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The American Heartworm Society and Association of Shelter Veterinarians' 2019 Shelter Heartworm Management Practices Survey[☆]

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ABSTRACT

The primary objective of the 2019 Shelter Heartworm Management Practices Survey was to identify the current practices employed for the prevention, diagnosis, and management of heartworm disease in animal shelters. Survey questions were developed to collect the information of interest for dogs, cats, and ferrets under the care of sheltering organizations along with demographic information about these organizations. An electronic survey was distributed to the American Heartworm Society and Association of Shelter Veterinarians' mailing lists in February-March 2019. Cross-posting of the survey on relevant lists was encouraged. The survey invitation was directed toward veterinarians delivering care in an animal shelter and excluded practitioners providing services for shelters, shelter animals, or recently adopted animals within a private practice setting. A total of 242 survey responses were received representing private humane societies/societies for the prevention of cruelty to animals (39.7%), municipal animal control facilities (24.9%), traditional (public-private partnership) shelters (21.7%), foster-based organizations (7.9%), sanctuaries (2.6%), and breed/species-specific rescues (2.1%). The largest proportion of respondent shelters were from the southeastern United States (36.9%) and over two-thirds of the shelters had full-time shelter veterinarians (69.0%). Most respondents provided monthly heartworm preventives for dogs (81.1%) and used oral ivermectin products per product labels (67.2%) to do so. Extralabel use of preventives was reported by 21.3% of respondents. Most respondents tested all dogs > 6 months of age for heartworm infection (81.9%) and did so during the intake examination (56.6%) with antigen tests (92.2%). At least some heartworm positive dogs were treated by most respondents (93.1%) using a 3-dose (42.5%) or 2-dose (37.9%) melarsomine protocol. Non-arsenical treatment protocols were utilized by 16.8% of respondents. Protocols typically included adjunctive treatment with doxycycline or minocycline (92.3%), prednisone (71.3%), and macrocyclic lactones (58.6%). Nearly two-thirds of respondents housed dogs within foster homes after treatment (65.1%). Heartworm prevention was provided by 29.9% of respondents that admitted cats and 9.9% of those that admitted ferrets. These results can be used to identify challenges to meeting recommended practices regarding prevention, diagnosis, and treatment of heartworm disease in the animal shelter setting and to target operational and educational resources toward the areas of greatest need.

1. Introduction

The AHS was founded in 1974 with the mission of leading the veterinary profession and the public in the understanding of heartworm disease (AHS, 2018a). The ASV was founded in 2001; its mission is to advance and support the practice of shelter medicine in order to improve community animal health and well-being (ASVa, n.d.). Recognizing the

impact of heartworm disease on the practice of shelter medicine and community animal health, both organizations joined together in 2014 to conduct a preliminary survey characterizing the current practices in heartworm disease management in North American animal shelters (AHS-ASV, 2014). With the information learned from that effort, the Heartworm Disease Resource Task Force was formed in 2015 to produce informational documents on canine and feline heartworm disease and a

Abbreviations: AHS, American Heartworm Society; ASV, Association of Shelter Veterinarians; SOP, Standard Operating Procedure

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Table 1
Demographic characteristics of 242 respondent shelters.

Characteristic	No. of responses	Response	N or N (%)
Previous year canine intake	180	Min.	10
		Max.	25,000
		Median	1,500
Approx. percentage heartworm positive dogs	120	Min.	0
		Max.	85
		Median	6
Previous year feline intake	160	Min.	10
		Max.	14,064
		Median	1,398
Approx. percentage heartworm positive cats	26	Min	0
		Max	1
		Median	0
Type of organization	189	Private humane society or SPCA	75 (39.7)
		Municipal animal control facility	47 (24.9)
		Traditional shelter (animal control + private humane society/SPCA)	41 (21.7)
		Foster-based	15 (7.9)
		Sanctuary	5 (2.6)
		Breed/Species-specific rescue	4 (2.1)
		Other	2 (1.1)
Geographic location	217	Southeast US	80 (36.9)
		Midwest US	55 (25.3)
		Northeast US	40 (18.4)
		Western US	32 (14.7)
		Other ^a	10 (4.6)
		Min	\$5,500
Annual medical budget	61 ^b	Max	\$6,000,000
		Median	\$100,000
		Full time	127 (69.0)
How many veterinarians are employed to manage the shelter population?	184 ^c	Part time	89 (48.4) ^d
		Contracted	84 (45.7) ^e

^a Includes 3 shelters in Ontario, Canada; 3 shelters in the United States Virgin Islands; 2 shelters in Puerto Rico, 1 shelter in Nakhon Pathom, Thailand; and 1 shelter in Quintana Roo, Mexico.

^b Three respondents reported an unlimited medical budget.

^c Respondents were asked to select all applicable options.

^d Includes 2 volunteer veterinarians.

^e Includes 3 volunteer veterinarians.

series of educational brochures for distribution to adopters (ASVb, n.d.). Since that time, the professionalization of shelter medicine practice has progressed with board certification of over two dozen veterinarians, veterinary pharmaceutical companies have established support programs targeted to sheltering organizations, and multiple new product formulations for the prevention and treatment of heartworm disease have been brought to market (Nolan, 2014; United States Food and Drug Administration, 2017; DVM360 Magazine, 2019; Boehringer Ingelheim, 2019; Zoetis, 2019). Along with these advancements, sheltering organizations continue to be the largest source of pet dogs in the United States and ongoing efforts have resulted in the continuous decline of shelter-based euthanasia (American Veterinary Medical Association, 2018; American Society for the Prevention of Cruelty to Animals, 2020). Despite such advancements, heartworm infection has continued to be a topic of frequent discussion on shelter medicine practice discussion boards and at continuing education conferences for veterinary and lay sheltering professionals alike. The current survey was launched with the aim of identifying the current practices employed for the prevention, diagnosis, and management of heartworm disease in animal shelters across a broad audience of stakeholders in order to target future educational and operational resources to the areas of greatest need.

2. Methods

A set of 53 survey questions was developed to identify the current practices employed for the prevention, diagnosis, and management of heartworm disease in animal shelters. Along with shelter demographics, survey questions collected the information of interest in dogs, cats and ferrets under the care of sheltering organizations. Survey questions were loaded into an online survey tool with skip logic (SurveyMonkey®, San

Mateo, CA) and were pilot tested by a select group of shelter veterinarians. Once finalized, a link to the survey was distributed to the AHS and ASV mailing lists in February-March 2019; cross-posting of the survey on relevant lists was encouraged. The survey invitation was directed toward veterinarians working in or with sheltering organizations and excluded practitioners that provide services for shelters, shelter animals, or recently adopted animals within a private practice setting. Respondents were instructed to respond to the questions in reference to their SOPs and/or most common scenarios. Participants that completed the survey were eligible for a free year of membership in either AHS or ASV; those that represented a registered non-profit organization or municipal facility were eligible for inclusion in a drawing for one of three monetary grant awards.

Survey responses were reviewed and summarized using descriptive statistics. Questions that called for open/free-text responses (i.e., What is your shelter's greatest challenge....) were reviewed individually and categorized by the predominant theme identified. If more than one theme was identified, the response was categorized by the first theme listed. If multiple themes were dependent upon one another or determined to be relatively equal in weight, responses were categorized as "other." For statistical analyses, shelter type was consolidated into similar operational models (traditional shelter/private humane society, municipal animal control, and foster-based/breed-specific/sanctuary). Fisher's exact test was used to assess associations between shelter type and region, how cats and dogs are treated by shelter type and region, and type of adulticidal treatment protocol for dogs by shelter type and region. Logistic regression models were used to evaluate whether key response items varied by shelter type and region. Key response items were: having heartworm management SOPs, receiving preventives, conducting testing, and receiving treatment (see Tables 2 and 3, Questions 1, 2, 3, and 5). For all analyses $p \leq 0.05$ was considered significant.

Table 2
Canine heartworm disease prevention, diagnosis, and management practices in 237 canine shelters.

Question	No. of responses	Response	N (%)
1. Do you have a standard operating procedure (SOP) for canine heartworm disease management? ^{*,**}	231	Yes	202 (87.4)
		No	29 (12.6)
2. Do dogs receive monthly heartworm preventive? ^{*,**}	228	Yes	185 (81.1)
		No	43 (18.9)
3. Are dogs tested for heartworm infection?	226	Yes, some or all dogs > 6 months	221 (97.8)
		No	5 (2.2)
4. Are secondary diagnostic tests pursued following a positive screening test?	217	Yes	85 (39.2)
		Sometimes	82 (37.8)
		No	50 (23.0)
5. Are heartworm positive dogs treated by your organization? [*]	218	Yes, some or all dogs > 6 months	203 (93.1)
		No	15 (6.9)
6. What is the primary adulticide protocol?	214	Melarsomine dihydrochloride x 3	91 (42.5)
		Melarsomine dihydrochloride x 2	81 (37.9)
		Ivermectin + doxycycline	19 (8.9)
		Moxidectin + imidacloprid + doxycycline	9 (4.2)
		Ivermectin monotherapy	2 (0.9)
		Other ^b	12 (5.6)
7. Are dogs routinely sedated or anesthetized during injection administration?	157	No	118 (75.2)
		Yes	39 (24.8)
8. When is spay-neuter surgery performed in relation to adulticidal therapy?	158	After diagnosis, prior to treatment	70 (44.3)
		After beginning doxycycline	37 (23.4)
		After melarsomine	14 (8.9)
		Prior to diagnosis	13 (8.2)
		After completing doxycycline	10 (6.3)
9. What adjunctive treatments are typically utilized? ^a	157	Other	14 (8.9)
		Doxycycline or minocycline	145 (92.3)
		Prednisone	112 (71.3)
		Macrocyclic lactones	92 (58.6)
		None	3 (1.9)
		Other	27 (17.2)
10. Where are dogs housed after treatment is initiated? ^a	212	Foster home	138 (65.1)
		In shelter, available	67 (31.6)
		Adopted home	86 (40.6)
		In shelter, unavailable	67 (31.6)
		Other	16 (7.5)
11. Are anxiolytics, antidepressants, or other psychopharmaceuticals routinely utilized during the period of exercise restriction?	207	No	159 (76.8)
		Yes	32 (15.5)
		Yes, if in shelter	11 (5.3)
		Yes, if in foster	5 (2.4)
12. What is your shelter's greatest challenge with canine heartworm management?	206	Cost	55 (26.7)
		Adopter/client education	28 (13.6)
		Foster home management	20 (9.7)
		Length of stay	20 (9.7)
		Activity restriction	19 (9.2)
		Treatment	17 (8.2)
		Diagnosis	12 (5.8)
		Volume of cases	12 (5.8)
		Prevention	8 (3.9)
		None	6 (2.9)
Other	9 (4.3)		

* = Region had a significant effect on some response items ($p \leq 0.05$).

** = Shelter type had a significant effect on some response items ($p \leq 0.05$).

^a Respondents were asked to select all applicable options.

^b Six out of the 12 "other" protocols included combinations of 2, 3, or an unspecified number of doses of melarsomine.

3. Results

A total of 244 survey responses were received; 2 responses were excluded from further analyses as they did not represent sheltering organizations. Eighty-two respondents were ASV members, 10 were AHS members, and 12 additional respondents held dual memberships. Responses represented a variety of shelter models, locations, animal intake and operational policies and procedures (Table 1, Supplementary Table 1). There was a significant association between shelter type and region ($p = 0.01$). There were a greater number of responses from traditional shelters/private humane societies overall (61%) and within each region as compared to municipal animal control facilities or foster-based/breed-specific/sanctuary facilities and 40% of all responses came from the southeast.

A majority of respondent shelters admitted dogs ($n = 237$, 97.9%)

and provided information regarding prevention, diagnosis, and treatment of canine heartworm disease (Table 2, Supplementary Table 2). Most respondent shelters ($n = 202$, 87.4%) had an SOP for managing canine heartworm disease which covered prevention, diagnostic testing, treatment, and adoption counseling. Controlling for region, municipal shelters had lower odds of having an SOP than traditional shelters (OR = 0.15, $p < 0.01$, 95% CI = 0.06-0.42); controlling for shelter type, the odds of having an SOP were lower in northeastern (OR = 0.15, $p = 0.05$, 95% CI = 0.38-0.56) and western (OR = 0.17, $p < 0.01$, 95% CI = 0.04-0.69) shelters than those in the southeast. Most respondent shelters ($n = 185$, 81.1%) provided monthly heartworm preventive to all dogs, consisting of oral ivermectin per labeled instructions ($n = 123$, 67.2%), oral milbemycin ($n = 49$, 26.8%), extralabel oral administration of ivermectin ($n = 39$, 21.3%), topical moxidectin ($n = 44$, 24.0%), topical selamectin ($n = 38$, 20.8%), and

parenteral moxidectin (n = 5, 2.7%). Controlling for region, municipal shelters had lower odds of providing preventive than traditional shelters (OR = 0.34, p = 0.02, 95% CI = 0.13-0.87); controlling for shelter type, the odds of providing preventive were lower in midwestern (OR = 0.09, p < 0.01, 95%CI = 0.02-0.51), northeastern (OR = 0.05, p < 0.01, 95% CI = 0.01-0.25) and western (OR = 0.03, p < 0.01, 95% CI = 0.01-0.18) shelters than those in the southeast. Most respondent shelters tested all dogs > 6 months of age (n = 185, 81.9%) for heartworms, tests were most commonly conducted during intake examination (n = 124, 56.6%), and antigen testing was most commonly utilized (n = 201, 92.2%). When secondary testing was used, microfilaria testing was most common (n = 127, 78.9%). A majority of respondent shelters (n = 203, 93.1%) treated heartworm in at least some dogs. Among those that did not offer treatment (n = 15, 6.9%), dogs were adopted without treatment (n = 9, 60%), transferred to a partnering organization for treatment (n = 7, 46.7%), or euthanized (n = 6, 40%). Treatment protocols containing a series of three melarsomine injections were most common (n = 91, 42.5%) along with the use of doxycycline as an adjunctive treatment (n = 145, 92.3%). Non-arsenical protocols were utilized by 36 respondents (16.8%). After initiating treatment, most respondents (n = 138, 65.1%) maintained dogs in foster homes while 67 respondents (31.6%) maintained dogs in the shelter unavailable for adoption. Psychopharmaceuticals were used by some respondents during the treatment course (n = 48, 23.2%) and the cost of treatment was the most commonly cited challenge of managing canine heartworms in respondent shelters (n = 55, 26.7%).

Two hundred sixteen respondent shelters (89.3%) admitted cats and provided information regarding prevention, diagnosis, and treatment of feline heartworm disease (Table 3, Supplementary Table 3). Most respondent shelters (n = 179, 91.3%) had an SOP for managing feline heartworm disease which covered prevention, diagnostic testing, treatment, and adoption counseling. Controlling for shelter type, the odds of having an SOP were lower in western shelters (OR = 0.21, p = 0.03, 95% CI = 0.05-0.84) than those in the southeast. A majority of respondent shelters (n = 139, 70.6%) did not provide monthly heartworm preventive to all cats. When provided, prevention consisted of topical selamectin (n = 42, 73.7%), topical moxidectin (n = 19, 33.3%), oral ivermectin per labeled instructions (n = 2, 3.5%), and extralabel oral administration of ivermectin (n = 1, 1.8%). Most respondent shelters (n = 155, 79.1%) did not test cats for heartworms; however, controlling for shelter type, the odds of conducting testing

were greater in shelters in northeastern (OR = 3.7, p = 0.02, 95% CI = 1.2-11.0) and "other" (OR = 7.2, p = 0.02, 95% CI = 1.5-35.6) regions than those in the southeast. When conducted, tests were commonly performed during intake examination (n = 18, 42.9%) or veterinary examination (n = 20, 47.6%); antigen (n = 26, 61.9%) and serum antibody (n = 20, 47.6%) testing were most commonly utilized. A majority of respondent shelters (n = 47, 53.4%) made heartworm positive cats available for adoption. How cats were treated was not associated with region (p = 0.3) but was significantly associated with shelter type (p < 0.01). A greater number of traditional shelters/private humane societies reported euthanizing and placing heartworm positive cats for adoption than other shelter types and municipal animal control facilities reported transferring heartworm positive cats more frequently than traditional shelters, though sample sizes were small. Diagnosis of feline heartworms was the most commonly cited challenge in respondent shelters (n = 70, 48.3%).

Only 81 respondent shelters (33.5%) admitted ferrets. Of these, 8 respondents (9.9%) indicated that they provided monthly heartworm preventive for ferrets.

4. Discussion

Heartworm disease management is a substantial concern for sheltering organizations. Management protocols necessarily differ based on variations in shelter operational model, organizational philosophy, annual intake, location, and resource allocation among other factors. Despite these variations, most shelters surveyed provided monthly, heartworm preventives per product labels for dogs, tested dogs for infection, and provided adulticidal treatment for infected dogs.

Current findings were compared to those of the 2014 AHS-ASV survey which was limited to 105 ASV-member shelter veterinarians (AHS-ASV, 2014). Raw data was not available for direct statistical comparison; however, the current results suggest an increase in the proportion of shelters providing heartworm preventive for dogs (81.2% versus 66% in 2014) and performing screening tests (81.9% versus 43% in 2014). These data suggest a decrease in the use of non-arsenical treatment protocols (16.8% versus 19% in 2014) along with an increase in the use of doxycycline (92.3% versus 80% in 2014).

A 2011 survey limited to sheltering agencies in the southeastern United States reported many similar findings to those of the current nationwide survey (Colby et al., 2011). In that report, a majority of

Table 3
Feline heartworm disease prevention, diagnosis, and management practices in 216 feline shelters.

Question	No. of responses	Response	N (%)
1. Do you have a standard operating procedure (SOP) for feline heartworm disease management?*	196	No	179 (91.3)
		Yes	17 (8.7)
2. Do cats receive monthly heartworm preventive?	197	No	139 (70.6)
		Yes	59 (29.9)
3. Are cats tested for heartworm infection?*	196	No	155 (79.1)
		Yes, all or some cats > 6 months	41 (20.1)
4. Are secondary diagnostic tests pursued following a positive screening test?	42	Yes	14 (33.3)
		Sometimes	14 (33.3)
		No	14 (33.3)
5. How are heartworm positive cats typically handled?*	88	Cats are placed for adoption	47 (53.4)
		Cats are euthanized	24 (28.4)
		Cats are transferred to another facility	7 (8.0)
		Other	9 (10.2)
6. What is your shelter's greatest challenge with feline heartworm management?	145	Diagnosis	70 (48.3)
		Cost	22 (15.2)
		Treatment	10 (6.9)
		Prevention	8 (5.5)
		None	8 (5.5)
		Adopter/client education	6 (4.1)
		Length of stay	1 (0.7)
		Other	20 (13.8)

* = Region had a significant effect on some response items (p ≤ 0.05).

** = Shelter type had a significant effect on some response items (p ≤ 0.05).

agencies provided monthly heartworm preventive to all dogs per product labeling, performed diagnostic screening tests, and treated infected dogs. The most common adulticidal protocol in the southeastern shelter survey included two doses of melarsomine while in the current nationwide survey a three-dose melarsomine protocol was most commonly employed. The 2011 survey also noted that differences in diagnostic testing protocols and likelihood of compliance with industry guidelines attributed to sheltering model. In the current study, shelter type was significantly associated with the presence of SOPs and administration of heartworm preventive for dogs. Not surprisingly, shelters in regions that tend to have lower incidence of heartworm infection (i.e., northeastern and western) had lower odds of having disease management SOPs than those of higher incidence regions (ie, southeastern). Municipal shelters, which tend to have the most severe resource limitations were less likely to have SOPs and administer preventives than other shelter models.

A companion survey to that described for dogs was also conducted in 2011 to characterize feline heartworm management protocols across shelters in the southeastern United States (Dunn et al., 2011). No heartworm prevention was provided for any cats in 69% and 70.6% of the southeastern United States and this study's respondent shelters, respectively. In the southeastern report, the lapse in prevention was attributed to the belief that diagnostic testing had to be performed prior to administration as well as cost. In shelter cats that were determined to be heartworm positive, corticosteroids, monthly ivermectin, and antibiotics (e.g., doxycycline, minocycline) were the most commonly employed therapies although a majority of shelters did not perform heartworm testing in any cats across both studies. Some of these similarities may be due to similarities in organizational operations, resources, and challenges in both study populations, particularly given that a majority of the current survey respondents were from the southeastern region of the United States. Regardless, this variation in practice from standard industry recommendations highlights feline heartworm management as an area of continuing challenge as well as an opportunity for which external stakeholders can create and provide enhanced education and access to resources for these shelters.

Two additional reports have described components of the diagnostic testing and treatment protocols for heartworms in animal shelters. The first, a nationwide survey of shelter managers regarding shelter veterinary medical services, found a comparatively lower rate of routine testing (54%) than that reported here (81.9%) which may be attributed to the operational knowledge (shelter managers versus shelter veterinarians) as well as the geographic makeup of survey respondents and their subsequent awareness of heartworm disease (Laderman-Jones et al., 2016; Self et al., 2019). The same geographic disparity likely also impacts the findings of the second report, which demonstrated that 37% of shelters in Colorado tested dogs and 6% tested cats for heartworm disease on intake to the shelter. A significantly greater proportion of shelters in this study performed testing when they accepted dogs from out-of-state sources (Fagre et al., 2017).

The vast majority of surveyed shelters that admitted ferrets (90.1%) did not provide heartworm prevention for these animals while in shelter care. To the author's knowledge, this is the only report to collect data related to the management of heartworm disease in ferrets under the care of animal shelters. Similarly, there are no known reports of infection prevalence or rates of preventive administration in privately owned pet ferrets. Heartworm disease represents a threat to the health and welfare of ferrets wherever dogs and cats are at risk and shares characteristics typical of both canine and feline infections (Zaffarano, 2015). The AHS recommends year-round prevention for ferrets (AHS, 2018b). As with shelter cats, this variation in practice from industry recommendations highlights an opportunity for additional industry-wide education and resource allocation.

This is also the first report to characterize the management policies of animals undergoing heartworm treatment in a shelter setting including the housing location and availability of treated animals for

adoption, the use of psychopharmaceuticals during the treatment course, and the timing of treatment in relation to elective sterilization. In this report, 31.6% of shelters maintained dogs in the shelter, unavailable for placement in a foster or adoptive home for the duration of treatment. Minimizing length of stay of shelter animals is a foundational component of protecting health and welfare and effective shelter population management. The finding that most respondents were able to provide heartworm treatment outside of the shelter setting through the use of foster homes and post-adoption treatment programs will be particularly relevant to those organizations that are subject to regulations, policies, or philosophies that hinder this practice and may help identify model programs that ensure heartworm treatment while also minimizing length of stay in the shelter. The relevance of this issue is further supported by the finding that the length of the treatment course represented the greatest challenge for 9.7% of shelter respondents.

Among surveyed shelters that provided canine heartworm treatment, 23.2% regularly utilized psychopharmaceuticals to aid in the period of activity restriction, while 9.2% indicated the period of activity restriction represented their greatest challenge. Protecting behavioral health in the shelter environment, particularly during prolonged shelter stays, is a foundational component of shelter practice. These findings suggest an opportunity for enhanced utilization of such medications, along with corresponding non-pharmaceutical strategies, during the recovery period for both their analgesic and anxiolytic properties.

A final important and unique finding is that at least 8.9% of respondent shelters typically perform elective sterilization procedures after the administration of adulticidal therapy. At least one study has demonstrated the safety of elective sterilization in heartworm-positive dogs (Peterson et al., 2014). In dogs with mild infection and no clinical signs of disease, the AHS recommends performing elective sterilization prior to adulticidal therapy or delaying such procedures a minimum of 6 months after the final melarsomine injection (AHS, 2018c, d). Sterilization surgery is frequently legally mandated prior to adoption in the United States, required by most shelter operational guidelines, and consistent with standard practices in animal sheltering (ASV, 2010). As discussed previously, the timing of heartworm treatment has significant implications on the length of stay of animals in the shelter system and prolonging length of stay unnecessarily has a significant negative impact on health and welfare (Stephen and Ledger, 2005; Scarlett et al., 2017). One opportunity to minimize length of stay for heartworm positive dogs, utilized by the majority of shelters surveyed in this report, is through completing elective sterilization procedures prior to adulticidal therapy thus avoiding post-treatment delays for surgical sterilization.

Two main limitations should be considered when evaluating the data from the current survey. First, the degree to which the practices identified represent the target population (i.e., predominantly North American animal sheltering organizations) is unknown. Estimates suggest there are ~3,500 animal shelters in the United States and an additional ~10,000 rescue organizations (HSUS, 2019); in that case the study population represents less than 2% of sheltering organizations in the United States alone. Survey responses were also not limited to North American organizations; geographic variations in regulations, pharmaceutical availability, and costs may have influenced the practices described in responses from organizations outside of this region. Second, data were self-reported and responders and operational practices were not verified. Although survey instructions clearly targeted veterinarians, data submission by non-veterinarians was possible. The survey invitation also requested description of the most commonly employed management practices, some of which may be unknown by the responding veterinarian or may differ between practitioners in shelters with multiple veterinarians. It is also possible that the means of distribution of the survey invitation resulted in a biased group of responders more likely to be familiar with and/or follow industry guidelines as a result of their affiliation with AHS and/or ASV.

It should be noted that sample sizes for some response items were small and the statistical analyses represent a preliminary model

containing clinically relevant predictors, namely shelter type and region. Future testing of models containing control variables is warranted. Despite these factors, the author believes the study population to be unique and the data offer new insights into the practices and challenges associated with heartworm management in a broad cohort of sheltering organizations.

5. Conclusions

Most sheltering organizations in this survey provided monthly, heartworm preventives per product labels for dogs, tested dogs for infection, and provided adulticidal treatment for infected dogs. Many shelters have successfully overcome the challenges associated with heartworm treatment such as its cost, community education, mitigating disease impact on length of stay, and challenges associated with maintaining activity restriction during treatment recovery. These factors remain substantial barriers for other organizations, offering an opportunity for enhanced collaboration and information-sharing within the field. The development and dissemination of additional educational and operational resources regarding the risk and management of heartworm disease in feline and ferret shelter populations should be prioritized.

CRedit authorship contribution statement

Brian A. DiGangi: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.vetpar.2020.109130>.

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