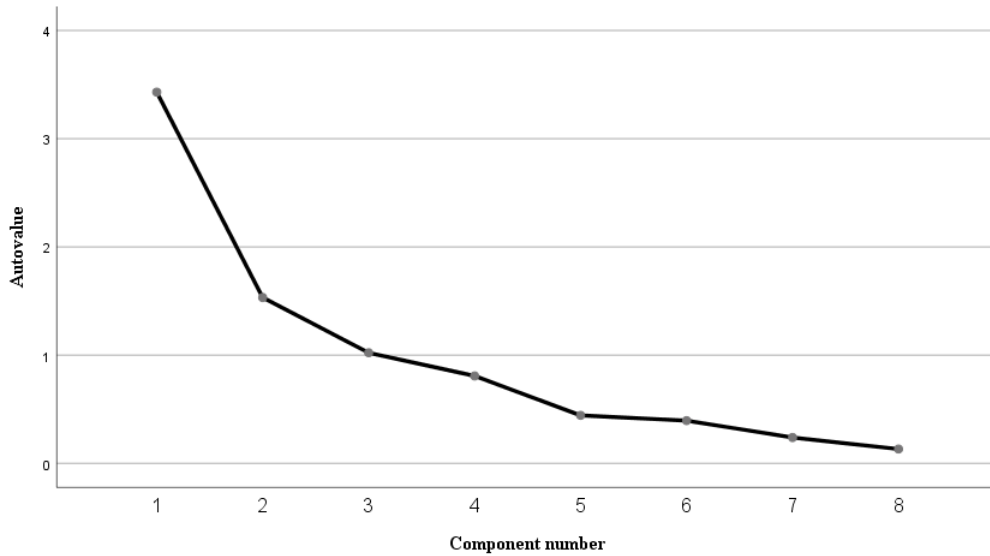


Figure 2: Questionnaire for egg consumers



Tables 4 and 5 of the rotated component matrix show the component data that were extracted, using the Varimax orthogonal rotation with Kaiser normalization, for eight components for egg producers and veterinarians and three components for consumers. The cut-off point as coefficient of factor loadings of the weights and weightings started at 0.5 within each factor, and the communality value was equal to or greater than 0.5.

The instrument or model studied for egg producers and veterinarians was structured with 22 items grouped into 9 factors or dimensions. For consumers, it was made up of 8 items and 3 factors or components.

Table 4: Rotated component matrix for egg producers and veterinarians

Rotated component matrix ^a										
Items	Component								Communality Extraction	
	1	2	3	4	5	6	7	8		
P1	.722									.762
P2	.694									.838
P3			-.718							.723
P6	.665									.681
P18						.865				.815
P8	.664									.678
P9	.732									.663
P28			.515							.670
P29								.819		.812
P17		.524			.616					.685
P14		-.673								.686

P16				.836	.789
P17				-.630	.771
P24	.664				.513
P15				.834	.793
P25				.817	.788
P26		.671			.633
P27	.616				.686
P19		.512			.647
P20				.592	.649
P10	.738				.663
P11	.788				.823

Extraction method: principal component analysis.
 Rotation method: Varimax with Kaiser normalization.
 a= Rotation has converged in 16 iterations.

Table 5: Rotated component matrix for consumers

Rotated component matrix ^a				
Items	Component			Communality Extraction
	1	2	3	
Q3	.925			.893
Q4	.903			.712
Q5	.867			.846
Q6	.843			.777
Q16		.871		.752
Q7		.863		.488
Q9			.851	.760
Q10			.607	.757

Extraction method: principal component analysis.
 Rotation method: Varimax with Kaiser normalization.
 a= Rotation has converged in 16 iterations.

The components according to the group of items, and to their internal consistency, that the model incorporates for egg producers and veterinarians are the following:

Factor 1, technical characteristics of the control and prescription of veterinary antibiotics, and knowledge and compliance with regulations for their use in poultry production. It comprises 9 items and accounts for 23.283 % of the total variance. For *Factor 2*, characteristics of veterinary antibiotics used in poultry production, accounts for 10.435 % of the total variance and contains 4 items. *Factor 3*, technical factors of poultry sanitary management and use of veterinary antibiotics, produces 9.140 % of the total variance and includes 4 items. *Factor 4*, time of duration of veterinary treatments when administered to

laying hens, is the cause of 7.769 % of the total variance and consists of 2 items. *Factor 5*, technical characteristics in the frequent application of veterinary antibiotics to laying hens, results in 5.948 % of the total variance and is grouped into 2 items. *Factor 6*, regular use of veterinary antibiotics in egg production and food safety, accounts for 5.444 % total variance, with a single item. *Factor 7*, technical characteristics of bird handling in the administration routes of veterinary antibiotics, has an explanatory value of 5.060 % of the total variance and is represented by 2 items. *Factor 8*, administrative management of the farms/veterinaries with respect to keeping records to establish traceability systems in the production, amounts to 4.955 % of the total variance and is represented by a single item.

The components extracted for the consumers incorporated into the model by group of items and their internal consistency are the following:

Factor 1, characteristic of egg consumption and frequency of consumption. It covers 42.884 % of the total variance, includes 4 items that have a positive correlation with the consumption of hen's eggs (table eggs) as food; the number of eggs consumed according to the frequency; the manner of egg consumption, and the frequency of consumption of eggs. *Factor 2*, purchase and verification of the quality and hygiene conditions of eggs at the point of sale (supermarket, market, other). This component accounts for 19.151 % of total variance and comprises 2 items and groups: when you buy the egg products, do you take notice of the packing date and expiration date and the type of commercial brand? Do you consider egg consumption to be safer than that of other foods? The latter corresponds to section 3. While, *Factor 3*, consumer perception of the presence of veterinary antibiotic residues in eggs and compliance with the regulations by poultry producers, represents the variables considered as consumer perception of compliance by poultry farmers with the sanitary measures in egg production. This component represents 12.772 % of the total variance, includes 2 items, and covers compliance of egg producers in the application of the Dominican animal health legislation to treat diseases in laying hens, as well as compliance with the withdrawal period of veterinary antibiotics in laying hens according to the antibiotic label when placing eggs on the market for consumption.

Discussion

The assessment of the potential risks of veterinary antibiotics in egg consumption and their impact on food safety is not easy to analyze due to various factors associated with the use of veterinary antibiotics. In this sense, this paper provides a practical tool to evaluate aspects related to the use of antibiotics and its role in ensuring food safety. In the present study, construct validity was assessed by means of an exploratory principal-component factor

analysis, and the internal consistency of the questionnaires was evaluated by means of Cronbach's alpha coefficient. Cronbach's alpha model in veterinary epidemiology has been applied very scarcely for the development, evaluation, and validation of questionnaires⁽¹³⁾; even so, it has been used in preventive veterinary medicine⁽¹⁴⁾, being useful for this research.

The content and logical validity assessments of the questionnaires by a group of experts were favorable. The majority of the surveyed professionals responded with a maximum score, indicating that they agreed with the format, wording, and usefulness of the questionnaire and that Cronbach's alpha model in veterinary epidemiology has been applied very scarcely for the development, evaluation, and validation of questionnaires.

The internal consistency of the questionnaires obtained a Cronbach's alpha of 0.799 for the egg producer/veterinarian questionnaire, and 0.771 for the consumers' questionnaire, indicating that the instruments have adequate reliability for the measurement of veterinary antibiotic use and the perception of food safety-related impact, respectively.

Regarding the construct validation, it was observed that the principal component analysis yielded 8 factors for the questionnaire for egg producers in poultry farms or veterinary establishments, and 3 factors for the consumer questionnaire, which associates the similarity of correlation between the variables of the evaluated study. This suggests that what has been described above constitutes a first insight into the perception by the farm owners, veterinarians, and consumers of the association that exists in the use and management of veterinary antibiotics or the use of antimicrobials in food production for human consumption.

The instrument applied to producers in egg farms and veterinary establishments and consumers was designed to evaluate the use of veterinary antibiotics in laying hens and the consumers' perception of the risk associated with table egg consumption and food safety. The results show that the hypothesis in the correlation matrix was positive between the variables with Bartlett's test of sphericity. The Kaiser-Meyer-Olkin (KMO) measures of sampling adequacy for egg producers and veterinarians (0.558) and consumers (0.797) have a high positive correlation, which indicates that their values are adequate because they range between 0 and 1, i.e., they are close to unity. These results coincide with those found by Salazar⁽¹⁵⁾, who obtained a relatively high KMO (of 0.725). A KMO of over 0.80 in the data matrix is appropriate for running the factorization⁽¹⁶⁾. In another study⁽¹⁷⁾, a high KMO value (0.94) was observed for the food estimation and food frequency section, where Bartlett's test of sphericity proved significant ($P < 0.001$), converging in 10 iterations and a six-factor structure.

The total variance tests of this study confirm that the variance matrix values, covariance, and percentage of each of the items, and the eigenvalues of the quantities of poultry production farms, veterinarians, and egg consumers are accounted for by each extracted factor and by

the related percentages in the equation model. The residual analysis for checking the goodness of fit of the utilized factorial model shows that the results of the differences between the initial observed correlation matrix and those reproduced by the model indicate that this value is considered an indicator of good fit as it is close to absolute zero.

The analysis of the resulting principal components that were above 0.5 according to the groups of items, both for egg producers/veterinarians and consumers, made it possible to determine the magnitude of the samples of the effect that the variables had on each one of the components that provide the best exposure of the initial variables obtained in each component, with their respective positive or negative factor loadings. Loadings of 0.50 can generally be considered strong and allow the magnitude of factor loadings to be evaluated as a function of sample size^(18,19). This allows the interpretation of the factor loadings that have an absolute value above 0.4 with their variance of the variables evaluated⁽²⁰⁾. In this sense, another validation study of the questionnaire on food estimation and frequency of food consumption⁽¹⁷⁾ found a correlation ≥ 0.40 with a reliability index of 0.92 for section estimation and of 0.90 for food frequency. The data found in this study allowed us to discriminate the variables with positive or negative factor loadings below 0.5, so that each of the dimensions of the instrument had acceptable values (≥ 0.5) and made it possible to perform the global scale analysis.

The domains or dimensions used for the evaluation of the use of veterinary antibiotic use and fowl management factors in poultry production are related to the items studied by Chah *et al*⁽²¹⁾ mainly in regard to the characteristics of antibiotic use in small-scale poultry farming, the knowledge, and the kinds and frequency of the antibiotics utilized in poultry farms. Speksnijder *et al*⁽²²⁾ also evaluated dimensions related to having a lower threshold for applying antibiotics to animals; their results resemble the ones obtained for the items evaluated in this research both in sections two and eight, on the characteristics of veterinary antibiotics used in poultry production and farm/veterinary administrative management, respectively.

Principal component analysis for the egg producers' and veterinarians' questionnaire confirmed that positive scores above 0.8 were related to such items as whether or not to vaccinate the birds regularly, the route of application of veterinary antibiotics, knowledge of the withdrawal periods of the antibiotics, keeping records of veterinary antibiotic applications, and treatment with antibiotics prohibited for birds. These findings prove that poultry producers adequately manage the following poultry components: 2) characteristics of veterinary antibiotics used in poultry production; 4) duration time of veterinary treatments administered to laying hens; 6) regular use of veterinary antibiotics in egg production and food safety; 7) technical characteristics of poultry handling in veterinary antibiotic administration routes, and 8) administrative management of farms/veterinaries with respect to keeping records to establish a production traceability system, respectively.

The highest score (0.9) for the consumer questionnaire was achieved in section or domain, characteristics of egg consumption, and frequency of egg consumption. The other assessed sections—including the consumers' perception of the presence of veterinary antibiotic residues in eggs and the verification of egg quality and hygiene conditions in sales outlets (supermarket, market, others)—have lower scores (≥ 0.6 and ≥ 0.8), which agree with the results obtained by other authors⁽¹⁷⁾. Studies carried out by various researchers^(23,24) assessed methods for developing food safety, knowledge, and attitude scales to determine criteria for reliability and validity. According to the study by Al-Makhroumi *et al*⁽²⁵⁾, in the three evaluated sections, the respondents had low food safety knowledge, with a value of 44 %, compared to the other sections such as good practices, with 70 %, and positive attitudes, with 77 %. Other researchers⁽²⁶⁾ found a moderately positive correlation between the mean scores of antibiotic knowledge and antibiotic use (0.55 $P < 0.001$), and a moderately positive correlation between the participants' mean scores on antibiotic resistance knowledge and their scores for knowledge of antibiotic use (0.41 $P < 0.001$). The results obtained from the consumers surveyed in this study show that the second domain, on the consumers' perception of the presence of veterinary antibiotic residues, and the third domain, of egg quality and hygiene verification at points of sale, have low scores compared to the first domain, on the egg consumption and frequency of consumption characteristics, indicating a lack of independent consumer awareness of poultry management practices and little knowledge of the antibiotics administered to laying hens.

Finally, in this study, in order to establish the model with a Cronbach's Alpha coefficient over 0.5, it was necessary to adjust the items, i.e., to eliminate some variables that could be important for future studies and discussions of the original model. Furthermore, as mentioned by Hernández and Amador⁽²⁷⁾, a confirmatory factor analysis should be performed to confirm the theory, as the purpose of the utilized factor analysis was to construct the theory.

Conclusions and implications

The results of the present study confirm the reliability and validity of the questionnaire items, finding a satisfactory fit between the use of veterinary antibiotics in egg production and egg consumption. The value of over 0.7 obtained for both questionnaires in the assessment of the validity and reliability of the results of Cronbach's Alpha coefficient shows that the established model fits the extracted components with their variance of over 50 %; this represents a strength of the research because the scale of competence used for the construct produces fast and reliable results that serve to measure the incidence or risks in the health of people due to the consumption of food contaminated through the use of veterinary antibiotics in laying hens as antimicrobials or as growth promoters for egg production.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board (or Ethics Committee) of the Iberoamerican International University (Universidad Internacional Iberoamericana) in the minutes registered with the number CR-181.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Annex 1: Questionnaires applied to poultry producers, veterinarians, and consumers
I. QUESTIONNAIRE APPLIED TO PRODUCERS AND VETERINARIANS

Section 1. General characteristics of egg producers, according to factors such as age, sex, name of the commercial establishment or poultry farm, sector, and province

1. Name of Business Establishment/ Poultry farm: _____
- Name of the respondent: _____
 - Age: _____
 - Sex: M F.
 - Sector: _____
 - Province: _____

Section 2. Technical characteristics of the control and prescription of veterinary antibiotics, and knowledge and compliance with regulations on their use in poultry production

Items	1 Totally disagree	2 Disagree	3 Neither agree nor disagree	4 Agree	5 Totally agree
2. Are vaccines and antibiotics used in egg production under prescription by a veterinary professional?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Do you have an antibiotic control or management program for egg production on the farm?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Do you have a veterinary professional in your establishment/poultry farm to guide and, if necessary, determine animal diseases and apply sanitary treatments?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Do you understand the national and international norms and regulations for poultry production and animal welfare?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Are you aware of the standards for the use of veterinary antibiotics to prevent the presence of harmful residues in food after treating an animal?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 3. Characteristics of veterinary antibiotics used in poultry production

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
7. Do you believe that veterinary antibiotics have a positive impact on bird welfare?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Do you know which antibiotics are prohibited by the Dominican government for use in egg production?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Do you know which veterinary antibiotics are most commonly used in poultry egg production?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Are you familiar with the following veterinary antibiotics: chloramphenicol, diethylstilbestrol (DES), and nitrofurans?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Have you treated the birds or sold one of these veterinary antibiotics (chloramphenicol, diethylstilbestrol (DES), and nitrofurans)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 4. Technical factors of poultry health management and use of veterinary antibiotics

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
12. Do you know which are the diseases that most frequently attack birds?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Do you understand that, in the case of birds, prevention is better than cure?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. For what types of treatments are veterinary antibiotics indicated? Please choose several options according to the type of antibiotic.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Respiratory and intestinal diseases.					
b. Prevention					
c. Growth promoter					
d. Hoarseness, aches and pains					
15. Have you applied any veterinary antibiotics to animals for which their use is not appropriate?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 5. Duration of veterinary treatments applied to poultry

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
16. What is the duration of preventive, curative, or topical treatments, according to the type of veterinary antibiotic?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. 3 days					
b. 4 to 7 days					
c. 5 days					
d. 10 days					
e. 15 days					
f. Curative, 5 to 7 days					
g. Preventive, 3 days					
h. 2 to 3 weeks					

Section 6. Frequent use of veterinary antibiotics in laying hens

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
17. What is the frequency of administration of antibiotics?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Every 24 hours					
b. Continually, every 24 hours					
c. Every 48 hours					
d. Every 72 hours					
e. Every 5 days					

Section 7. Regular use of veterinary antibiotics in egg production and food safety

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
18. Do you think that birds should be vaccinated regularly if they do not exhibit any apparent symptoms?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. Do you understand that national regulations regarding the use of veterinary antibiotics in poultry production are being complied with?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. Do you understand the harm that can be caused by veterinary antibiotics utilized for treating animal (poultry) health, if any, when the necessary	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

precautionary measures are not taken during the withdrawal period?

Section 8. Farm or veterinary administrative management

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
21. Do you keep records of veterinary antibiotic applications, whether preventive, curative, or topical?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. Do you understand that it is important to read the labels of veterinary products before applying them to animals?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. Do you comply with the warnings stipulated on the labels of veterinary antibiotics when administering them to animals?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. Do you frequently read the labels of veterinary products before applying them to animals?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 9. Withdrawal period of veterinary antibiotics prior to use of poultry products

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
25. Do you know the withdrawal times of veterinary antibiotics before application?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. Do you comply with the withdrawal times for veterinary antibiotics when applied to animals before the products and by-products are destined to the consumer?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. What is the withdrawal period of each of the antibiotics applied?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
• ___ 2 to 5 days					
• ___ 7 to 10 days					
• ___ 12 days					
• ___ 15 days					
• ___ 17 days					
• ___ 20 days					
• ___ 25 days					
• ___ 30 days					
• ___ Other					

Section 10. Management of poultry by route of administration of veterinary antibiotics

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
28. Do you know at what age class the veterinary antibiotics are applied to the animals in egg production?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. Which is the most recommended route of application of the veterinary antibiotics recommended to poultry producers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Oral route					
b. Subcutaneous route (injected)					
c. Ocular route					
d. Spray					

II. FOOD SAFETY QUESTIONNAIRE ON THE CONSUMPTION OF FOOD CONTAMINATED WITH VETERINARY ANTIBIOTICS

Section 1. General consumer characteristics

1. Consumer characteristics:

1. Age: _____.
2. Sex: M F.
3. Sector: _____, Province: _____

Section 2. Characteristics of egg consumption such as quantity and frequency

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
2. Have you ever been sick from eating contaminated food?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Do you consume hen's eggs (table eggs) as food?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. How often do you consume eggs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Every day					
b. Every other day					
c. Every 3 days					
d. Every 5 days					
e. Weekly					
f. Does not know					
5. How many eggs do you eat, by frequency? Please specify:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Less than one egg					
b. 1 egg					
c. 2 eggs					
d. 3 eggs					
e. 4 eggs					
f. More than 5 eggs					
6. When you eat eggs, how do you eat them? Please choose one of the following options:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Fresh and raw					
b. Boiled or hard-boiled					
c. Poached					
d. Fried or scrambled					
e. Frozen cooked					
f. Pastry					

Section 3. Consumer perception of veterinary antibiotic residues in eggs and poultry producers' compliance with regulations

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
7. Do you consider that it is safer to consume eggs than other foods?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Do you consider that domestically produced eggs may contain veterinary antibiotic residues?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Do you understand that egg producers comply with Dominican animal health legislation for treating diseases in laying hens?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Do you believe that egg producers comply with the withdrawal period of veterinary antibiotics in laying hens as specified on the label when they put egg products on the market for consumption?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Do you understand that organically produced eggs may contain veterinary antibiotics?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 4. Relationship between egg consumption and intoxications due to egg ingestion

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
12. Have you ever been intoxicated by the ingestion of eggs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. How many times have you been poisoned by eating contaminated eggs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Once					
b. Twice					
c. Thrice					
d. 4 times					
e. More than 5 times					
14. After getting sick, have you had any tests done to determine the reason for your illness?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15. Have you changed your consumption habits as a result of this situation of getting sick from the consumption of this product?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 5. Purchase and verification of the quality and hygiene conditions of eggs at the point of sale (supermarket, market, etc.)

Items	1 Totally disagree	2 Disagree	3 Neither disagree nor agree	4 Agree	5 Totally agree
16. When you buy egg products, do you take notice of the packing date, expiration date, and brand name?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. Do you check the quality and hygienic conditions of eggs when you purchase them, such as whether they are dirty or broken?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>