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Pharmacists' Knowledge of Veterinary Pharmacotherapy and the Impact of an Educational Intervention

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Abstract

Background: To date, there is very limited data regarding pharmacists' preparedness to handle animal prescriptions. No previous studies exist examining the impact of a veterinary-pharmacy–focused educational intervention. **Objective:** To assess pharmacists' baseline knowledge of veterinary pharmacotherapy, as relevant to their professional responsibilities, and assess the impact of a piloted educational program. **Methods:** Two studies were conducted. The first study involved a statewide assessment of pharmacists' knowledge of veterinary pharmacotherapy; the second study assessed the impact of an educational intervention to improve pharmacists' veterinary pharmacotherapy knowledge base. Participants in the pilot study were assessed via pretest and posttest. **Results:** The statewide sample of participants (n = 602) received a mean score of 5.9 (SD = 2.6) on a 17-item questionnaire. There were no discernible differences in participants' knowledge based on the subject matter of the question (pathophysiology, dosing, counseling, compounding, legality, and toxicology). Using the same 17-item questionnaire, pilot study participants (n = 60) received a mean score of 5.2 (SD = 2.4) on the pretest and 16.6 (SD = 0.7) on the posttest. **Conclusion:** The findings of this study suggest that a substantial portion of pharmacists lack the knowledge needed to process and dispense the veterinary prescriptions most commonly encountered in community pharmacies. Furthermore, this study shows that implementation of an educational intervention can increase pharmacists' knowledge of core concepts necessary to safely care for animal patients.

Keywords

veterinary pharmacy, veterinary, veterinary medicine, pharmacy education

Introduction

The field of veterinary medicine is changing at a dramatic pace. Veterinary therapy options have expanded. Additionally, societal views on the importance of animals in our lives and homes continue to change the way we care for our pets.[1] Many households consider their animal to be a member of the family.[1]

With this increased willingness to invest in their animal's well-being, owners now spend more on prescription medications for their pets.[1] While veterinary clinics can offer clients cost-effective generic animal drug products, a majority of companion animal medications are reformulated human drug products. This has led to a significant increase in veterinary prescriptions sent to community or online pharmacies.[1] In May 2015, the US Food and Drug Administration estimated that 75 000 pharmacies fill 6 350 000 compounded prescriptions for animals annually.[2]

Having felt the effects of Direct and Indirect Remuneration fees, community pharmacies may find the pursuit of additional income appealing. But this new endeavor comes at a significant risk. The pharmacists behind the counter are likely unprepared to safely dispense and counsel animal prescriptions. According to a 2012-2013 survey of 707 veterinarians, one third knew of a dispensing error that occurred at a community pharmacy.[3] Of those reports, one tenth resulted in harm to the animal.[3]

Currently, the Accreditation Council for Pharmacy Education's Standards do not require veterinary

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pharmacotherapy education as part of any curricula for the training of Doctor of Pharmacy. Furthermore, few accredited Schools of Pharmacy in the United States offer a didactic elective in veterinary pharmacy, clinical rotations, or other specialized learning opportunity. This leaves many graduating pharmacists with limited exposure to veterinary pharmacotherapy and may further put animals at risk for harm. To date, there are very limited data regarding pharmacists' preparedness to handle animal prescriptions.[3-10] Thus, the goal of the present study was to fill this gap in literature by investigating pharmacists' baseline knowledge of veterinary pharmacotherapy and evaluate the learning gains obtained from a veterinary pharmacotherapy training program. The authors' overarching aim of this research is to achieve safe and effective care for veterinary patients and strengthen the working relationship between veterinarians and community pharmacists.

We accomplished the aforementioned goal by conducting 2 independent studies. The first study involved assessing the veterinary pharmacotherapy knowledge of a statewide sample of pharmacists in North Carolina. The second study involved assessing the baseline knowledge of community pharmacists, who did not take part in the initial statewide assessment, to determine the degree to which validity evidence was discernible with regard to convergence and reproducibility of findings between the 2 assessments. Participants in the second study then completed a veterinary pharmacotherapy training program and their potential learning gains were assessed via a posttest.

Materials and Methods

Design of Veterinary Pharmacotherapy Questionnaire

The assessment was constructed by 2 pharmacists with extensive training and full-time involvement in veterinary pharmacy. A coinvestigator of this study, a nationally recognized expert on the subject of veterinary pharmacotherapy and a Diplomate of the International College of Veterinary Pharmacy, served as the validating authority of the assessment. The 17-item multiple-choice assessment was intended to identify barriers to the safe dispensing of medications to animal patients. The items selected were based on dispensing errors (pharmacotherapy, substitutions, pathophysiology, and legality and compounding concepts) most commonly reported in available literature[3] and through the authors' professional experience. To score the questionnaire, individuals received 1 point for each correct answer. The maximum number of points an individual could score was 17 points. A copy of the instrument is available in the Appendix.

Study 1: Investigation of a Pilot Veterinary Pharmacy Training Program

Design. The pilot study consisted of a quasi-experimental design utilizing pretest and posttest groups. The 17-item questionnaire was administered to participants in the pilot study. The pretest was administered to pharmacists in May 2017 in an effort to measure their baseline knowledge of veterinary pharmacotherapy concepts. An educational intervention was created with the intention to improve pharmacists' knowledge of relevant veterinary concepts. This prerecorded, self-paced webinar was provided to all participants following the pretest. The training program began on May 15, 2017, and concluded on October 15, 2017. Because participants are more likely to accurately recall information simply due to the recency of instruction ("recall effect"),[11] and because research has noted that memory begins to fade within hours and days immediately following a learning event (the "forgetting curve"),[12,13] we administered the posttest no less than 5 days after completion of the training in an effort to minimize these types of measurement errors from distorting score accuracy.

Educational Intervention. The educational program was a 3-hour session that included information on veterinary drug resources, species-specific pharmacokinetics and dispensing considerations, toxicology principles, compounding, and an overview of statutes and regulations governing veterinary pharmacy practices. The pharmacists were also exposed to veterinary pharmacotherapy training through implementation of their new veterinary pharmacy program and one-on-one training with a pharmacist trained in the field. This final training period offered pharmacists' reinforcement of the veterinary principles and opportunities for topic clarifications. Participants were also given access to numerous references, including veterinary drug handbooks.

Participants. A convenience sample of 60 pharmacists was drawn from all employees at a large community pharmacy group in North Carolina. Participants were informed that participation was voluntary, not required as part of their employment obligations, and no incentives would be provided. For inclusion in the study, the participants had to be employed pharmacists with access to the Internet. In an attempt to increase the response rate, a survey reminder was sent 1 week after the initial e-mail. The survey remained open for a total of 2 weeks. A breakdown of participants' demographic characteristics is presented in Table 1.

Analysis. The impact of the pilot program was assessed by comparing pretest and posttest results. Both parametric and nonparametric procedures were performed to compare

Table 1. Demographic Characteristics in Pilot Study and Statewide Study.

Variable	Pilot Study (n = 60), n (%)	Statewide Study (n = 602), n (%)
Gender		
Female	40 (66.7)	395 (65.6)
Male	20 (33.3)	207 (34.4)
Race/ethnicity		
American Indian or Alaskan Native	0 (0.0)	2 (0.3)
Asian/Pacific Islander	0 (0.0)	10 (1.7)
Black or African American	1 (1.7)	17 (2.8)
Hispanic	1 (1.7)	12 (2.0)
White/Caucasian	58 (96.7)	549 (91.2)
No response	0 (0.0)	12 (2.0)
Age (years)		
18 to 24	0 (0.0)	7 (1.2)
25 to 34	19 (31.7)	194 (32.2)
35 to 44	24 (40.0)	126 (20.9)
45 to 54	7 (11.7)	137 (22.8)
55 to 64	8 (13.3)	99 (16.4)
65 to 74	2 (3.3)	38 (6.3)
75 or older	0 (0.0)	1 (0.2)
Setting		
Community	60 (0.0)	233 (38.7)
Independent	0 (0.0)	78 (13.0)
Hospital	0 (0.0)	157 (26.1)
Other	0 (0.0)	15 (2.5)
No response	0 (0.0)	119 (19.8)
Experience		
<1 year	Not recorded	42 (7.0)
At least 1 year but <3 years	Not recorded	61 (10.1)
At least 3 years but <5 years	Not recorded	48 (8.0)
At least 5 years but <10 years	Not recorded	85 (14.1)
>10 years	Not recorded	366 (60.8)
Previous training in veterinary pharmacy		
Yes	Not recorded	54 (9.0)
No	Not recorded	548 (91.0)

group performance. First, an independent samples *t* test with Welch's correction was utilized to compare mean scores. Next, a Mann-Whitney *U* test was performed to compare median scores. Alpha was set to .05 to detect statistically significant differences.

Study 2: Assessment of North Carolina Pharmacists' Knowledge of Veterinary Pharmacotherapy

Design. The same 17-item questionnaire administered to the pilot sample was administered to participants in the statewide study. The North Carolina State University's Institutional Review Board classified both studies exempt from review (IRB Protocols 12264 and 12298).

Participants and Procedures. A population of 11 941 licensed pharmacists were available via an electronic mailing list software application. Given a population of this size, a sample size of 561 was needed in order to achieve a margin-of-error of 3.5% using a 95% confidence level, which is comparable with most national public opinion polls.[14] In August 2017, the assessment was distributed to licensed North Carolina pharmacists noting the request was purely voluntary and all responses would remain anonymous. Study participants were asked to identify the correct answer to each item. No immediate feedback was provided. The data were collected electronically via SurveyMonkey.

For inclusion in the study, the participants had to be licensed pharmacists with access to the Internet. In an attempt to increase the response rate, a survey reminder was sent 1 week after the initial e-mail. The survey remained open for a total of 2 weeks.

Analysis. On conclusion of the data collection period, data were subsequently exported for analysis. Data analysis

consisted of scoring the data with Winsteps measurement software.[15] Results were then exported to SPSS statistical software (version 24)[16] for further analysis, which included calculating descriptive statistics and comparing participants' performance by various demographic variables: age, gender, race, pharmacy practice setting, number of years practicing pharmacy, and prior exposure to veterinary pharmacotherapy training. Various inferential statistical techniques (eg, χ^2 tests, *t* tests, and analyses of variance) were used to compare group performance by demographic variable. All significance testing was performed with α set to .05.

Results

Study 1: Pilot Veterinary Pharmacy Training Program

Of the 60 individuals invited to participate in the study, all 60 (100%) completed the pretest and 44 (73.3%) completed the posttest. With regard to the pretest, scores largely were normally distributed and ranged from 0 to 12 correct. The mean score was 5.2 (SD = 2.4), and the median was 5. The raw score was 5 out of 17 items correct.

With regard to the posttest, scores ranged from 15 to 17 correct, with a mean score of 16.6 (SD = 0.7) and a median of 17. When comparing group performance between the pretest and posttest, an independent samples *t* test with Welch's correction indicated a statistically significant difference in the total knowledge scores of veterinary pharmacotherapy ($t[102] = -30.7$, $P < .001$). A Mann-Whitney *U* test indicated scores also were statistically significantly different ($P < .001$). There were no statistically significant differences observed between subgroups.

Study 2: Assessment of North Carolina Pharmacists' Knowledge of Veterinary Pharmacotherapy

In total, 602 participants completed the study, resulting in a response rate of 5.0%. The sampling margin-of-error was 3.4%. Participants' scores were normally distributed (skewness = .821, kurtosis = .673) with scores ranging from 1 to 16, a mean of 5.9 (SD = 2.6), and a median of 5. Given both the mean and median, raw scores approximated 5 to 6 (out of 17 items). There were no discernible differences in participants' knowledge based on the subject matter of the question (pathophysiology, dosing, counseling, compounding, and legality and toxicology).

Score results were compared based on various demographic variables. Results indicated that no statistically significant differences were discernible based on gender, race/ethnicity, age, practice setting, or years of experience. An independent samples *t* test, however, did indicate that a statistically significant difference ($P < .001$) was discernible based on previous training in veterinary pharmacotherapy. More specifically, the 54 individuals who indicated they had previous veterinary pharmacotherapy training yielded a mean score of 8.5 (SD = 3.4) compared with the 548 individuals with no previous training (mean = 5.6, SD = 2.4), $t(600) = 6.1$, $P < .001$.

Discussion

Validity Evidence

Results from the statewide pharmacists' assessment were consistent with pretest results from participants in the pilot study with mean scores approximating 5 to 6 correct responses out of 17 items. The convergence of scores across the similar samples provides evidence that speaks to the convergent and generalizability aspects of validity.[17,18] Posttest scores obtained at minimum 5 days after completion of veterinary pharmacotherapy training also lend evidence to support genuine learning gains of a substantial magnitude. Participants' raw scores increased from 5/17 to 16/17.

Given a 3.4% margin-of-error (95% confidence level), there is evidence to support the adequacy of the sample obtained for the statewide assessment given the margin-of-error is comparable with the statistical precision of most national public opinion polls.[14] Furthermore, this precision likely ensures the results obtained from the statewide sample of pharmacists reflect those of the entire statewide population of pharmacists. This finding also supports the generalizability of the study.[17,18]

Substantive Findings

Various publications have highlighted the significant need for pharmacists to receive clinically relevant veterinary pharmacotherapy training.[3-10] Alongside the rapidly growing market of pet expenditures, the emerging field of veterinary pharmacy is experiencing dramatic growth. According to the Accreditation Commission for Health Care, the veterinary pharmacy compounding market will rise at a compounded annual growth rate of 7.1% through at least the year 2025.[9]

The factors leading to this explosive growth are easy to see. High-end pet hotels, specialty animal diets, and even the rise of pet social media have made the support and encouragement of our domestic companions as important as any other family member. This level of care has translated to ensuring our pets' medication regimens are as error-proof and successful as humans'. But, in order to achieve a higher level of care, a number of training and operational hurdles in local pharmacies have to be overcome. The results of this sample of North Carolina pharmacists illustrated just how serious the veterinary education gap is at local pharmacies across the state. Of the 602 pharmacists surveyed, 41.3% said they would dispense xylitol, a potentially lethal animal toxicant, to a canine patient.

The lack of reliable pharmacies to fill veterinary prescriptions is not the fault of dispensing pharmacists—in 2015, only 4% of graduating pharmacists received any veterinary pharmacotherapy training.[10] It is not part of the core curriculum, and opportunities for training are limited. However, much like human medicine, this research shows that pharmacy schools should offer increased access to clinically relevant specialized training in veterinary medicine.

One portion of this study was designed to test pharmacists on core concepts required to safely dispense medications commonly sent to community pharmacies. By and large, the results showed that pharmacists lack an understanding of veterinary pathophysiology, legal aspects of compounding, and pharmacotherapy. With an average overall score between 29.4% and 35.3% correct, a success rate that is only slightly better than random chance (25%), the data indicate pharmacists are not prepared to take care of veterinary prescriptions they may encounter in their professional responsibilities.

Results from the pilot study demonstrated the importance of a training program to improve pharmacists' ability to safely dispense a drug for an animal. After exposure to applicable veterinary pharmacotherapy concepts and immersion in a professional program, pharmacists' scores more than doubled with a 64.7% increase in performance, a statistically significant difference ($P < .001$). The authors strongly suggest increased education in pharmacy schools and training through professional organizations that allow pharmacists to respond to medication questions posed by clients, understand the differences in animal physiology, and provide appropriate drug information to support pet owners and serve as an interprofessional collaborator with local veterinarians.

The authors acknowledge various limitations of this research, including the selection of the pilot program organization. This group was chosen as a convenience sample, as it is a large population of community pharmacists who are accessible via their affiliation with one of the coinvestigator's veterinary pharmacy program. Nonetheless, results from both the statewide assessment and the pilot study assessment indicated that results did not differ in any substantive way. Thus, the pilot sample of participants likely represents a cross-section of the statewide pharmacists with regard to knowledge of veterinary pharmacotherapy.

A second limitation of this study involves the limited geographical area from which participants were drawn. At the time of this writing, 2 of the 3 pharmacy schools in the survey area offer veterinary pharmacy elective courses and student practice experience in animal therapeutics, in collaboration with a regional college of veterinary medicine. The state is also one of the leading concentrated areas for providing professional support, and for continuing education and postgraduate programs focused on the field of veterinary pharmacy. This suggests that other groups throughout the United States and abroad may demonstrate even lower scores.

Of the 602 pharmacists in the statewide assessment, only 311 participants identified their employment setting as community pharmacy. By including hospital/inpatient and other pharmacists not involved in dispensing medication to animal patients, the scores from this questionnaire may have been skewed lower. The authors' acknowledge this weakness and recommend that future studies should involve only community pharmacists.

A limitation of the pilot study was participants' pretest and posttest data could not be directly compared because of the anonymous nature of the assessment. Personally identifiable information was not collected due to a coinvestigator's professional affiliation with this cohort. The identity of these participants, with regard to their responses, had to remain anonymous for the institutional review board's approval. Thus, pretest and posttest comparisons were based on group-level differences only.

With regard to validity threats, typical concerns regarding pretest and posttest study designs, such as error contamination due to recall effects, were minimal for this study for 3 primary reasons: (1) there were no stakes associated with either the baseline (pretest) assessment or the post-training (posttest) assessment; (2) correct answers were not provided to participants at the conclusion of the pretest; and (3) more than 1 month elapsed between assessments.

A final limitation of this study was the lack of data on the sustainable impact of the educational intervention. While all pilot study participants had at least 5 days of a washout period, future research should study the long-term effect of this educational intervention. Furthermore, it would be helpful to know if the educational intervention parlayed to changes in practice behaviors. Exploring the practical significance of an educational intervention such as the one described here was beyond the scope of this work. However, future work should make such studies a priority.

Conclusion

This study demonstrates the importance of veterinary pharmacology education for pharmacists, a concept highly encouraged by the American Veterinary Medical Association.[5] Substantial pharmacy graduates lack the knowledge they need to adequately handle the most commonly received prescriptions they will encounter in community practices. Additionally, this research supports the stance of the National Association of Boards of Pharmacy that pharmacists dispensing medications for veterinary patients should possess competence to do so and have ready access to veterinary drug references.[6] Finally, this study supports the need for the development of additional strategies to disseminate effective veterinary pharmacology education and practice experience.

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Appendix

List of Assessment Items and Pharmacists' Success Rates on Statewide Pretest.

Item	Success Rate
1. When dispensing levothyroxine for a dog, which of the following is true? a. The medication should always be administered on an empty stomach. b. There is no FDA-approved product for use in a dog. c. 0.8 µg is an appropriate dose. d. 0.8 mg is an appropriate dose.	22.09%
2. Which of the following is inappropriate to dispense? a. Prednisone for a dog. b. Prednisone for a cat. c. Prednisone for a hamster. d. Prednisone for a guinea pig.	5.32%
3. What would be your concern in dispensing some artificially sweetened medications to a canine patient? a. Sucralose can cause toxicity in a dog. b. Aspartame can cause toxicity in a dog. c. Sorbitol can cause toxicity in a dog. d. Xylitol can cause toxicity in a dog.	31.89%
4. You compound a medication using simple syrup and purified water. You have no information regarding a stability-indicating assay. What BUD should you assign? a. 14 days at room temperature b. 30 days at room temperature c. 14 days in the refrigerator d. 30 days in the refrigerator	13.46%
5. The FDA would most likely take regulatory action against the pharmacy in which of the following scenarios? a. Duplicating a commercially available product. b. Compounding with bulk drug substances for use in food animals. c. Compounding with bulk drug substances for use in nonfood animals. d. Compounding when no veterinary-client-patient relationship exists.	46.18%
6. You receive a prescription to compound 10 mg/mL doxycycline oral suspension for a dog. Which of the following should you consider first? a. Is doxycycline stable in a fixed-oil suspension? b. Is doxycycline stable in an aqueous suspension? c. If there is an FDA-approved product that can be used? d. Should doxycycline monohydrate or doxycycline hyclate be used as the bulk ingredient?	59.47%
7. The veterinary abbreviation "SID" stands for: a. Once daily b. Twice daily c. Three times daily d. Four times daily	18.44%
8. An owner comes into the pharmacy asking about an appropriate dosing of Claritin for her dog. What do you do? a. Refer to *Plumb's Veterinary Drugs Handbook* for an appropriate dosing regimen. b. Tell the owner you will need a prescription from the dog's veterinarian. Federal law prohibits you from making any recommendation. c. Ask her what her veterinarian has suggested. You must make sure a veterinarian-client-patient relationship exists before making a recommendation. d. Ask for the dog's weight. This information is essential when dosing medications in animals.	60.96%
9. Which of the following sources might you request from a veterinarian in order to verify they are appropriately licensed? a. The veterinarian's state veterinary license number. b. The veterinarian's National Provider Identifier (NPI) number. c. The veterinarian's Drug Enforcement Agency (DEA) registration number. d. The veterinarian's Social Security Number.	18.11%
10. An owner calls the pharmacy to report an adverse drug reaction in one of your veterinary patients. How do you report this? a. FDA MedWatch b. NC VMA Form Number 230b c. FDA Form Number 1932a d. AVMA Form Number 45	29.90%

(continued)

Appendix (continued)

Item	Success Rate
11. What is an important consideration when dispensing Vetsulin for a cat with diabetes? a. Provide the owner with U-40 syringes. b. Provide the owner with U-100 syringes. c. Counsel the owner to avoid taking blood samples from the marginal ear vein and paw pads. d. Counsel the owner to avoid shaking the insulin prior to dosing.	63.12%
12. You dispense a potassium bromide compound for a dog with idiopathic epilepsy. What is an important counseling point? a. Polyuria and polyphagia are signs of toxicity. If you notice any of these adverse effects, contact your veterinarian immediately. b. Do not allow your dog to ingest salt water while out playing on the beach. c. Weight loss is a common adverse effect seen with this medication. d. A benefit of this medication is that therapeutic drug-level monitoring is unnecessary. This will prevent regular follow-up trips to the veterinarian.	27.41%
13. Some canine breeds display a genetic polymorphism that increases their risk of severe central nervous system toxicity with particular medications like loperamide. Which patient below would you need to be concerned about dispensing loperamide to? a. Collie b. Boxer c. Golden Retriever d. Chihuahua	60.13%
14. You receive 2 prescriptions for a canine patient. The DVM would like to start the patient on a concurrent regimen of ketoconazole and cyclosporine. What should you, the dispensing pharmacist, do? a. This combination could result in a potentially dangerous drug-drug interaction. Contact the veterinarian. b. Cyclosporine is contraindicated in dogs. Contact the veterinarian. c. Ketoconazole is contraindicated in dogs. Contact the veterinarian. d. This is an intentional drug-drug interaction. There is no need to contact the veterinarian.	17.44%
15. Which of the following oral medications are safe to administer to a rabbit? a. Fluoroquinolones b. Macrolides c. Beta-lactams d. Corticosteroids	32.72%
16. Some medications are contraindicated during the first trimester of pregnancy. Which pregnant canine below could not safely receive these medications? a. A dog that is 55 days pregnant. b. A dog that is 15 days pregnant. c. A dog that is 35 days pregnant. d. A dog that is 25 days pregnant.	11.30%
17. Canines are at risk of developing keratoconjunctivitis sicca (KCS) when given which of the following medications? a. Fluoroquinolones b. Sulfonamides c. Cephalosporins d. Aminoglycosides	69.77%

Abbreviations: FDA, Food and Drug Administration; BUD, beyond use date; SID, once per day; NC VMA, North Carolina Veterinary Medical Association; AVMA, American Veterinary Medical Association; DVM, Doctor of Veterinary Medicine.