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Original Research

Baseline knowledge of potential pet toxins: a survey of pharmacists

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Abstract

Background: Consumer expenditures on their family pets are rapidly increasing, part of which can be attributed to prescription and OTC medications. In turn, community pharmacies are seeking and receiving an increased number of prescriptions for animals. Community pharmacists' ability to safely care for animal patients is relatively unexplored. Human medications, their normal dosing and even medication excipients could be lethal in some animal patients.

Objective: The overarching objective of this study was to assess pharmacists' baseline knowledge of potential pet poisons.

Methods: The sample consisted of licensed pharmacists registered with the North Carolina Board of Pharmacy. The Pet Toxins Survey (PTS), a survey consisting of 25 potential pet toxins, was administered during October and November 2015. Analyses consisted of calculating descriptive statics (including graphical summaries to test for normality), and inferential statistics (two-tailed t-tests and ANOVAs) to compare responses across demographic variables.

Results: A 6.3% response rate was obtained. After selecting either a dog or a cat to establish a frame of reference, participants in this study were able to correctly identify 15 of the 25 listed items as toxic to a pet (60% accuracy). Participants did not express adequate concern for the ingestion of several potential toxins. This includes potential excipients found in medication formulations such as xylitol, tea tree oil and caffeine. Female participants and those age 50 years and older were more likely to indicate concern for each potential toxin. There was no significant difference observed in responses based on the pharmacists' work setting.

Conclusions: The findings of this investigation suggest that pharmacists are deficient in their understanding of veterinary toxicology. Given the rise of community pharmacists caring for animal patients, it's paramount that pharmacists be able to confidently distinguish potential pet toxins from non-toxins. It is also important that pharmacists receive a better understanding of what exposures require immediate action and what action should be taken.

Keywords

Pets; Poisons; Animal Diseases; Health Knowledge, Attitudes, Practice; Education, Pharmacy; Pharmacies; Pharmacists; Surveys and Questionnaires; North Carolina

INTRODUCTION

Society is entering a new age for the modern family pet. Many owners today view their pet as a member of the family.[1] This change in mindset is altering the way in which animals are cared for as well. According to the American Pet Products Association, more than USD 58 billion was spent on pets in 2014, part of which could be attributed to prescription and OTC medications.[2] Projections estimated the total consumer expenditures to rise to $60.6 billion in 2015 and growth to continue in subsequent years.[2]

Community pharmacies are receiving an increasing number of pet prescriptions to meet the demands of the growing willingness to better care for pets.[2] Convenience, potential savings, changes in compounding regulations and crossover drugs (developed for humans but with accepted use in veterinary medicine) are driving this increase. Retailers are encouraging owners to pick up prescriptions for the whole family, pets included, at local pharmacies. Veterinary prescriptions often come without the hassle of dealing with insurance payers, meaning more profits and fewer interruptions in workflow. It seems only logical that companies would take advantage of this new view of pets as family members.

Unfortunately, pharmaceutical care provided by pharmacies to non-human species may not be as safe as pet owners would like. While the field of pharmacy has evolved significantly with pharmacists now completing a 4-year doctoral program, most are significantly under-qualified to dispense veterinary medications. To date, veterinary pharmacotherapy is not a mandatory element of any pharmacy education core curriculum.[3] Yet the growth of pet prescriptions in retail pharmacy settings continues to soar.

Dogs and cats are anatomically, physiologically, and metabolically unique. A normal dosage given to a human could be far too much or too little to treat a pet, even when scaled based on weight (e.g. mg/kg). Even if given at an appropriate dosage for a pet, the presence of certain additives in some human drug formulations could be lethal. It is unlikely most pharmacists realize this, unfortunately, given their lack of veterinary pharmacotherapy education.[3] To date there is no known research assessing the baseline knowledge of pharmacists as it pertains to potentially toxic substances for non-human patients. This study sought to fill that void by assessing the current knowledge level of

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Table 1. Demographic characteristics of sample	
Variable	**n (%)**
Sex	
Male	287 (41.0)
Female	413 (59.0)
Age (years)	
20-29	89 (12.7)
30-39	184 (26.2)
40-49	178 (25.5)
50-59	126 (18.0)
60+	123 (17.6)
Setting	
Community	258 (36.8)
Independent	207 (29.6)
Hospital	77 (11.0)
Internet	2 (0.2)
Other	156 (22.3)
State	
North Carolina	697 (99.6)
Other	3 (0.4)

practicing pharmacists with respect to toxic agents in veterinary patients.

METHODS

Participants

At the time this study was conducted there were 11,599 pharmacists in North Carolina. A total of 704 pharmacists completed the survey, resulting in a 6.3% response rate. The margin of error when using a 95% confidence level was 3.58%. A chi-squared test was performed to determine if the pharmacist sample was reflective of the state's population of pharmacists by sex and age variables. Results indicated the sample was statistically significantly different ($p<0.001$) for both variables. A closer inspection of data indicated a discernible underrepresentation from males and persons over 60 years of age. In order to mitigate the sampling bias, auxiliary statistics were obtained from the North Carolina Board of Pharmacy and post-stratification weights were applied to correct for over/under representation based on age and sex variables. After statistical weights were applied to correct for sampling bias, the sample size was adjusted to n=700. Participants were classified by four demographic items: age, gender, pharmacy practice setting and state of primary practice. A breakdown of demographic statistics is presented in Table 1.

Instrumentation

The Pet Toxins Survey (PTS), a survey consisting of 25 potential pet toxins, was administered to pharmacists licensed to practice pharmacy in the state of North Carolina. The PTS sought to measure NC pharmacists' knowledge of potential pet toxins. All responses were anonymous. Pharmacists were asked to select either a cat or a dog as a frame of reference for answering each of the 25 items appearing on the PTS. Toxins were presented to participants as a list. Respondents were instructed to provide their level of concern should this animal consume each particular substance. The PTS utilized a 5-point rating scale consisting of the following categories: 1=Not at all concerned (Not a poison emergency); 2=Slightly concerned; 3=Somewhat concerned; 4=Quite concerned; and 5=Extremely concerned (Very serious poison emergency).

The potential toxins (as presented) were: loratadine (Claritin), macadamia nuts, Sago Palms, alliums (onions, garlic, chives), English Ivy, tea tree oil, grapes, caffeine, artificial sweeteners (xylitol), acetaminophen (Tylenol), ethanol, nicotine, chocolate, moth balls and DEET (insect

Table 2. Concerns for Each Potential Pet Toxin						
	Dogs (n = 604)		**Cats (n = 96)**		**p-value**	**d**
	M	**SD**	**M**	**SD**		
Macadamia nuts	2.80	1.29	2.33	1.18	0.002*	0.38
Chocolate	4.11	0.92	3.37	1.22	< 0.001*	0.68
Famotidine	2.15	1.19	2.65	1.33	< 0.001*	0.40
Tea tree oil	3.13	1.17	3.18	1.23	0.711	0.04
Loratadine	1.98	1.14	2.49	1.29	< 0.001*	0.42
Allium (onions, garlic, chives)	2.97	1.41	2.71	1.47	0.100	0.18
Nicotine	4.08	0.97	4.04	1.12	0.697	0.04
English ivy	3.07	1.23	3.01	1.39	0.702	0.05
Artificial sweeteners (xylitol)	3.49	1.30	3.21	1.36	0.060	0.21
Moth balls	4.16	1.04	4.40	0.90	0.035†	0.25
Pony tail palm	2.97	1.26	2.79	1.20	0.205	0.15
Leather	2.19	1.18	2.18	1.25	0.923	0.01
Pumpkin	1.60	0.96	1.72	1.11	0.271	0.12
Grapes	3.22	1.52	2.24	1.44	< 0.001*	0.66
Green beans	1.31	0.71	1.47	0.92	0.124	0.19
Tomatoes	1.65	0.94	1.72	1.14	0.564	0.07
Sago palm	2.95	1.23	3.03	1.23	0.542	0.07
African violet	3.29	1.24	3.28	1.27	0.956	0.01
DEET (insect repellant)	4.23	0.98	4.31	1.00	0.435	0.08
Bananas	1.53	0.88	1.68	1.03	0.123	0.16
Acorn squash	1.61	0.91	1.66	0.99	0.587	0.05
Acetaminophen	3.75	1.28	4.27	0.97	< 0.001*	0.46
Caffeine	3.46	1.17	3.60	1.11	0.301	0.12
Ethanol	3.89	1.13	3.97	1.06	0.515	0.07
Paper	1.73	0.94	1.72	1.04	0.926	0.01
*Denotes statistical significance ($p < 0.002$) after a Bonferroni correction. †Denotes statistical significance ($p < 0.05$) before Bonferroni correction.						

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Table 3. Concerns for each potential pet toxin by sex

	Males (n = 287)		Females (n = 413)		p-value	d
	M	SD	M	SD		
Macadamia nuts	2.76	1.26	2.72	1.30	0.695	0.03
Chocolate	3.87	1.07	4.10	0.93	0.003†	0.23
Famotidine	2.21	1.17	2.23	1.25	0.824	0.02
Tea tree oil	3.07	1.19	3.19	1.17	0.192	0.10
Loratadine	2.05	1.13	2.06	1.21	0.882	0.01
Allium (onions, garlic, chives)	2.69	1.37	3.09	1.43	< 0.001*	0.29
Nicotine	4.01	1.04	4.12	0.95	0.140	0.11
English ivy	3.00	1.28	3.10	1.24	0.351	0.08
Artificial sweeteners (xylitol)	3.29	1.36	3.56	1.27	0.009†	0.21
Moth balls	4.21	1.04	4.18	1.02	0.669	0.03
Pony tail palm	2.75	1.33	3.07	1.18	0.002*	0.25
Leather	1.98	1.10	2.33	1.23	< 0.001*	0.30
Pumpkin	1.65	1.03	1.60	0.96	0.544	0.05
Grapes	2.78	1.53	3.29	1.52	< 0.001*	0.33
Green beans	1.40	0.81	1.30	0.69	0.094	0.13
Tomatoes	1.71	1.04	1.62	0.91	0.272	0.09
Sago palm	2.85	1.26	3.03	1.20	0.062	0.15
African violet	3.20	1.32	3.35	1.19	0.110	0.12
DEET (insect repellant)	4.08	1.03	4.35	0.94	0.001*	0.27
Bananas	1.55	0.90	1.55	0.91	0.956	0.00
Acorn squash	1.61	0.94	1.62	0.91	0.947	0.01
Acetaminophen	3.82	1.18	3.82	1.31	0.981	0.00
Caffeine	3.41	1.12	3.53	1.19	0.186	0.10
Ethanol	3.71	1.15	4.03	1.097	< 0.001*	0.28
Paper	1.77	1.00	1.70	0.92	0.351	0.07

*Denotes statistical significance ($p < 0.002$) after a Bonferroni correction. †Denotes statistical significance ($p < 0.05$) before Bonferroni correction.

repellant). The non-toxins (as presented to participants) were: green beans, bananas, pumpkin, acorn squash, tomatoes, paper, famotidine (Pepcid-AC), leather, Pony Tail Palms and African Violets).

Procedures

The PTS was administered to all licensed NC pharmacists, currently registered with the North Carolina Board of Pharmacy (NC BOP) during October and November 2015. An email containing a link to the survey instrument was distributed via the North Carolina Board of Pharmacy mailing list. SurveyMonkey software was used to record participant responses. Respondents were allowed three weeks to complete the survey. A reminder email was sent after two weeks in an effort to increase participation. This study was declared 'Exempt' by the North Carolina State University's Institutional Review Board (IRB), protocol #6126.

Data analysis

All data analyses were performed using SPSS statistical software. Analyses consisted of calculating descriptive statistics (including graphical summaries to test for normality), and inferential statistics (two-tailed t-tests and ANOVAs) to compare responses across demographic variables. Because multiple comparisons were used the potential for family-wise error increased. To combat this potential problem we utilized a Bonferroni correction in which the p-value was adjusted to a $p \leq 0.002$. Tukey's post-hoc tests were performed to identify significant differences resulting from the ANOVA. Further, Cohen's d effect size estimates were calculated for each t-test to determine the "practical significance" of each result.[4] Eta-squared (η^2) effect size estimates were calculated for ANOVA tests. Instances of absent data among participants' response vectors were treated as 'missing'. The Cronbach's α reliability estimate was 0.90, indicating participants' scores are highly reliable.[5]

RESULTS

Participants were asked to select either a dog or a cat to establish a frame of reference and then answer all questions with this animal in mind. Results indicate six substances (macadamia nuts, chocolate, famotidine, loratadine, grapes and acetaminophen) resulted in statistically significant differences between dogs and cats ($p<0.002$). Cohen's d effect size estimates ranged from 0.38 to 0.68 with most effect sizes approximating 0.50 in magnitude indicating a moderate effect size for each statistically significantly different pair. Table 2 provides a breakdown of full results and p-values based on participant responses by dog and cat.

Based on the species frame-point chosen, participants did not express significant concern for the ingestion of nine potential toxins (macadamia nuts, tea tree oil, loratadine, allium, English Ivy, xylitol, grapes, Sago Palm, and caffeine) and a heightened level of concern for a non-toxin (African Violet). Participants were therefore able to identify 15 of the 25 items listed as toxic to a dog of cat (60% accuracy).

An independent samples t-test was performed to compare responses by sex (Table 3). Of the 25 potential toxins, six yielded a statistically significant difference ($p \leq 0.002$) after the Bonferroni adjustment (allium, pony tail palm, leather, grapes, DEET and ethanol). In all six instances, male pharmacists reported lower levels of concern on average than female pharmacists. Effect size estimates

Table 4. Concerns for each potential pet toxin by age

	20-29	30-39	40-49	50-59	60+	F (df)	p-value	η^2
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)			
Macadamia nuts	2.75 (1.24)	2.71 (1.31)	2.58 (1.24)	2.76 (1.30)	2.95 (1.31)	1.473 (4)	0.209	0.009
Chocolate	4.01 (0.92)	3.97 (1.05)	4.03 (1.09)	4.11 (0.84)	3.95 (0.98)	0.557 (4)	0.694	0.003
Famotidine	2.27 (1.22)	2.03 (1.16)	2.20 (1.15)	2.35 (1.38)	2.35 (1.23)	1.759 (4)	0.135	0.011
Tea tree oil	2.91 (1.11)	2.97 (1.15)	3.33 (1.13)	3.12 (1.22)	3.29 (1.23)	3.270 (4)	0.011	0.020
Loratadine	1.78 (1.11)	1.84 (1.12)	2.07 (1.10)	2.31 (1.32)	2.30 (1.18)	5.379 (4)	<0.001*	0.031
Allium	2.73 (1.39)	3.10 (1.39)	2.87 (1.51)	2.98 (1.47)	2.89 (1.28)	1.191 (4)	0.313	0.007
Nicotine	3.82 (1.08)	3.94 (0.97)	4.19 (0.98)	4.24 (0.93)	4.13 (0.96)	3.973 (4)	0.003†	0.023
English ivy	3.00 (1.11)	2.88 (1.25)	3.14 (1.19)	3.12 (1.33)	3.19 (1.35)	1.467 (4)	0.211	0.009
Art. sweeteners	3.31 (1.38)	3.34 (1.30)	3.48 (1.35)	3.60 (1.30)	3.51 (1.24)	1.021 (4)	0.396	0.006
Moth balls	3.73 (1.12)	3.95 (1.11)	4.25 (0.98)	4.48 (0.83)	4.51 (0.87)	13.202 (4)	<0.001*	0.073
Pony tail palm	2.89 (1.11)	2.88 (1.22)	2.92 (1.25)	3.14 (1.30)	2.90 (1.36)	0.879 (4)	0.476	0.006
Leather	2.23 (1.22)	2.28 (1.21)	2.18 (1.19)	2.10 (1.20)	2.12 (1.13)	0.536 (4)	0.709	0.003
Pumpkin	1.73 (1.04)	1.51 (0.95)	1.61 (0.93)	1.59 (0.99)	1.74 (1.06)	1.236 (4)	0.294	0.007
Grapes	3.25 (1.54)	3.25 (1.53)	3.06 (1.58)	3.05 (1.52)	2.78 (1.52)	1.931 (4)	0.104	0.011
Green Beans	1.36 (0.75)	1.33 (0.75)	1.29 (0.65)	1.31 (0.77)	1.43 (0.83)	0.743 (4)	0.563	0.004
Tomatoes	1.72 (1.04)	1.70 (1.00)	1.57 (0.86)	1.57 (0.94)	1.77 (1.04)	1.125 (4)	0.343	0.007
Sago palm	2.69 (1.18)	2.81 (1.10)	2.94 (1.27)	3.15 (1.32)	3.22 (1.20)	3.655 (4)	0.006†	0.022
African violet	3.13 (1.18)	3.24 (1.16)	3.38 (1.28)	3.33 (1.32)	3.32 (1.27)	0.675 (4)	0.609	0.004
DEET	4.01 (1.05)	4.16 (1.01)	4.35 (0.94)	4.36 (0.92)	4.25 (1.01)	2.501 (4)	0.041†	0.015
Bananas	1.61 (0.92)	1.45 (0.87)	1.52 (0.80)	1.57 (1.00)	1.70 (0.97)	1.446 (4)	0.217	0.009
Acorn squash	1.79 (0.98)	1.55 (0.93)	1.61 (0.84)	1.53 (0.96)	1.66 (0.95)	1.287 (4)	0.274	0.008
Acetaminophen	3.43 (1.37)	3.62 (1.27)	4.07 (1.14)	4.11 (1.20)	3.74 (1.22)	6.921 (4)	<0.001*	0.040
Caffeine	3.13 (1.27)	3.22 (1.11)	3.70 (1.15)	3.71 (1.14)	3.57 (1.08)	7.309 (4)	<0.001*	0.042
Ethanol	3.53 (1.19)	3.78 (1.14)	4.04 (1.06)	4.10 (1.09)	3.94 (1.10)	4.797 (4)	0.001*	0.027
Paper	1.69 (0.95)	1.70 (1.00)	1.72 (0.90)	1.66 (0.99)	1.89 (0.95)	1.061 (4)	0.375	0.006

*Denotes statistical significance ($p < 0.002$) after a Bonferroni correction. †Denotes statistical significance ($p < 0.05$) before Bonferroni correction.

approximated 0.29 in magnitude, indicating a low-moderate effect size. Full results and p-values are presented in Table 3.

An ANOVA was performed to determine if participants' responses varied by age. After a Bonferroni adjustment, five substances resulted in statistically significant differences ($p<0.002$) based on age (loratadine, moth balls, acetaminophen, caffeine and ethanol). Table 4 presents all results and p-values. In 15 instances, older pharmacists (age 50 years and older) were more likely to indicate concern for each potential toxin. Eta-squared effect size estimates indicated small (0.01) to moderate (0.06) effect sizes.[4]

Pharmacists' responses were compared based on the setting in which they worked. Because only two pharmacists indicated they were Internet pharmacists, these responses were excluded from the ANOVA. A breakdown of results is presented in Table 5. Results indicate no statistically significant differences were discernible after a Bonferroni adjustment ($p<0.002$).

DISCUSSION

Participants in this study could correctly classify slightly more than one half of the listed items as toxic or non-toxic. For the purposes of discussion, a rating of 3.5 and above represents appropriate heightened concern for toxic exposure. The qualitative distinctions for ratings of 3 and 4 respectively were "somewhat" and "quite" concerned. We arbitrarily selected 3.5 as an appropriate cut-point to indicate where serious level of concern might lie. In this study, based on the species frame-point chosen, participants did not express adequate concern for the ingestion of several potential toxins (macadamia nuts, tea tree oil, loratadine, allium, English Ivy, xylitol, grapes, sago palm, and caffeine). Conversely, a rating of 3 or more for exposure to a non-toxic item was considered an inaccurate level of concern. As mentioned previously, a rating of 3 qualitatively represents "somewhat concerned." Anything below this cutpoint (indicating "not at all concerned" or "slightly concerned") was arbitrarily selected as an appropriate level of concern for a non-toxin. This occurred with only one of the listed items (African Violet). Based on these criteria, participants were able to correctly identify 15 of the 25 listed items as toxic to a dog or cat (60% accuracy).

Perhaps more concerning is that pharmacists achieved accuracy on just 50% of the pharmaceutical related items listed (acetaminophen, loratadine, famotidine and xylitol). When asked about xylitol, an artificial sweetener found in many products, including medications like gabapentin solutions, pharmacists ranked the consumption of xylitol by a dog as "somewhat concerning." As the literature shows, xylitol consumption by a dog is considered a very serious poison emergency and can lead to hypoglycemia, liver failure, and even death.6 Just a small amount of xylitol (100 mg/kg) can elicit signs of toxicity, especially in smaller dogs.[6]

Dogs and cats were the chosen as the frame-point since they are the predominate species encountered in the community pharmacy setting. A comparison was made between the two to see if pharmacists could be discerning with respect to potential toxins. Some potential toxins are clinically important in both dogs and cats while others are important in only one species. The authors hypothesized that responses would not deviate significantly because

Table 5. Concerns for Each Potential Pet Toxin by Practice Setting

	Community	Independent	Hospital	Other	F (df)	*p*	η^2
	M (SD)	M (SD)	M (SD)	M (SD)			
Macadamia nuts	2.70 (1.27)	2.75 (1.30)	2.86 (1.30)	2.71 (1.28)	0.345 (3)	0.793	0.002
Chocolate	4.00 (0.96)	4.03 (1.06)	3.97 (1.06)	4.03 (0.94)	0.093 (3)	0.964	0.000
Famotidine	2.13 (1.21)	2.17 (1.14)	2.19 (1.29)	2.45 (1.29)	2.261 (3)	0.080	0.010
Tea tree oil	3.14 (1.22)	3.19 (1.13)	3.12 (1.14)	3.08 (1.20)	0.247 (3)	0.864	0.001
Loratadine	1.90 (1.11)	2.15 (1.18)	2.04 (1.21)	2.21 (1.25)	2.710 (3)	0.044†	0.012
Allium	2.85 (1.42)	3.08 (1.41)	2.80 (1.43)	2.93 (1.42)	1.216 (3)	0.303	0.005
Nicotine	4.05 (1.03)	4.19 (0.92)	3.74 (1.15)	4.14 (0.90)	3.939 (3)	0.008†	0.017
English ivy	2.95 (1.27)	3.21 (1.23)	2.82 (1.23)	3.16 (1.25)	2.662 (3)	0.047†	0.012
Art. sweeteners	3.37 (1.33)	3.50 (1.28)	3.58 (1.28)	3.46 (1.33)	0.679 (3)	0.565	0.003
Moth balls	4.12 (1.05)	4.24 (0.99)	4.01 (1.18)	4.35 (0.93)	2.554 (3)	0.054	0.011
Pony tail palm	2.93 (1.21)	2.96 (1.21)	3.09 (1.38)	2.86 (1.33)	0.505 (3)	0.679	0.002
Leather	2.31 (1.24)	2.07 (1.09)	2.05 (1.23)	2.21 (1.19)	1.814 (3)	0.143	0.008
Pumpkin	1.63 (0.97)	1.61 (0.99)	1.67 (1.16)	1.61 (0.92)	0.073 (3)	0.974	0.000
Grapes	3.07 (1.55)	3.19 (1.52)	3.03 (1.62)	3.01 (1.55)	0.472 (3)	0.702	0.002
Green beans	1.35 (0.76)	1.28 (0.69)	1.41 (0.88)	1.35 (0.72)	0.650 (3)	0.583	0.003
Tomatoes	1.68 (1.01)	1.61 (0.94)	1.83 (1.03)	1.61 (0.90)	1.079 (3)	0.357	0.005
Sago palm	2.91 (1.20)	3.06 (1.23)	2.90 (1.29)	2.95 (1.24)	0.585 (3)	0.625	0.003
African violet	3.30 (1.21)	3.33 (1.22)	3.19 (1.32)	3.27 (1.30)	0.230 (3)	0.875	0.001
DEET	4.17 (0.97)	4.27 (1.00)	4.10 (1.11)	4.39 (0.92)	2.099 (3)	0.099	0.009
Bananas	1.54 (0.87)	1.57 (0.97)	1.51 (0.90)	1.58 (0.88)	0.143 (3)	0.934	0.001
Acorn squash	1.58 (0.87)	1.64 (0.98)	1.71 (1.04)	1.58 (0.86)	0.469 (3)	0.704	0.002
Acetaminophen	3.64 (1.35)	3.86 (1.27)	3.78 (1.20)	4.07 (1.06)	3.889 (3)	0.009†	0.017
Caffeine	3.33 (1.16)	3.61 (1.21)	3.34 (1.12)	3.63 (1.11)	3.475 (3)	0.016†	0.015
Ethanol	3.89 (1.15)	3.83 (1.16)	3.78 (1.19)	4.07 (0.99)	1.777 (3)	0.150	0.008
Paper	1.75 (0.95)	1.64 (0.91)	1.91 (1.13)	1.75 (0.94)	1.494 (3)	0.215	0.007

*Denotes statistical significance ($p < 0.002$) after a Bonferroni correction. †Denotes statistical significance ($p < 0.05$) before Bonferroni correction.

pharmacists lacking veterinary toxicology training are unlikely to know which substances are poisonous for dogs, but not cats (and vice versa). Participants did indicate statistically significant different levels of concern ($p<0.002$) between dogs and cats for six substances (macadamia nuts, chocolate, famotidine, loratadine, grapes and acetaminophen). Of these items, acetaminophen would be the only potential toxin that has a clinically different level of concern based on species (dog versus cat).

Females in this study tended to express more concern for pets ingesting or being exposed to potential toxins. It is plausible that this is due to the humanistic nature of females to express more caution and concern.[7] Younger participants tended to express less concern about the ingestion of a potential hazard. Again, this could be due to the humanistic nature of being less experienced with animals and situations that resulted in harm.[8] There was no significant difference observed in responses based on the setting in which pharmacists work.

Implications

Several practical implications can be drawn from this study. First, pharmacists assessing poisoning risk need a better understanding of what exposures require immediate action and what that action should be. However, pharmacists trained in veterinary toxicology should be encouraged to only offer basic triage information and to refer pet owners to proper veterinary professionals when a suspected toxin exposure occurs.

Second, pharmacy education should include how to utilize veterinary toxicology resources to find information of pet poisoning. These resources should contain easily accessible information on poisoning symptoms with clear instructions on when and how to seek help.

Limitations and Future Research

The sample in this study included only pharmacists licensed in North Carolina, making it difficult to generalize the results to pharmacists throughout the United States and beyond. Future studies should be conducted on a broader population of participants to determine pharmacists' perception of what substances are hazardous to pet health.

Another limitation of this study is that it was conducted through a web-based survey. While these types of surveys ensure participants' anonymity and facilitate data collection, using this type of survey might affect the generalizability to all pharmacists because of lack of access to the North Carolina Board of Pharmacy email list, technical incompatibilities, and/or their use of email. The privacy conditions of a web-based survey also limit researchers' ability to monitor participants completing the survey and ensure there is no use of information resources. In addition, the web-based format of the survey may have contributed to the lack of response. To improve future response rates, utilizing a combination of multiple response-inducing techniques (such as email and postal mail) should be considered.

The nature of this research design also limits the scope of the conclusions that can be drawn regarding the relationship between concern for poisoning and ability to accurately identify a potential pet toxin. Parameters, such as dose-dependency and time since toxin ingestion, affect the level of concern following a toxic ingestion or exposure. For example, ingestion of just a single acetaminophen tablet can be highly concerning in cats but a dog has a

higher toxicity threshold. The size of the animal also depends on the level of concern after consumption. The same limitations apply with loratadine. This medication has clinical use in dogs and cats and is not universally toxic. The amount consumed would be the deciphering factor for appropriate level of concern. In the authors' judgement, it was impossible to assign specific criteria given the numerous hypothetical combinations and would be unwieldy in a survey of this nature. However, generic impressions about each substance do provide a reasonable approximation of its perceived toxicity to pets. Clearly, additional research is needed in this area of inquiry.

CONCLUSIONS

The findings of this investigation suggest that pharmacists are deficient in their understanding of veterinary pharmacology, particularly in regards to toxicology. Despite the increase in veterinary prescriptions in the community pharmacy setting, many pharmacists are deficient in their ability to advise on toxin exposure. Given human medications have consistently been responsible for the majority of pet poisoning cases in the United States (16%)[9], it is paramount that pharmacists, particularly those in the community setting, have a baseline knowledge of which drug products and excipients cannot be safely administered to an animal.

While colleges of pharmacy still struggle to include veterinary pharmacotherapy in the pharmacy curriculum, there are select groups of pharmacists who are specially trained in veterinary pharmacy. Organizations such as the Society of Veterinary Hospital Pharmacists (SVHP) and the American College of Veterinary Pharmacists (ACVP) offer training and educational opportunities to the rest of the pharmacy profession. Through their continued work and increasing awareness of pet ownership, it is possible that community pharmacies will soon acquire the competence to provide appropriate non-human patient care.

CONFLICT OF INTEREST

None declared.

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