Evaluation of the education in antimicrobial stewardship and resistance by students of two Belgian Faculties of Veterinary Medicine

Evaluatie van de opleiding in antibioticabeleid en antibioticaresistentie door studenten van twee Belgische Faculteiten Diergeneeskunde

N. Sarnino, I. Chantziaras, P. Joosten, J. Dewulf

Veterinary Epidemiology Unit, Department of Internal Medicine, Reproduction and Population Health, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium

Jeroen.dewulf@ugent.be

ABSTRACT

Antimicrobial stewardship (AMS) is an essential step in limiting the selection of antimicrobial resistance (AMR). A questionnaire was filled-out by 122 last-year students of Veterinary Medicine of Ghent University (UGhent) and Liège University (ULiège) to assess their perception of preparedness, the education quality, and their satisfaction regarding the education of AMS and AMR. UGhent students felt better prepared to clinically use antimicrobial agents (3.23 versus 2.98, p = 0.03). There were no statistically significant differences in the other two fields of perception of preparedness, i. e. pharmacology and AMR knowledge. The overall result of the knowledge score was 4.68 (sd 1.26) out of 8, and there was no statistically significant difference between the results of the two faculties. Less than 50% of the students were satisfied with their education in AMS and AMR. Most participants acknowledged the need for extra education in rational antibiotic use. UGhent students were more familiar with guidelines for antimicrobial use than ULiège students. The results of this study can help improve the quality of veterinary education in AMS and AMR in Belgium.

SAMENVATTING

Antibioticabeleid is een essentiële stap in de beperking van de selectie van antibioticaresistentie. In deze studie wordt de evaluatie van 122 laatstejaarsstudenten Diergeneeskunde van de Universiteit Gent (UGent) en de Universiteit Luik (ULuik) weergegeven met betrekking tot de perceptie van het voorbereid zijn, de kwaliteit van het onderwijs en de tevredenheid over het onderwijs van antibioticabeleid en -resistentie. UGent-studenten voelden zich beter voorbereid op het klinisch gebruik van antimicrobiële middelen dan ULuik-studenten (3,23 versus 2,98, p = 0,03). Er waren geen statistisch significante verschillen voor wat betreft de andere twee velden van perceptie van paraatheid (farmacologie en kennis van antibioticaresistentie). Het totale resultaat van de kennisscore was 4,68 (sd 1,26) op 8, en er was geen statistisch significant verschil tussen de resultaten van de twee faculteiten. Minder dan 50% van de studenten was tevreden over hun opleiding over antibioticabeleid en -resistentie. De meeste deelnemers erkenden de noodzaak van extra voorlichting over rationeel antibioticagebruik. UGent-studenten waren meer bekend met formularia voor antimicrobieel gebruik dan ULuik-studenten. De resultaten van dit voorliggende onderzoek kunnen de kwaliteit van het veterinair onderwijs van antibioticabeleid en -resistentie in België helpen verbeteren.

INTRODUCTION

With the term antimicrobial stewardship (AMS), the coordinated interventions designed to measure and optimize the use of antimicrobial agents, including the way of administration, dosing and duration of the therapy is intended. AMS has, within its main goals, the limitation of the emergence of antimicrobial-

resistant bacterial strains (Fishman, 2012).

The education in AMS and antimicrobial resistance (AMR) represents an important part of the modern veterinary-medicine-student curricula (Espinosa-Gongora, 2021). In recent times, it has become even more important due to the concern of antimicrobial use in both companion (Joosten, 2020) and farm animals (Joosten, 2019; Caekebeke, 2020) and the subsequent increase of antimicrobial resistance (Chantziaras, 2014).

This study is part of PREPARE-VET, a survey developed for European veterinary medicine students of 31 countries made to evaluate the education of the participants in AMS (Espinosa-Gongora, 2021). In accordance with similar studies performed in South Africa (Smith, 2019) and Australia (Hardefeldt, 2018), the European study shows a lack of satisfaction among veterinary medicine students concerning their AMS education (Espinosa-Gongora, 2021).

In this study, the evaluation by students of two Belgian Veterinary Medicine Faculties, Ghent University (UGhent) and Liège University (ULiège) is focussed upon. The aim was to evaluate the knowledge of and satisfaction with the education of AMS and AMR of Belgian veterinary medicine students and to focus on the critical points for improvement.

MATERIALS AND METHODS

Questionnaire development and distribution

The questionnaire was developed in 2017 by a group of experts of the PREPARE-VET group (Espinosa-Gongora, 2021). It includes 27 questions divided in six categories: (I) student's profile; (II) student's perception of preparedness in AMS; (III) assessment of student's preparedness; (IV) student's perception of the impact of veterinary antimicrobial use on AMR problems in humans; (V) teaching methods; and (VI) overall satisfaction with the received education in AMS. The full methodology has been described in Espinosa-Gongora (2021).

To evaluate the perception of preparedness, the participants had to answer 15 specific questions divided in three fields: pharmacology of antimicrobial agents, clinical use of antimicrobial agents, and AMR. Students were asked to evaluate their perception of preparedness, ranking it from 0-4 corresponding to: 0) I have not received any teaching/training in the topic, 1) not at all prepared, 2) poorly prepared, 3) sufficiently prepared, and 4) well prepared. The student's preparedness was assessed through scoring the number of correct answers to eight questions (Q14–18, Q21–23). Questions 19–20 were removed from the score due to multiple possible correct answers. The estimated impact of the use of antimicrobials in veterinary medicine on clinical problems caused by resistant bacteria in humans was calculated assigning values to each answer: Very low (0), Low (1), Medium (2), High (3), and Uncertain (NA). The questionnaire was delivered to the last-year students in an electronic format between October 2017 and June 2018.

Furthermore, the participants were asked to evaluate their performance as veterinary medicine student on a scale from 1 to 10: 10 representing a top student, 5 an average student, and 1 a student at the bottom of the rank.

Data analysis

Data analysis and data visualization were performed using R version 4.0.2 and Microsoft Excel©. Potential differences between the perception of preparedness and the results of students from UGhent and ULiège were tested by means of a t-test. Furthermore, one-way ANOVA was used to assess the effect of teaching methods on the perception of preparedness and the test results. Spearman's rank correlation coefficient was used to assess the strength and direction of the association between perception of preparedness and the knowledge test result. The association between students' preparedness and field of interests was tested with ANOVA. The association between university and knowledge of guidelines was assessed by means of a chi square test. The relationship between students' field of interest and opinion on the relative contribution of the veterinary use of antimicrobial agents to clinical problems caused by resistant bacteria in humans, and the relationship between students' field of interest and satisfaction with the education in AMS/AMR were assessed by Fisher's test.

RESULTS

Participants' profiles

In total, 123 students from two Belgian Veterinary Medicine Faculties, UGhent and ULiège, participated in filling out the survey. One profile was excluded because the student declared he/she had had a minimum of a five-years education in Veterinary Medicine, while the minimum training duration in Belgium is six years, and could thus not be included in the data analysis.

Participants included in the final analysis (n=122) were mostly women (81%), on average 26-year-old and intended to specialize in companion animal/equine medicine (64%), food animal medicine (25%), other (7%), or were undecided about future specialization (4%). The estimated response rate was 46% in UGhent (91 out of 200 eligible students), and 12% in ULiège (31 out of 275 eligible students).

When asked to rank their performance as student from 1 (student at the bottom of the rank) to 10 (top student), the biggest part of participants gave themselves 7 as rank (median; IQR = 1). More than half

of the participants (60.6%) had Belgian nationality, while 23% were from the Netherlands, 7.4% from France, 3.3% from other countries and 5.7% of the students did not specify any nationality or it was unclear.

Students' perception of preparedness

The students' perception of preparedness was evaluated by means of 15 questions in three topics: pharmacology of antimicrobial agents, clinical use of antimicrobial agents and AMR knowledge. The average score of the students' perception of preparedness was 2.96 (sd 0.24) for pharmacology of antimicrobial agents, 3.17 (sd 0.21) for the clinical use of antimicrobial agents and 3.34 (sd 0.28) in AMR knowledge. Students from UGhent felt better prepared for clinical use of antimicrobial agents (3.23 versus 2.98, p = 0.03). The score for AMR knowledge was 3.38 and 3.24 for UGhent and ULiège, respectively. The difference was not statistically significant (p= 0.4). Students from ULiège showed a positive trend (p= 0.06) toward a higher score for pharmacology (3.14) compared with their fellow students from UGhent (2.89). Students interested in food animals were the only ones to declare to feel "sufficiently prepared" in all the three topics of perception of preparedness. Students interested in companion animals declared to feel "poorly prepared" for pharmacology of antimicrobial agents, and "sufficiently prepared" for the other two topics. Participants who selected "other" as field of interest felt "sufficiently prepared" only for AMR knowledge, and the group of students who hadn't decided yet about a specialization, felt "poorly prepared" for clinical use of antimicrobial agents and "sufficiently prepared" for the other two topics.

The students were also asked how often a certain education method was used to teach on antimicrobials, antimicrobial resistance and antimicrobial use. Lectures were the most common education method, with 68.1% of the participants from UGhent and 45.1% from ULiège declaring to have attended "very often" (Table 1). Discussion of clinical cases was another popular teaching methods, with more than 50% of participants from both faculties responding "very often" and "sometimes".

Assessment of students' preparedness

In Table 2, the results of the knowledge test are described. More than 50% of the students were able to answer correctly at least five questions out of eight in total. The highest scores were achieved in the topics nomenclature, spectrum of activity and infection control, while less than half of the students gave correct answers to all questions related to AMR (e.g. only 7.4% of students chose oxacillin as antimicrobial used in laboratory detection of AMR in *staphylococci*). Overall, the respondents scored a mean of 4.68 (sd 1.26) correct answers out of 8. Students from UGhent obtained on average 4.72 (sd 1.33) points and students from ULiège on average 4.58 (sd 1.02). These results did not differ significantly (p = 0.53).

There was a weak positive correlation (p = 0.04) between the perceived level of preparedness with regard to the clinical use of antimicrobials and the overall knowledge test results of students from Ghent University. For the UGhent students, the perceived preparedness with regard to pharmacology of antimicrobial agents and AMR knowledge had no significant correlation with the knowledge test results. None of the three fields of perception of preparedness was

Table 1. Frequency of used teaching methods on antimicrobials, antimicrobial resistance and antimicrobial use at UGhent and ULiège. Between brackets: the number of students who selected this option.

		Very often	Sometimes	Rarely	Never	I don't know
Lectures	UGhent	68.1% (62)	27.5% (25)	4.4% (4)	0% (0)	0% (0)
	ULiège	45.1% (14)	32.2% (10)	19.3% (6)	0% (0)	3.2% (1)
Small group teaching	UGhent	6.6% (6)	18.7% (17)	41.7% (38)	33% (30)	0% (0)
	ULiège	32.2% (10)	58% (18)	6.4% (2)	0%	3.2% (1)
Discussions of clinical cases	UGhent	22% (20)	31.8% (29)	33% (30)	12.1 (11)	0% (0)
	ULiège	35.5% (11)	54.8% (17)	9.6% (3)	1.1% (1)	0% (0)
Active learning assignment (article review, oral presentation)	UGhent	9.9% (9)	17.6% (16)	35.1% (32)	37.3% (34)	0%(0)
	ULiège	16.1% (5)	45.1% (14)	32.2% (10)	6.4% (2)	0% (0)
E-learning	UGhent	2.2% (2)	12.1% (11)	33% (30)	51.6% (47)	1.1% (1)
	ULiège	3.2% (1)	19.3% (6)	35.5% (11)	38.7% (12)	3.2% (1)
Clinical rotations	UGhent	22% (20)	53.8% (49)	18.7% (17)	4.4% (4)	1.1% (1)
	ULiège	19.3% (6)	54.8% (17)	22.6% (7)	3.2% (1)	0% (0)

Table 2. Knowledge test and percentage of correct answers.

Question	Correct answer	Percentage correct answers	
		UGhent	ULiège
Which of the following antibiotics is a lincosamide?	Clindamycin	87.9%	87%
Which of the following β-lactam antibiotics has the broadest spectrum?	Amoxicillin-clavulanic acid	84.6%	80.6%
Which of the following antibiotics can cause kidney damage?	Gentamicin	52.7%	77.4%
What is an extended-spectrum β-lactamase (ESBL)?	A bacterial enzyme hydrolysing β-lactam antimicrobials	56%	16.1%
Which of the following antibiotics is used for laboratory detection of resistance in staphylococci?	Oxacillin	6.5%	9.6%
Which of the following strategies is NOT in line with the concept of antimicrobial stewardship?	To administer/prescribe antimicrobials at the lowest dose recommended by the manufacturer	30%	16.1%
Which of the following antibiotic classes should be regarded as a second-line drug and reserved for management of complicated infections?	Fluoroquinolones	78%	90.3%
When using gloves, when should you wash your hands?	Before and after using gloves	75.8%	80.6%

correlated with the test results of the students from ULiège. Also, the teaching methods were not significantly associated with the knowledge test score of students from both faculties ($p > 0.05$).

There was no association between the students' field of interest and students' preparedness ($p > 0.05$).

The majority of the participants were able to indicate the right answer in topics, such as etiology and treatment with the exception of greasy diarrhea' in 20-30 kg pigs' agent (48.4% correct answer) and canine superficial pyoderma treatment (36.9% correct answers). The questions with the most correct answers were regarding cystitis treatment (92.6%) and causative agent of upper respiratory infection in cats (84.4%).

Knowledge of practice guidelines for rational antibiotic use

Students were asked to express their familiarity with practice guidelines for rational antibiotic use (Table 3). Out of 122 students, 42 (34.4%) declared not to be familiar with any practice guidelines for rational antibiotic use. For those who declared to be familiar with the guidelines, AMCRA was the most popular choice, with 56 answers. Regarding UGhent, 71.4% (65) of the students declared to be familiar with at least one guideline (Table 4). In a follow-up question, it was asked to specify the name of the guideline with which the student was

Table 3. Students' familiarity with (inter)national practice guidelines for rational antibiotic use. Between brackets: the number of students who selected this option.

	UGhent		ULiège	
Yes		**71.4% (65)**		**8.4% (15)**
	AMCRA	58.2% (53)	AMCRA	9.7% (3)
	FAGG	1.1% (1)	CBIP	9.7% (3)
	WHO	1.1% (1)	AFSCA	3.2% (1)
			AVMA	3.2% (1)
	Not specified/unclear	10.1% (10)	Not specified/unclear	22.6% (7)
No		**28.6% (26)**		**51.6% (16)**

Table 4. Students' opinion on the relative contribution of the veterinary use of antimicrobials to clinical problems of resistant bacteria in humans. Between brackets: the number of students who selected this option.

	UGhent	ULiège
High (>50%)	17.6% (16)	32.2% (10)
Medium (10-20%)	56% (51)	41.9% (13)
Low (<5%)	18.7% (17)	22.6% (7)
Very low (<0.1%)	3.2% (1)	0% (0)
Uncertain	7.7% (7)	0% (0)

familiar, and six of those who answered "yes" to the previous question, were not able to specify any correct guideline.

Forty-eight percent (15) of the students of ULiège declared to be familiar with at least one guideline. To the follow-up question, 8 of those who indicated to be familiar with a guideline in the previous question, were not able to specify any correct guideline. There was a statistically significant association between university and familiarity with guidelines ($p < 0.01$).

Students' perception of the impact of veterinary antimicrobial use

Students were asked for their opinion on the relative contribution of the veterinary use of antimicrobial agents to clinical problems caused by resistant bacteria in humans (Table 4). Over 21% of the students believed that the impact is high, 52.4% answered medium, while the rest answered low, very low or was uncertain. The students interested in companion animals considered the contribution mostly medium (47.4%) and high (28.2%), while 19% of them answered low and the rest was uncertain. On the other hand, only 6.4% of the students interested in food animals considered the contribution high. The rest of them answered medium (61.3%), low (25.8%) or uncertain (5.1%). Students interested in other fields or who hadn't decided about the field of interest yet, answered mostly medium (around 60% for both groups). There was no statistically significant relationship ($p=0.8$) between the students' field of interest and their opinion on the contribution of the veterinary use of antimicrobial agents to AMR in humans.

Satisfaction with the received education in AMS

Forty-four percent of the students declared to be satisfied with their received education in AMS, while one student over three felt the need of extra education in rational antimicrobial usage. Twenty-one percent of the students declared to feel the need for more education in both general antibiotic treatment and rational antibiotic use; the rest of the students was uncertain. The percentage of satisfied students regarding the education in AMS was 45% in UGhent and 42% in ULiège. The students interested in food animals, the students who hadn't decided yet which field of interest, and the students interested in other fields, were the most satisfied about their education in AMS and AMR. In these three groups, around 60% of the respondents declared to have received adequate teaching to face antibiotic and resistance issues in clinical practice. Only 36% of the participants interested in companion animals declared to be satisfied with their education. The relation between field of interest and satisfaction with the education in AMS/AMR was statistically significant ($p=0.04$).

DISCUSSION

The results of this study give an insight into the education and knowledge of last-year students of Veterinary Medicine in Belgium. Yet, a limitation of the study was the disproportionality between the participants of the two universities with a participation rate of 46% in UGhent and only 12% in ULiège.

Therefore, the overall results are mainly influenced by the UGhent respondents. The lower participation rate of ULiège (12%) may have caused bias, for example by the response of only the most diligent students, or by the response of only students interested in AMS.

In general, the students of both universities felt sufficiently prepared. Their perception of preparedness was sufficient in two fields over three, namely clinical usage of antimicrobials and AMR knowledge. In a study by Espinosa-Gongora (2021), in which the same methodology was used and the education in AMS in 31 European countries was evaluated, the overall mean was below "sufficiently prepared" in all three fields of perception of preparedness. In line with Espinosa-Gongora (2021), the lower score in the perception of preparedness in pharmacology was also seen in the present study.

Although the students' perception of preparedness was on average sufficient, the knowledge test, with an average score of 4.68 out of 8, showed some margin for improvement. In general, the students performed relatively well for topics related to general knowledge and to the clinical use of antimicrobial agents, while some insufficiencies were seen in questions related to AMR. In any case, eight questions may not be enough to evaluate the students' knowledge of AMS and AMR. For future studies, it may hence be advisable to focus on the students' knowledge of these fields to evaluate the education quality.

Some questions had a low correct answer percentage, as for example only 16.1% of the students of ULiège were able to correctly define extended-spectrum β-lactamase (ESBL) and only 6.6% of the participants of UGhent were able to indicate oxacillin as antimicrobial used in the detection of methicillin resistance in *staphylococci*. On the other hand, over 80% of the participants were able to correctly indicate the fluoroquinolones as an antibiotic class that should be regarded as a second-line drug and reserved for the management of complicated infections. There were some differences in obtained scores between the two universities, yet the overall score was not significantly different. Also, a weak association was found between some components of the perceived level of preparedness and the overall knowledge test indicating that students who feel better prepared are on average also a bit more knowledgeable. This was also observed in the study by Espinosa-Gongora, et al. (2021).

A notable difference between the students of UGhent and the ULiège students was observed with regard to their familiarity with practical guidelines for rational antibiotic use. Where more than 60% of the UGhent students were able to indicate at least one correct guideline, only around 23% of the students from ULiège were able to do the same. This could potentially be associated with the assessment of preparedness of students from ULiège in the clinical use of antimicrobial agents, that was indicated to be "poorly prepared" in this field. Moreover, several students who declared to be familiar with guidelines, were not able to specify any of them or referred to organizations such as the Belgian Food Agency (AFSCA) that does not issue any antimicrobial guideline. In the study by Espinosa-Gongora, et al. (2021), only 29.6% of students of the 31 European countries taken in consideration declared to be familiar with a guideline for rational antibiotic use. Focusing on practical guidelines for rational antibiotic use may be a possible solution to improve the veterinary education in AMS. Furthermore, with a better preparedness on these guidelines, it may be possible to avoid some mistakes regarding the choice of correct antibiotics, dose, the way of administration and the duration of the therapy, and thus avoiding the onset of AMR. The survey was distributed before the COVID-19 pandemic, and it is noteworthy that only 2.4% of the participants declared to have received online education "very often", while 48.3% of the students declared that up till then, they had never received e-learning as a teaching method. The pandemic has surely changed the (veterinary) education approach and online education has become the principal teaching method during lockdowns (Routh, 2021). It might be interesting to check if e-learning will remain a major teaching method in the veterinary curriculum and to study how this factor might influence the quality of the education in AMS in the future.

Overall, only 44% of the students were satisfied with their education in AMS/AMR, but looking at the fields of interests, around 60% of the participants, except for the group of students interested in companion animals, declared to be satisfied about their education in AMS and AMR. In any case, students interested in companion animals represented 64% of the participants and influenced the results the most. Students interested in food animals represented 25% of the participants, while only 7% selected "other" as answer, and the rest of the students had not decided on any specialization yet. Among all the fields of interests, students interested in companion animals were the group with the highest percentage of participants declaring to consider the relative contribution of veterinary use of antimicrobials to the clinical problems of resistant bacteria in humans "high" (28.2%). It is possible that this group of students consider the education in AMS and AMR particularly important, and is hence in favor of more trainings in these topics. Another hypothesis is that, in specializations such as farm animals or research, there is more focus on AMS or AMR. For example, last-year-master students specializing in companion animals at UGhent have 40 contact hours and 120-hours' training in applied pharmacology, while students specializing in ruminants have 55 contact hours and 155 hours of study time. The group of students that indicated to be interested in food animals was the only group to feel sufficiently prepared in all the topics of perception of preparedness, and the only group to feel sufficiently prepared in pharmacology of antimicrobial agents. Since a large part of the students declared they do not feel confident in their education in pharmacology, increasing the training in this part of the curriculum could be a possible way to improve the education in AMS and AMR.

Regarding the opinion on the relative contribution of the veterinary use of antimicrobials to clinical problems of resistant bacteria in humans, students from ULiège appeared to be closer to the results described in the study by Espinosa-Gongara, et al. (2021), with more than one student out of three considering the contribution high. On the other hand, the answers of the UGhent students were more in line with a study from South Africa (Smith, 2019) and one from Australia (Hardefeldt, 2018).

Although the use of antimicrobials in animal production is clearly contributing to the selection of antimicrobial resistance (Travers, 2002; Singer, 2003; Gaze, 2008; Spoor, 2013), it is not clear how big this

contribution actually is (van den Bogaard, 2000). The influence of the veterinary use of antimicrobials on the occurrence of AMR in humans could be overestimated (McEwen, 2012; Chang, 2015; Guardabassi, 2020); hence, it remains difficult to categorize the exact impact of the veterinary use of antimicrobials on the occurrence of AMR.

CONCLUSIONS

The last-year students of Veterinary Medicine of UGhent and ULiège indicated to feel overall sufficiently prepared regarding their education in AMS and AMR. There is however room for improvement regarding the education in AMR and the rational use of antimicrobials. This is also felt by the students themselves as less than half of them are satisfied with their education and feel the need for extra training. Increasing the focus on practical guidelines for rational antibiotic and on pharmacology of antimicrobial agents may definitely contribute to further improve the education and acquire a wider knowledge on AMS and AMR.

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