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Article

A Spanish Survey on the Perioperative use of Antimicrobials in Small Animals

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Simple Summary: Inappropriate use of antimicrobials during surgeries in small animals can lead to the emergence of drug-resistant bacteria, increased costs, and disruption of natural microorganisms. To address this issue, a survey was conducted among Spanish veterinarians to evaluate their current practices regarding antimicrobial use in perioperative settings. The survey revealed that a significant proportion of participants administered antimicrobials before and after surgeries, even in cases where they may not be necessary. Factors such as the level of wound contamination, patient's weakened immune system, and use of influenced antimicrobial selection. Moreover, participants without postgraduate training were more likely to misuse antimicrobials. This highlights the need for evidence-based guidelines and education to ensure proper antimicrobial usage, reducing risks and costs while promoting the overall well-being of animals undergoing surgery.

Abstract: Appropriate use of perioperative antimicrobials can significantly reduce the risk of postoperative infections. However, inappropriate antimicrobial use can result in the creation of multidrug resistant bacteria, increased costs, host flora disruption, side effects, and increased risk of hospital-acquired infections This survey evaluated the current perioperative use of antimicrobials in small animals by Spanish veterinarians using a web-based questionnaire. Responses were represented using descriptive statistics and a statistical analysis of the association between demographic data and perioperative antimicrobial use was performed. Preoperative antimicrobials were administered in clean surgery by up to 68.3% of participants, 81.0% in clean-contaminated surgery and 71.3% in dirty surgery, while in the postoperative period, antimicrobials were administered by up to 86.3% of participants in clean surgery, 93.2% in clean-contaminated surgery and 87.5% in dirty surgery. Factors considered "very important" for antimicrobial selection were the degree of wound contamination, patient immunosuppression, and use of prosthesis. The most frequently used antimicrobial was beta-lactamase-resistant penicillin. Postoperative antimicrobial use was associated with participants without postgraduate training. This study highlights an overuse of antimicrobials in perioperative procedures in small animal surgery in Spain. Therefore, evidence-based guidelines and further education regarding the correct use of antimicrobial prophylaxis are recommended.

Keywords: nosocomial infections; questionnaire; veterinarians; small Animals; nntimicrobial use.

1. Introduction

Nosocomial infections, including surgical site infections (SSI), and multidrug resistant bacteria, constitute an important and growing challenge for human and veterinary medicine. These infections increase morbidity, mortality and hospital stays, especially in Intensive Care Units, which translates into economic losses [1–3]. Different veterinary medicine studies specifically evaluating SSI described this complication in 3.0–8.7% of small animal surgeries, with significant variation between different surgical procedures [4–10]. SSIs lead to several negative outcomes in human and veterinary medicine including tissue destruction, prolonged wound healing, longer hospital stays, and increased direct patient costs and mortality [11–13].

Appropriate perioperative antimicrobial use can significantly reduce the risk of postoperative SSI and mortality in human medicine [13–15]. However, inappropriate and uncontrolled use of antimicrobial therapies can result in the emergence of multidrug resistant bacteria, increased costs, alteration of normal host flora, drug side effects, and increased risk of hospital-acquired infections [4,16–19]. The World Health Organization (WHO) expressed concerns over the current situation surrounding the use of and resistance to antimicrobials, arguing that antimicrobial resistance is a major threat to human health, requiring greater awareness about the adequate prophylactic use of perioperative antimicrobials [20]. Most guidelines for the use of preoperative antimicrobials in human medicine are based on studies that compare SSI incidence when perioperative antimicrobials are used and the anticipated level of contamination during the surgical procedure (clean, clean-contaminated, contaminated, and dirty) [21–24]. However, guidelines in veterinary medicine [8,13] are usually based on recommendations from current veterinary practice and the available human medicine literature [15,22,25–27].

Some surveys have previously evaluated perioperative antimicrobial use in veterinary medicine [28–30]. A survey performed in the United Kingdom, described the use of antimicrobials in clean surgery in up to 25% of small (<1cm) lumpectomies and 32% of prescrotal castrations [29]. Additionally, 66% of respondents reported administering antimicrobials before surgery [29]. A Colombian survey about antimicrobial use in different clinical contexts reported perioperative antimicrobial use in elective ovariohysterectomies and castrations by up to 86% of participants [28]. One retrospective study in horses undergoing arthroscopic surgery found that perioperative antimicrobial use routinely ignored standard recommendations for perioperative prophylaxis [30].

To the authors’ knowledge, this is the first study evaluating the current use of perioperative antimicrobials in small animal surgery in Spain. Therefore, the aims of this study were: (1) to describe current practices for perioperative antimicrobial use in Spain; (2) to identify factors that influence decision making about antimicrobial use; (3) to determine the most commonly used antimicrobial agents and their administration route and (4) to compare data for perioperative antimicrobial use with participant demographic data. Additionally, our hypotheses were that (1) overuse of perioperative antimicrobials would be observed with the majority of participants; (2) decision making factors considered important by previous surveys would influence participant decision making regarding antimicrobial use; (3) the most commonly used antimicrobial agent would be the first-generation cephalosporin and (4) less trained participants would be more inclined to administer antimicrobials more often.

2. Materials and Methods

A web-based questionnaire (Appendix A and B) using an online platform (Google Forms®) was designed to evaluate the current perioperative use of antimicrobials in small animal surgery. The Google Forms system, although anonymous, avoids duplication in the event of a user attempting to fill in the survey from the same email address more than once. The survey was based on a previous questionnaire about perioperative antimicrobial use [29], and the clinical experience of the authors. Prior to distribution, the questionnaire was tested by 11 small animal surgeons to evaluate its quality and to correct any ambiguous, misleading, or inappropriate language.

Although the survey had no time limit, it was designed to be completed in 15 minutes. Respondents were able to review and change their answers before submitting the questionnaire. The questionnaires were sent from April 1st to September 1st, 2018, by e-mail to 5,371 registered AVEPA members, including 2,416 males (45.0%) and 2,995 females (55.0%). The questionnaire was anonymous and had no incentives attached. All participants signed an informed consent for the analysis of submitted data [31].

The questionnaire was divided into three sections: 1) demographic data; 2) perioperative antimicrobial use and factors that influence their use; and 3) "agree or disagree" statements related to perioperative antimicrobial use and the emergence of bacterial resistance.

The first section (Section 1) included questions to ascertain each participant's demographic information, including: gender, university where the respondent obtained their veterinary degree, and postgraduate surgical training (non-surgical training, ECVS/ACVS diploma, postgraduate masters, postgraduate course, PhD related to small animal surgery), percentage of time dedicated annually to small animal clinical practice (less than and more than 75 % of their activity dedicated to small animal veterinary practice), years of experience and percentage of time dedicated annually to small animal surgery (divided into less than and more than 75 % of their activity dedicated to surgery). Regarding the centre where the respondent practiced professionally, information was gathered on the type of veterinary facility (public or private), geographical region in Spain, total number of veterinarians, number of veterinarians performing surgeries and total number of veterinary assistants.

The second section (Section 2) was further classified in six parts related to the prophylactic use of antimicrobials during the perioperative period and the criteria applied to determine their use. The first part considered the frequency of use (never, rarely, sometimes, usually, always) of pre- and postsurgical antimicrobial therapy for different types of hypothetical surgeries, depending on the degree of contamination. The procedures investigated were the surgeries most commonly performed in small animal practices, classified as clean, clean-contaminated, contaminated and dirty, by the National Research Council (NRC) [21–24]. The following procedures were included: routine laparotomy ovariohysterectomy in dogs, routine laparotomy ovariohysterectomy in cats, routine orchiectomy in cats, nodulectomy of non-ulcerated 2 cm skin nodules in dogs and closed fracture of the femur with internal fixation in dogs (classified as clean surgery); ovariohysterectomy for open pyometra in dogs, excision of lip mass in dogs, enterotomy for a foreign body and tarsorrhaphy (classified as clean contaminated); cystotomy with urinary tract infection (considered contaminated surgery) and acute traumatic wound in dogs (classified as dirty surgery). The second part assessed the importance of patient and surgical factors when deciding on antimicrobial use, giving each factor a score from 1 to 5 (1=not important; 5=very important). The factors included: degree of wound contamination, possibility of evisceration, patient immunosuppression, presence of a drain, use of a prosthesis, acquisition of surgical preparation standards, preoperative presence of prostheses, impaired physical condition of the patient, surgery time, hollow viscus incision, emergency surgery versus routine surgery, level of clinical experience, hospitalization time and presence of an intravenous catheter. Subsequently, the third part of section 2 contained 12 different classes of antimicrobial agent. Each participant was asked to rank them according to frequency of use from 1 to 12 (1 = least used; 12 = most used). The classes of antimicrobial agent reported in this study included: beta-lactamase-resistant penicillins (e.g. amoxicillin-clavulanic acid), beta-lactamase-sensitive penicillins (e.g. amoxicillin), first-generation cephalosporins (e.g. cefazolin, cephalexin), third-generation cephalosporins (e.g. cefovecin), fluoroquinolones (e.g. enrofloxacin, marbofloxacin), nitroimidazoles (e.g. metronidazol), potentiated sulfonamides (e.g. sulfamethoxazole - trimethoprim), tetracyclines (e.g. doxycycline), macrolides (e.g. erythromycin), lincosamides (e.g. clindamycin), aminoglycosides (e.g. gentamicin, amikacin), and phenicols (e.g. chloramphenicol, florfenicol). The fourth part considered the importance of factors determining antimicrobial selection, giving each factor a score from 1 to 5 (1=not important; 5=very important). Factors pertaining to antimicrobial choice included potency, activity spectrum, duration of activity, intensity of side effects, bactericidal *versus* bacteriostatic, license for veterinary use, potential to produce microbial resistance, available routes of administration, cost, and shelf life. Additionally, wound location and recommended clinical action protocols were also included. The fifth part considered the administration routes (subcutaneous, intravenous, intramuscular, oral and topical) and time (route not used, before, during and after surgery, and postoperative time) for the chosen antimicrobial. Additionally, the sixth section evaluated how frequently a given information source was used, giving a score from 1 to 4 (1 = least used; 4 = most used). These sources included books/drug use guidelines, prospectus/vademecum and conference proceeding/scientific articles which were consulted to choose the appropriate agent and determine its administration regime.

The third section (Section 3) included 11 agree or disagree statements about issues frequently related to perioperative antimicrobial use, including the effectiveness of preoperative and postoperative antimicrobial administration in reducing the risk of wound SSI in clean and clean-contaminated surgeries, the effectiveness of preoperative and postoperative antimicrobial administration reducing the risk of SSI in contaminated surgical wounds, owners' agreement with the cost of administering antimicrobials, the need for antimicrobial prophylaxis in all surgical procedures, and the need for preoperative and postoperative antimicrobials in all surgical procedures. Additionally, a statement regarding the potential negative impacts of inappropriate antimicrobial use in small animals, leading to bacterial resistance, was included.

Statistical analysis

A statistical analysis was performed to verify any association between the participant demographic data and data for perioperative antimicrobial use.

Categorical variables were presented as percentages. For continuous variables, data distribution normality was evaluated with the Kolmogorov-Smirnov test. Normal continuous distribution data were presented as a mean (± standard deviation) while non-normal continuous distributions were presented as medians (interquartile range [IQR]). Ordinal data were expressed as percentages, median and IQR. A univariate logistic regression model was performed to compare the demographic data of the participants with the pre- and postoperative antimicrobial use. For statistical analysis, frequency of use of pre- and postsurgical antimicrobial therapy for different types of hypothetical clean surgeries (including laparotomy ovariohysterectomy in dogs and cats, and orchiectomy in dogs and cats) were categorized as never, rarely, sometimes, usually and always; however, due to the low number of cases meeting a particular classification, this variable had to be reclassified as low-frequency (never, rarely and sometimes) and high-frequency (including usually and always). Surgical training was classified as non-surgical training, ECVS/ACVS diploma, postgraduate master, postgraduate course and PhD related to small animal surgery. However, similar to the previous parameter, the low number of participants with postgraduate training meant that this variable had to be reclassified as non-surgical postgraduate training and surgical postgraduate training (ECVS/ACVS diploma, postgraduate master, postgraduate course and PhD related to small animal surgery). Demographic variables including gender (man/woman), total number of veterinarians (≤ 3/ >3), number of surgeons out of the total number of veterinarians at the centre (≤ 2/ > 2), and years of

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experience (≤ 14 / > 14) were obtained. A multivariate regression model was constructed based on the univariate regression model. Variables with a p-value < 0.100 in the univariate regression analysis were deemed significant and included in the multivariate logistic regression analysis. The final model was developed using a stepwise forward selection and backward elimination approach. The significance levels for the forward selection and backward elimination steps were set at $p < 0.050$ and $p < 0.100$, respectively. Effect estimates and a 95% confidence interval (CI) were calculated and presented as odds ratio (OR). STATA statistical package (StataCorp, 13.1., TX, USA) was used for the analysis. A p value of <0.050 was considered statistically significant.

3. Results

3.1. Demographic data (Section 1 of the Questionnaire)

Questionnaires were answered by 558 (10.4% response rate) small-animal veterinary practitioners (44.6% males and 55.4% females) throughout Spain. Most participants (99%) had completed their degree at a Spanish university. Fifty-seven percent of the participants had no surgical training, 28.0% had some postgraduate training, 6.5% had a postgraduate masters, 5.2% had a PhD related to small animal surgery and 2.7% an ECVS diploma. Ninety-seven percent of participants worked in centres with more than 75% of their activity dedicated to small animal veterinary practice. The percentage of participants performing a high number of surgeries (more than 75% of total work) was 11.5%. Of the total number of participants, 92.8% of veterinarians worked at a private facility. The highest number of responses was obtained from veterinarians working in Madrid (23.5%) and Catalonia (17.0%). The median number of years of experience of participants was 14 (IQR 7 - 24 years). The median number of veterinarians working at the respondent's centre was 3.0 (IQR 2.0-7.5), of whom 2.0 (IQR 2.0-3.0) performed surgery. Additionally, the median number of veterinary technicians working at the respondent's centre was 2.0 (IQR 1.0-3.0). Demographic data collected during the study are shown in Table 1.

Table 1. Demographic data of survey participants (N=558).

Variable	Category	Respondents (%)	Respondents (n)
Gender	Female	55.4	249
	Male	44.6	309
University where respondent obtained their Veterinary degree	Faculty of Barcelona (UAB)	0.9	5
	Faculty of Córdoba	16.7	93
	Faculty of Las Palmas de Gran Canaria	8.2	46
	Faculty of Cáceres	2.3	13
	Faculty of León	3.9	22
	Faculty of Lugo	7.9	44
	Faculty of Madrid (UCM)	7.3	41
	Private University Alfonso X El Sabio	21.7	121
	Faculty of Murcia	5.2	29
	Private University Cardenal Herrera CEU Valencia	5.6	31
	Private University Católica de Valencia San Vicente Mártir	3.4	19
	Faculty of Zaragoza	16.8	94
Postgraduate training in surgery	No surgical training	57.7	322
	ECVS/ACVS Diploma	2.7	15
	Postgraduate masters	6.5	36
	Postgraduate course	28.0	156
	PhD related to small animal surgery	5.2	29
Percentage of activity of the veterinary clinic dedicated to small animals (%)	≤ 75	3.0	17
	> 75	97.0	541
Annual average percentage dedicated to small animal surgery (%)	≤ 75	79.9	446
	> 75	20.1	112
Type of veterinary centre	Public	7.2	40
	Private	92.8	518
Autonomous communities of Spain where you currently work	Andalucía	8.4	47
	Aragón	5.4	30
	Principado de Asturias	3.0	17
	Islas Baleares	4.1	23
	Canarias	4.7	26
	Cantabria	1.6	9

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	Castilla La Mancha	1.8	10
	Castilla y León	5.9	33
	Cataluña	17.0	95
	Comunidad Valenciana	6.8	38
	Extremadura	1.8	10
	Galicia	6.6	37
	La Rioja	1.3	7
	Comunidad de Madrid	23.5	131
	Comunidad Foral de Navarra	1.1	6
	País Vasco	5.0	28
	Región de Murcia	2.0	11
Years of experience		14.0 *	(7.0-24.0)**
Total number of veterinarians		3.0 *	(2.0-7.5)**
Surgeons out of the total number of veterinarians in the center.		2.0*	(2.0-3.0)**
Total number of veterinary assistants		2.0*	(1.0-3.0)**

*Median; **IQR

3.2. Prophylactic use of antimicrobials in the perioperative period and factors that determine their use (Section 2 of the Questionnaire)

3.2.1. Antimicrobial use in pre- and postoperative procedures

All participants answered all the questions about antimicrobial use in pre- and postoperative procedures (Table 2). For the hypothetical cases of clean surgery, preoperative antimicrobials were always used by 44.6-68.3% of participants and never used by 15.1-42.0% of them. Preoperative antimicrobials were always used by 43.4-81.0 % of participants and never used by 2.6-32.4% of respondents in the different clean-contaminated surgeries. Finally, in surgeries considered dirty, preoperative antimicrobials were always used by 71.3% of participants but never by 8.1%.

Table 2. Frequencies and percentages of veterinarians who use perioperative antimicrobials for ovariohysterectomy and orchiectomy in dogs and cats.

Type of surgery	Use of antimicrobials pre/post	Frequency (%) of respondents who perform this surgery					Respondents who do not perform this type of surgery N (%)
		Never	Rarely	Sometimes	Usually	Always	
Clean	Routine laparotomy ovariohysterectomy in dog pre	28.8	9.9	4.5	2.2	54.6	23 (4.1)
	Routine laparotomy ovariohysterectomy in dog post	9.5	9.1	5.2	8.0	68.1	22 (3.9)
Clean	Routine laparotomy ovariohysterectomy in cat pre	33.8	7.9	2.8	2.8	52.6	29 (5.2)
	Routine laparotomy ovariohysterectomy in cat post	12.5	10.0	7.8	8.7	61.1	29 (5.2)
Clean	Routine orchiectomy in dog pre	39.0	6.1	3.5	3.1	48.3	14 (2.5)
	Routine orchiectomy in dog post	16.1	12.3	7.5	8.1	56.0	12 (2.2)
Clean	Routine orchiectomy in cat pre	42.0	4.9	2.9	3.3	46.9	19 (1.8)
	Routine orchiectomy in cat post	29.7	19.7	7.5	8.8	34.3	10 (1.8)
Clean	Excision of a 2-cm, non-ulcerated skin nodule in dog pre	36.2	8.7	4.6	5.9	44.6	16 (2.9)
	Excision of a 2-cm, non-ulcerated skin nodule in dog post	15.4	14.5	15.8	15.3	39.0	14 (2.5)
Clean	Closed fracture of the femur, with internal fixation in dog pre	15.1	4.1	6.3	6.3	68.3	142 825.4)
	Closed fracture of the femur, with internal fixation in dog post	2.4	2.9	2.9	5.5	86.3	143 (25.6)
Clean-contaminated	Ovariohysterectomy for open pyometra in dog pre	2.6	1.8	6.0	8.6	81.0	12 (2.2)
	Ovariohysterectomy for open pyometra in dog post	2.4	0.7	1.5	2.2	93.2	11 (2.0)
Clean-contaminated	Tarsorrhaphy in dog pre	32.4	9.2	8.9	6.0	43.4	112 (20.1)
	Tarsorrhaphy in dog post	16.6	11.4	18.6	11.9	41.5	112 (20.1)
Clean-contaminated	Enterotomy for a foreign body, without discharge of content into the abdominal cavity in dog pre	11.5	6.9	11.1	10.5	60.1	34 (6.1)
	Enterotomy for a foreign body, without discharge of content into the abdominal cavity in dog post	2.9	2.7	3.8	5.9	84.7	34 (6.1)

Clean-contaminated	Excision of lip mass in dog pre	26.8	8.0	9.9	6.1	49.2	32 (5.7)
	Excision of lip mass in dog post	10.1	9.5	15.4	14.5	50.5	33 (5.9)
Contaminated	Cystotomy with urinary tract infection in dog pre	3.7	2.5	5.8	8.3	79.8	39 (7)
	Cystotomy with urinary tract infection in dog post	1.9	0.4	1.4	2.5	93.8	40 (7.2)
Dirty	Surgery for an acute traumatic wound in dog pre	8.1	3.7	8.1	8.8	71.3	14 (2.5)
	Surgery for an acute traumatic wound in dog post	1.5	1.3	5.0	4.8	87.5	15 (2.7)

By contrast, 34.3-86.3% and 2.5-29.7% of participants reported always or never using postoperative antimicrobials in clean surgeries, respectively. Postoperative antimicrobials were always used by 41.5-93.2% of participants and never used by 1.9-16.6 % of respondents in the different clean-contaminated surgeries. Finally, for dirty surgeries, postoperative antimicrobials were always used by 87.5% of participants and never used by 1.5%.

3.2.2. Relevance of criteria for determining antimicrobial use

Perioperative factors considered "very important" for antimicrobial selection were degree of wound contamination (median 5, IQR 5-5, n=557), patient immunosuppression (median 5, IQR 4-5, n=557), and whether the surgical procedure involved using a prosthesis (median 5, IQR 4-5, n=545). Factors considered of intermediate importance were possibility of evisceration (median 4, IQR 3-5, n=557), presence of a drain (median 4, IQR 3-5, n=556), surgical preparation standards (median 4, IQR 3-5, n=551), impaired physical condition of the patient (median 4, IQR 3-5, n=557), surgery time (median 4, IQR 3-5, n=556), hollow viscus incision and emergency surgery (median 4, IQR 3-5, n=549). The factors considered "unimportant" included the presence of an intravenous catheter (median 3, IQR 2-3, n=546), length of hospital stay (median 3, IQR 2-4, n=548), and surgeon's level of experience (median 3, IQR 2-4, n=553) (Table 3).

Table 3. Number of respondents, percentage and median score of veterinarians who ranked different factors in the decision to use perioperative antimicrobials.

Factors	1 (%)	2(%)	3 (%)	4 (%)	5 (%)	n	Median	25	75
Degree of wound contamination	4 (0.7)	6 (1.1)	18 (3.2)	87 (15.6)	442 (79.4)	557	5.0	5.0	5.0
Possibility of evisceration	69 (12.4)	60 (10.8)	104 (18.7)	139 (25.0)	185 (33.2)	557	4.0	3.0	5.0
Patient immunosuppression	8 (1.4)	13 (2.3)	60 (10.8)	160 (28.7)	316 (56.7)	557	5.0	4.0	5.0
Presence of a drain	14 (2.5)	30 (5.4)	124 (22.3)	193 (34.7)	195 (35.1)	556	4.0	3.0	5.0
Surgery with use of a prosthesis	9 (1.7)	16 (2.9)	67 (12.3)	132 (24.2)	321 (58.9)	545	5.0	4.0	5.0
Surgical preparation standards	28 (5.1)	31 (5.6)	111 (20.1)	125 (22.7)	256 (46.5)	551	4.0	3.0	5.0
Preoperative presence of prostheses	56 (10.3)	55 (10.1)	149 (27.4)	120 (22.1)	164 (30.1)	544	4.0	3.0	5.0
Impaired physical condition of the patient	22 (3.9)	29 (5.2)	92 (16.5)	177 (31.8)	237 (42.5)	557	4.0	3.0	5.0
Surgery time	23 (4.1)	65 (11.7)	110 (19.8)	143 (25.7)	215 (38.7)	556	4.0	3.0	5.0
Hollow viscus incision	18 (3.3)	36 (6.6)	116 (21.1)	172 (31.3)	207 (37.7)	549	4.0	3.0	5.0

Emergency surgery *versus* routine surgery	45 (8.2)	45 (8.2)	167 (30.4)	145 (26.4)	147 (20.4)	549	4.0	3.0	5.0
Level of clinical experience	91 (16.5)	61 (11.0)	144 (26.0)	144 (26.0)	113 (20.4)	553	3.0	2.0	4.0
Hospitalization time	77 (14.0)	88 (16.0)	178 (32.4)	130 (23.8)	75 (23.8)	548	3.0	2.0	4.0
Presence of an intravenous catheter	129 (23.6)	129 (23.6)	156 (28.6)	80 (14.7)	52 (9.5)	546	3.0	2.0	3.0

3.2.3. Antimicrobial agents and drug classes used

All participants answered all the questions about different classes of antimicrobial agent used. The most frequently used antimicrobials were beta-lactamase-resistant penicillins, such as amoxicillin-clavulanic acid (median 8, IQR 7-12), followed by first-generation cephalosporins, such as cefazolin or cephalexin (median 7, IQR 5-10). Fluoroquinolones, such as enrofloxacin and marbofloxacin (median 6, IQR 4-9), nitroimidazoles such as metronidazole (median 6, IQR 3-8) and third-generation cephalosporins, such as cefovecin (median 6, IQR 3-8) constituted the third most used antimicrobials. Beta-lactamase-sensitive penicillins, such as amoxicillin (median 4, IQR 1-8) and tetracyclines, such as doxycycline (median 4, IQR 1-6) were less common. Aminoglycosides (gentamicin and amikacin: median 1, IQR 1-3), phenicols (chloramphenicol and florfenicol: median 1, IQR 1-1.25), macrolides such as erythromycin (median 1, IQR 1-2) and potentiated sulphonamides, such as sulfamethoxazole-trimethoprim (median 2, IQR 1-5) represented the least used drugs (Table 4).

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Table 4. Ranking of antimicrobials according to their frequency of use, median, and interquartile range. Frequency of antimicrobial use ranged from 1 to 12 (1 = least used; 12 = most used).

Antimicrobials	0 (%)	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	9 (%)	10 (%)	11 (%)	12 (%)	n	Median	25	75
Beta lactamase resistant penicillins (eg. amoxicillin-clavulanic acid)	7 (1.3)	27 (4.8)	20 (1.8)	11 (2.0)	11 (2.0)	20 (3.6)	25 (4.5)	36 (6.5)	149 (26.7)	5 (0.9)	18 (3.2)	31 (5.6)	208 (37.3)	558	8,0	7,0	12,0
Beta lactamase sensitive penicillins (eg. amoxicillin)	58 (10.4)	135 (24.2)	37 (6.6)	32 (5.9)	30 (5.4)	41 (7.3)	41 (7.3)	37 (6.6)	51 (9.1)	12 (2.2)	22 (3.9)	23 (4.1)	38 (6.8)	558	4,0	1,0	8,0
1st generation cephalosporins (eg Cefazolin, cephalexin)	19 (3.4)	31 (5.6)	24 (4.3)	22 (3.9)	32 (5.7)	37 (6.6)	58 (10.4)	57 (10.2)	88 (15.8)	24 (4.3)	46 (8.2)	66 (11.8)	54 (9.7)	558	7,0	5,0	10,0
3rd generation cephalosporins (e.g. cefovecin)	26 (4.7)	47 (8.4)	51 (9.1)	51 (9.1)	48 (8.6)	53 (9.5)	54 (9.7)	56 (10.0)	41 (7.3)	41 (7.3)	57 (10.2)	22 (3.9)	11 (2.0)	558	6,0	3,0	8,0
Fluoroquinolones (e.g. enrofloxacin, marbofloxacin)	9 (1.6)	28 (5.0)	21 (3.8)	52 (9.3)	53 (9.5)	66 (11.8)	64 (11.5)	45 (8.1)	65 (11.6)	50 (9.0)	48 (8.6)	41 (7.3)	16 (2.9)	558	6,0	4,0	9,0
Nitroimidazoles (e.g. metronidazol)	29 (5.2)	46 (8.2)	27 (4.8)	53 (9.5)	50 (9.0)	62 (11.1)	55 (9.9)	47 (8.4)	78 (14.0)	39 (7.0)	33 (5.9)	24 (4.3)	15 (2.7)	558	6,0	3,0	8,0
Potentiated sulfonamides (e.g. Sulfamethoxazole - trimethoprim)	68 (12.2)	172 (30.8)	78 (14.0)	40 (7.2)	50 (9.0)	41 (7.3)	47 (8.4)	25 (4.5)	14 (2.5)	10 (1.8)	7 (1.3)	4 (0.7)	2 (0.4)	558	2,0	1,0	5,0
Tetracyclines (e.g. doxycycline)	54 (9.7)	120 (21.5)	47 (8.4)	52 (9.3)	50 (9.0)	68 (12.2)	48 (8.6)	43 (7.7)	39 (7.0)	13 (2.3)	12 (2.2)	8 (1.4)	4 (0.7)	558	4,0	1,0	6,0

Macrolides (e.g. erythromycin)	119 (21.3)	262 (47.0)	65 (11.6)	50 (9.0)	18 (3.2)	14 (2.5)	10 (1.8)	12 (2.2)	3 (0.5)	2 (0.4)	1 (0.2)	0 (0)	2 (0.4)	558	1,0	1,0	2,0
Lincosamides (e.g. clindamycin)	82 (14.7)	153 (27.4)	78 (14.0)	56 (10.0)	56 (10.0)	35 (6.3)	35 (6.3)	29 (5.2)	15 (2.7)	9 (1.6)	5(0.9)	5(0.9)	0 (0)	558	2,0	1,0	4,0
Aminoglycosides (e.g. gentamicin, amikacin)	104 (18.6)	216 (38.7)	86 (15.4)	57 (10.2)	24 (4.3)	31 (5.6)	16 (2.9)	7 (1.3)	6 (1.1)	4 (0.7)	4 (0.7)	2 (0.4)	1(0.2)	558	1,0	1,0	3,0
Phenicols (e.g. chloramphenicol, florfenicol)	119 (21.3)	300 (53.8)	58 (10.4)	30 (5.4)	14 (2.5)	10 (1.8)	14 (2.5)	4 (0.7)	5 (0.9)	1 (0.2)	1 (0.2)	0 (0)	2 (0.4)	558	1,0	1,0	1,3

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3.2.4. Importance of antimicrobial characteristics influencing antimicrobial selection

The antimicrobial characteristic that most influenced antimicrobial choice was the spectrum of activity, classified as "very important" (median 5 IQR 4.25-5, n=556), followed by duration of activity (median 4 IQR 3-5, n=552), intensity of side effects (median 4 IQR 3-5 n=554), bactericidal versus bacteriostatic (median 4 IQR 3-4, n=552), potential to produce microbial resistance (median 4 IQR 3-5, n=552), available administration routes (median 4 IQR 3-5, n=555), wound location (median 4 IQR 3-4, n=554) and recommended clinical action protocols (median 4 IQR 3-5, n=552). Less important factors were the license for use in veterinary medicine (median 3 IQR 2-4, n=553), cost (median 3 IQR 2-4, n=554) and half-life (median 3 IQR 2-4, n=555) (Table 5).

Table 5. Number of respondents, percentage and median score of veterinarians who ranked various factors in the decision to select a particular antimicrobials perioperatively.

Factors	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	n	Median	25	75
Antimicrobial potency	16 (2.9)	32 (5.8)	139 (25.1)	205 (37.1)	161 (29.1)	553	4.0	3.0	5.0
Activity spectrum	2 (0.4)	4 (0.7)	20 (3.6)	113 (20.3)	417 (75.0)	556	5.0	4.3	5.0
Duration of activity	19 (3.4)	51 (9.2)	136 (24.6)	174 (31.5)	172 (31.2)	552	4.0	3.0	5.0
Intensity of side effects	12 (2.2)	54 (9.7)	142 (25.6)	171 (30.9)	175 (31.6)	554	4.0	3.0	5.0
Bactericidal *versus* bacteriostatic	42 (7.6)	56 (10.1)	129 (23.4)	190 (34.4)	135 (24.5)	552	4.0	3.0	4.0
The antimicrobial has a license for veterinary use	116 (20.9)	86 (15.5)	119 (21.4)	107 (29.2)	128 (23.0)	556	3.0	2.0	4.0
Potential to produce microbial resistance	46 (8.3)	64 (11.6)	116 (21.0)	135 (24.5)	191 (34.6)	552	4.0	3.0	5.0
Available administration routes	10 (1.8)	27 (4.9)	106 (19.1)	216 (38.9)	196 (35.3)	555	4.0	3.0	5.0
Wound location	38 (6.9)	64 (11.6)	142 (25.6)	175 (31.6)	135 (24.4)	554	4.0	3.0	4.0
Recommended clinical action protocols	23 (4.2)	20 (3.6)	138 (25.0)	217 (39.3)	154 (27.9)	552	4.0	3.0	5.0
Cost	58 (10.5)	92 (16.6)	195 (35.1)	148 (26.7)	62 (11.2)	555	3.0	2.0	4.0
Shelf life	62 (11.2)	89 (16.0)	173 (31.2)	157 (28.3)	74 (13.3)	555	3.0	2.0	4.0

3.2.5. Route and time of administration

Of the 558 (100%) participants who answered all the questions, the subcutaneous route for preoperative antimicrobial administration was selected by 55.9% of respondents, followed by intravenous (31.9%), intramuscular (10.9%), oral (10.9%) and topical (7.3%) routes. Oral administration was the selected postoperative route for 84.1% of participants, followed by topical route (29.2%), with the remaining options presenting negligible rates of application (Table 6).

Table 6. Number of respondents, percentage and median score of veterinarians who ranked routes and time of perioperative antimicrobial administration.

Category	Before surgery n (%)	During surgery n (%)	After surgery n (%)	Postoperatory n (%)	Administration route of not used n (%)
Subcutaneous	312 (55.9)	26 (4.7)	106 (19.0)	41 (7.3)	73 (13.1)
Intravenous	178 (31.9)	247 (44.3)	17 (3.0)	9 (1.6)	107 (19.2)
Intramuscular	105 (18.8)	18 (3.2)	60 (10.8)	28 (5.0)	347 (62.2)
Oral	61 (10.9)	0 (0.0)	8 (1.4)	469 (84.1)	20 (3.6)
Topical	41 (7.3)	3 (0.5)	50 (9.0)	163 (29.2)	301 (53.9)

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3.2.6. Information source consulted for antimicrobial selection

The evaluation of the information source used for antimicrobial selection and to decide the relevant dosage is presented in Table 7.

Table 7. Number of respondents, percentage and median score of veterinarians who ranked the information source for determination of the dose and posology of perioperative antimicrobials.

Category	1 (%)	2 (%)	3 (%)	4 (%)	n	Median	25	75
Prospectus / *Vademecum*	102 (21.2)	85 (17.7)	140 (29.1)	154(32)	481	3.0	2.0	4.0
Books and user guidelines	22 (4.6)	33 (6.9)	127 (26.5)	298 (62.1)	480	4.0	3.0	4.0
Conference proceedings	83 (17.4)	136 (28.6)	143 (30)	114 (23.9)	476	3.0	2.0	3.0
Scientific articles	95 (19.6)	119 (24.6)	120 (24.8)	150 (31)	484	3.0	2.0	4.0

The main source indicated by respondents to determine dosage and posology were books and drug use guidelines (median 4, IQR 3-4, n=480), followed by prospectus and vademecum (median 3, IQR 2-4, n=481), conference proceedings (median 3, IQR 2-3, n=476) and scientific articles (median 3, IQR 2-4, n=484).

3.3. Statements regarding perioperative antimicrobial use (Section 3 of the Questionnaire)

The statements regarding perioperative antimicrobial use and the proportion of respondents who agreed or disagreed with each one are presented in Table 8.

Table 8. Proportion of respondents who agreed or disagreed with statements regarding perioperative antimicrobial use.

Variable	No (%)	Yes (%)
Preoperative antimicrobials decrease the risk of wound infection in clean surgery	324 (58.1)	234 (41.9)
Postoperative antimicrobials decrease the risk of wound infection in clean surgery	257 (46.1)	301 (53.9)
Preoperative antimicrobials decrease the risk of wound infection in clean-contaminated surgery	56 (10.0)	502 (90.0)
Postoperative antimicrobials decrease the risk of wound infection in clean-contaminated surgery	56 (10.0)	502 (90.0)
Preoperative antimicrobials decrease the risk of infection of a contaminated surgical wound	65 (11.6)	493 (88.4)
Postoperative antimicrobials decrease the risk of infection of a contaminated surgical wound	30 (5.4)	528 (94.6)
The owners agree with the budget that the administration of antimicrobials entails	37 (6.6)	521 (93.4)
I'm not sure if antimicrobial prophylaxis is necessary, but I usually prescribe it	269 (48.2)	289 (51.8)
The use of preoperative antimicrobials is necessary in all surgical procedures	439 (78.7)	119 (21.3)
The use of postoperative antimicrobials is necessary in all surgical procedures	461 (82.6)	97 (17.4)
The inappropriate use of antimicrobials in small animals leads to resistant bacteria	1 (0.2)	557 (99.8)

The percentage of respondents who agreed with each statement regarding antimicrobial use in surgical procedures was: 41.9% for preoperative and 53.9% for postoperative antimicrobials in clean surgery, 90.0% for preoperative and 90.0% for postoperative antimicrobials in clean-contaminated surgery and 88.4% for preoperative and 94.6% for postoperative antimicrobials in contaminated surgery. Additionally, the percentage of respondents who agreed with the following statements were: 93.4% for agreement with the administration of antimicrobials, 51.8% for prescribing antimicrobial prophylaxis even when unsure of the need, 21.3% who believed that preoperative antimicrobials are necessary in all surgical procedures, 17.4% who believed that postoperative antimicrobials are necessary in all surgical procedures, and 99.8% for the association between inappropriate antimicrobial use in small animals and resistance in bacteria.

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3.4. Demographic analysis of perioperative antimicrobial use

Greater use of postoperative antimicrobials was associated with veterinarians with non-surgical postgraduate training during the postoperative period for canine ovariohysterectomy (adjusted-OR 2.20, CI95% 1.43-3.45, $p < 0.001$), feline ovariohysterectomy (adjusted-OR 2.22, CI95% 1.49-3.33, $p < 0.001$), canine orchiectomy (adjusted-OR 1.89, CI95% 1.30-2.70, p=0.001) and feline orchiectomy (adjusted-OR 1.45, CI95% 1.02-2.08, p=0.040).

Moreover, statistically significant, but inconclusive associations were found for other demographic variables analysed and the use of perioperative antimicrobials, such as "Percentage of annual average time dedicated to small animal surgery (%)", "Surgeons out of the total number of veterinarians in the centre", "Total number of veterinarians" and "Years of experience" (Table S1).

4. Discussion

Surgical site infections (SSIs) are a significant concern in veterinary medicine, leading to increased morbidity, mortality, and costs [5]. Antibiotic prophylaxis is commonly used to prevent SSIs, but the choice of antibiotics, optimal duration, and indication have been debated. A judicious approach, considering patient risk, surgical factors, and local antimicrobial susceptibility patterns, is crucial. Although research studies on the use of antibiotics in small animals have been realized [32–47] there is limited research specifically focused on perioperative antibiotic use in small animals, particularly in Spain [28,29,48].

The main findings of this study were (1) preoperative antimicrobials were administered in clean surgery by up to 68.3% of participants, 81.0% in clean-contaminated surgery and 71.3% in dirty surgery, while in the postoperative period, antimicrobials were administered by up to 86.3% of participants in clean surgery, 93.2% in clean-contaminated surgery and 87.5% in dirty surgery, (2) factors considered "very important" for antimicrobial selection were the degree of wound contamination, patient immunosuppression and use of a prosthesis; (3) the most frequently used antimicrobials were beta-lactamase-resistant penicillin; and (4) postoperative antimicrobial use was associated with participants without postgraduate training.

Most participants in this study would administer pre- and postoperative antimicrobials in clean surgery. Classifying surgeries based on contamination level remains controversial [21–24], particularly in the context of greater surgical complexity [49]. Although limited evidence is available, some studies suggest that the use of preoperative antimicrobial prophylaxis in clean procedures generates no benefits [4,5,9,10,50–54]. In human medicine, discontinuing antimicrobial administration within 24 hours after surgery is recommended [15]. However, in veterinary surgery there are no evidence-based guidelines informing common practice regarding duration of antimicrobial use, particularly after orthopaedic procedures. Some retrospective studies have reported the potential benefit of postoperative antimicrobial administration [55,56]. However, recent studies suggested no benefit from postoperative antimicrobial administration [5,10,53,57,58]. The first hypothesis of the present study was that a significant majority of participants would overuse perioperative antimicrobials. Our findings provided compelling evidence in support of this hypothesis. Previous surveys conducted in different countries have also identified a suboptimal use of perioperative antimicrobials in small animal surgery [28,29,41,45]. Furthermore, the percentage of participants using prophylaxis antimicrobials in our study is higher, especially in feline and canine ovariohysterectomy [29] and similar [28] than previously published surveys.

Factors considered "very important" for perioperative antimicrobial selection by the participants were degree of wound contamination, patient immunosuppression and use of a prosthesis, as observed by other authors [29]. In addition, the presence of a drain and potential evisceration were considered "very important" factors in other studies [29]. The implantation of a prosthesis is considered a crucial factor because infections stemming from prostheses can lead to fatal outcomes [55,59,60]. The use of postoperative antimicrobials appears to reduce surgical site infections around prosthetics. However, a recent systematic review evaluating postoperative antimicrobial use in dogs following surgery involving the use of a prosthesis (tibial plateau levelling osteotomy) identified insufficient evidence to support its use. Few limitations have been observed in the available literature, including the lack of prospective surveys and the absence of standard treatment protocols [57,58]. Some research studies indicate that the degree of wound contamination and patient immunosuppression are important factors regarding infection and antibiotic use [4–8,53] contrary to other results [61]. Studies by Espinel et al. (2019), Brown et. Al (1997) and Eugster et al. (2004) have established an association between immunosuppression, particularly related to corticosteroid treatment and antibiotic use. The divergent conclusions between studies can be attributed to variations in research design and methodology. Moreover, the cost of the antimicrobial was not deemed a significant factor in decision-making, which could be attributed to the customer's willingness to accept the necessary price [29,46,62,63]. This contrasts with another study performed in South Africa where cost was identified as one of the main limiting factors for antimicrobial use [43].

Considering the widespread use of first-generation cephalosporins as an antimicrobial prophylaxis in human medicine [15,22] and companion animals [28,51], and according to the authors' experience, our initial hypothesis was that this antimicrobial class would be the main choice of veterinarians. However, our study's findings contradicted this hypothesis, with beta-lactamase-resistant penicillin emerging as the most commonly used antimicrobial prophylaxis, thus rejecting our third hypothesis. This finding is consistent with previous surveys performed in different countries [34,64–68] and it has also been described as antimicrobial prophylaxis in some studies [29,35,36,46,69]. The preference for beta-lactamase-resistant penicillins [70], particularly amoxicillin-clavulanic acid, may be attributed to their historical recommendation for prophylaxis [71]. However, antimicrobial resistance guidelines [72] recommended non-potentiated penicillin (e.g. amoxicillin, ampicillin) or first-generation cephalosporins (e.g. cefalexin) as the preferred choice for prophylaxis over beta-lactamase-resistant penicillin (potentiated penicillin, e.g. amoxicillin-clavulanic acid) to prevent the emergence of greater resistance [73]. Additionally, the incidence of adverse effects, such as hypotension and/or cutaneous signs, appears to be higher with the administration of intravenous amoxicillin-clavulanate than with intravenous cefuroxime for prophylactic antimicrobial therapy in dogs undergoing surgery [74]. First-generation cephalosporins was the second most frequently chosen group of antimicrobials. Other antimicrobials such as third-generation cephalosporins (e.g. cefovecin), fluoroquinolones (e.g. enrofloxacin, marbofloxacin) and nitroimidazoles (e.g. metronidazole) were also chosen by veterinarians in this study as the third most effective antimicrobial prophylaxis, as previous studies [75]. Quinolones and third-generation cephalosporins and other advanced generations, are among the few available therapies for severe Salmonella spp. and E. coli infections in human medicine and should be used only for the treatment of these infections, due to their high incidence in human medicine. Nitroimidazoles, such as metronidazole, may be the only therapy for anaerobic infections (including C. difficile) in some geographic settings, and should be used with caution [72,76].

In our study, we observed significant differences in the use of pre- and postoperative antimicrobials by participants with or without postgraduate training in small animal surgery. Due to the differences in the level of training in the group of participating veterinarians with some postgraduate training, these findings must be carefully evaluated and no reliable conclusions can be drawn from this group. However, participants with no postgraduate training (which constitutes a homogeneous group) used significantly more antimicrobials post-surgery. This difference may be attributed to lower levels of knowledge among participants without postgraduate training, as well as their adherence to the existing recommendations on antimicrobial use. As previously described, veterinary professionals who receive training on antimicrobial control, animal management practices, and diagnostic protocols, may be further prepared to make informed decisions about antimicrobial use [37,77]. Consequently, investing in adequate education and training for veterinarians may play a significant role in promoting responsible antimicrobial use in veterinary medicine, making it a critical strategy for mitigating the impact of antimicrobial resistance. Additionally, the implementation of continuing education programs and adherence to clinical guidelines, as supported by some authors [51,78,79], can further promote appropriate antimicrobial use in veterinary medicine.

The route and time of antimicrobial administration are important factors when administering perioperative antimicrobial therapies. Some respondents in this study highlighted the administration of preoperative antimicrobial prophylaxis by subcutaneous and intramuscular routes. This finding has also been reported in previous surveys [29]. This result underscores an additional concern regarding prophylactic administration, as this alternative route, compared to the intravenous one, is unsuitable due to the prolonged time it takes to achieve necessary plasma and tissue concentrations. To ensure effective antimicrobial activity, it is crucial to reach adequate concentrations of antimicrobials in both serum and tissue, matching the minimum inhibitory concentration for the most likely microorganisms. These levels should be achieved before the initial incision (injected intravenously within 60 minutes prior) and maintained until the end of surgery [19]. The subcutaneous and intramuscular routes may not reach peak skin concentration by the start of the surgery, leading to increased antimicrobial-associated morbidity [80]. Therefore, subcutaneous administration is preferable to the intravenous route .

In our study, the majority of participants most commonly consulted books and guides as their primary information source for decision making about antimicrobial selection and dosage, which is consistent with other studies in human medicine [81] and small animal veterinary medicine [28]. Nevertheless, this finding differs from another survey conducted in small animals, which identified clinical experience as the primary information source [29]. Moreover, the participants in this study considered antimicrobial prospectus a useful information source (median score=3). Antimicrobial prospectus are recommended by agencies such as the European Medicines Agency (EMA) as a reliable source of detailed information [82]. However, veterinarians' preference for books and guides over prospectus may be attributed to familiarity, convenience, or the perception that they provide more up-to-date information.

Most veterinarians in our study agreed with the statement that "the inappropriate use of antimicrobials in small animals leads to resistance in bacteria". This highlights the recognition by veterinarians of the significant global challenge posed by multi-resistant bacteria [1–3]. Despite this awareness, inappropriate antimicrobial use by the majority of participants in this survey was observed. As previously mentioned, this may be due to the lack of guidelines and adequate training regarding antimicrobial use. Moreover, veterinarians generally agree on the use of antimicrobials to treat infections, but their use in preventive measures remains debated.

This study represents the first survey conducted to evaluate the current use of antimicrobials in Spain. However, several limitations in our survey methodology should be noted. One of the main limitations was the small number of respondents, which may impact the generalizability of our findings. Additionally, the low response rate introduces a potential selection bias, further affecting the representativeness of the sample. However, this survey targeted a well selected population of members from AVEPA, and the gender distribution of the participants aligned with AVEPA's registration data at the time of the survey. Finally, the survey focused on antimicrobials commonly used in veterinary medicine and did not consider other agents used in human medicine, such as carbapenems, which are not recommended for veterinary medicine.

5. Conclusions

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This study highlights the overuse of perioperative antimicrobial prophylaxis in small animal surgery in Spain. The majority of respondents did not follow the recommended agents and administration regimen. Due to the significant consequences stemming from inappropriately using antimicrobial prophylaxis, evidence-based guidelines, and further education about the correct use of antimicrobial prophylaxis are recommended.

Supplementary Materials: The following supporting information can be downloaded at: Table S1: Univariate and multivariate logistic regression model of use of perioperative antimicrobials for ovariohysterectomy and orchiectomy in dogs and cats and demographic data.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

First page of the questionnaire on perioperative antimicrobial use in Spain in small animal veterinary medicine.

Dear colleague,

The aim of this questionnaire is to better understand the current situation regarding perioperative antimicrobial use for small animals in small animal veterinary practices in Spain and to describe the factors that determine its use.

The questionnaire is part of a larger multidisciplinary study involving a public hospital in Madrid. We are seeking to investigate the epidemiology of multidrug-resistant bacteria in companion animals, the implications for antimicrobial use with pets, and to identify the n in nosocomial infection and its importance in Public Health. As you know, multi-resistant bacteria are a serious problem nowadays as they increase the morbidity and mortality of hospitalised human and animal patients, as well as the zoonotic risk.

Based on the results of this study, our objective is to formulate evidence-based guidelines for antimicrobial use and for the prevention of hospital-acquired infections. We will not be undertaking an individual assessment of participant's knowledge of antimicrobial use.

Your participation is essential to achieving this goal and we thank you in advance for your collaboration.

Answering the questionnaire takes between 5 and 10 minutes and is completely anonymous. Your individual answers will remain confidential and will be compiled with those of other participants.

You can submit your e-mail address together with the completed questionnaire so that we can send you a report of the study on completion.

If you have any further questions regarding the questionnaire, you can contact us at the following e-mail address: gortidie@uax.es

Thank you very much for your participation.

Appendix 2

Question and answer options contained in the questionnaire regarding perioperative antimicrobial use for veterinary medicine in Spain. Survey translated from the original Spanish version.

1) DEMOGRAPHIC DATA.

1. How many years have you been working in veterinary clinical practice?
2. In which university did you obtain your veterinary degree?
3. Gender.
   - ☐ Male
   - ☐ Female
4. Indicate the veterinary surgery specialization that you hold.
   - ☐ None
   - ☐ ECVS Diploma
   - ☐ Master's
   - ☐ Postgraduate course
   - ☐ PhD related to small animal surgery
5. Indicate the average amount of time dedicated annually to small animals in your veterinary clinical practice.
6. Indicate the average amount of time dedicated annually to surgery in small animals at your practice.
7. Indicate the type of veterinary centre where you work.
   - ☐ Public
   - ☐ Private
8. In which autonomous region of Spain do you currently work?
9. How many veterinary surgeons perform surgery at the centre?
10. How many veterinary surgeons work at the centre?
11. How many veterinary technicians or veterinary nurses work at the centre?
12. Indicate the person responsible at the veterinary centre for making decisions to use antimicrobials during the perioperative period.
    - ☐ Myself
    - ☐ Following the centre's protocols established by others.

2) PROPHYLACTIC USE OF ANTIMICROBIALS IN THE PERIOPERATIVE PERIOD AND THE FACTORS THAT DETERMINE THEIR USE.

1. Below, we present a series of surgeries with different degrees of contamination in order to understand pre- (an hour before surgery) and postoperative (more than 24 hours after surgery) antimicrobial use.

	Never	Rarely	Sometimes	Usually	Always	I do not perform this kind of surgery
Preoperative						
Postoperative						

1.1.1 Routine laparotomy ovariohysterectomy in dog.
1.1.2 Ovariohysterectomy for open pyometra in dog.
1.1.3 Routine laparotomy ovariohysterectomy in cat.
1.1.4 Routine orchiectomy in dog.
1.1.5 Routine orchiectomy in cat.

1.1.6 Enterotomy for a foreign body, without discharge of content into the abdominal cavity in dog.
1.1.7 Excision of lip mass in dog.
1.1.8 Excision of a 2-cm, non-ulcerated skin nodule in dog.
1.1.9 Closed fracture of the femur, with internal fixation in dog.
1.1.10 Cystotomy with urinary tract infection in dog.
1.1.11 Surgery for an acute traumatic wound in dog.
1.1.12 Tarsorrhaphy in dog.

2. Importance of specific factors in determining the use of antimicrobials. Evaluate the importance of the following factors when deciding on the use of perioperative antimicrobials from 1 to 5 (1= not important to 5=very important):

Degree of wound contamination	**1**	**2**	**3**	**4**	**5**
Possibility of evisceration	**1**	**2**	**3**	**4**	**5**
Patient immunosuppression	**1**	**2**	**3**	**4**	**5**
Presence of a drain	**1**	**2**	**3**	**4**	**5**
Surgery with use of a prosthesis	**1**	**2**	**3**	**4**	**5**
Surgical preparation standards	**1**	**2**	**3**	**4**	**5**
Preoperative presence of prosthesis	**1**	**2**	**3**	**4**	**5**
Impaired physical condition of the patient	**1**	**2**	**3**	**4**	**5**
Surgery time	**1**	**2**	**3**	**4**	**5**
Hollow viscus incision	**1**	**2**	**3**	**4**	**5**
Emergency surgery vs routine surgery	**1**	**2**	**3**	**4**	**5**
Level of clinical experience	**1**	**2**	**3**	**4**	**5**
Hospitalization time	**1**	**2**	**3**	**4**	**5**
Presence of an intravenous catheter	**1**	**2**	**3**	**4**	**5**

3. Importance of specific factors in the selection of antimicrobials. Give the following factors a score from 1 to 5 reflecting their importance when deciding on a particular perioperative antimicrobial (1= not important and 5=very important).

Potency	**1**	**2**	**3**	**4**	**5**
Activity spectrum	**1**	**2**	**3**	**4**	**5**
Duration of activity	**1**	**2**	**3**	**4**	**5**
Intensity of side effects	**1**	**2**	**3**	**4**	**5**
Bactericidal *versus* bacteriostatic	**1**	**2**	**3**	**4**	**5**
License for veterinary use granted	**1**	**2**	**3**	**4**	**5**
Potential to produce microbial resistance	**1**	**2**	**3**	**4**	**5**
Available administration routes	**1**	**2**	**3**	**4**	**5**

Wound location	**1**	**2**	**3**	**4**	**5**
Recommended clinical action protocols	**1**	**2**	**3**	**4**	**5**
Cost	**1**	**2**	**3**	**4**	**5**
Shelf life	**1**	**2**	**3**	**4**	**5**

4. Rank the antimicrobials from 0 to 12 for their frequency of use (1 being the least used, 12 being the most used). If you do not use a specific antimicrobial, leave the option blank.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Beta-lactamase-resistant penicillins **(e.g amoxicillin with clavulanic acid)**												
Beta lactamase sensitive penicillins **(e.g Amoxicillin)**												
First-generation cephalosporins **(e.g cefazolin, cephalexin)**												
Third-generation cephalosporins **(e.g cefovecin: Convenia®)**												
Fluoroquinolones **(e.g enrofloxacin, marbofloxacin)**												
Nitroimidazoles **(e.g metronidazole)**												
Potentiated sulfonamides **(e.g sulfamethoxazole-trimetropim)**												
Tetracyclines **(e.g doxycycline)**												
Macrolides **(e.g erythromycin)**												
Lincosamides **(e.g clindamycin)**												
Aminoglycosics **(e.g gentamicin, amikacin)**												
Phenicols												

(e.g chloramphenicol, flofenicol)												

5. Route and time of administration: this question seeks to ascertain how and when the chosen antimicrobial is usually administered.

	Before surgery	**During surgery**	**After surgery**	**Postoperative**	**Route not used**
Subcutaneous					
Intravenous					
Intramuscular					
Oral					
Topical					

6. Selection of dose and posology. When deciding on an antimicrobial, what information sources do you use to determine dosage and posology? Four options are offered. Rank the option based on frequency of use, with 1 being the least used and 4 being the most used.

	1	**2**	**3**	**4**
Prospectus / *Vademecum*				
Books and user guidelines				
Conference summaries				
Scientific articles				

3) EVALUATE THE FOLLOWING STATEMENTS ABOUT PERIOPERATIVE ANTIMICROBIAL USE.

In this section 7 statements relating to perioperative antimicrobial use are presented. Indicate your agreement or disagreement with each one.

	YES	NO
Preoperative antimicrobials decrease the risk of wound infection in clean surgery		
Postoperative antimicrobials decrease the risk of wound infection in clean surgery		
Preoperative antimicrobials decrease the risk of wound infection in clean-contaminated surgery		
Postoperative antimicrobials decrease the risk of wound infection in clean-contaminated surgery		
Preoperative antimicrobials decrease the risk of infection of a contaminated surgical wound		
Postoperative antimicrobials decrease the risk of infection of a contaminated surgical wound		
Owners agree with the cost entailed by the administration of antimicrobials		
I'm not sure if antimicrobial prophylaxis is necessary, but I usually administer it		
The use of preoperative antimicrobials is necessary in all surgical procedures		
The use of postoperative antimicrobials is necessary in all surgical procedures		
The inappropriate use of antimicrobials in small animals leads to resistance in bacteria		

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