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ORIGINAL RESEARCH ARTICLE

Zoonotic and Non-Zoonotic Intestinal Parasites in Shelter Dogs at Admission and Before Discharge

Denaé N. Campanale[1], Heather D. S. Walden[2]*, Lawrence N. Garcia[3], P. Cynda Crawford[4] and Jorge A. Hernandez[5]

[1]Department of Clinical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY, USA; [2]Department of Comparative, Diagnostic and Population Medicine, College of Veterinary Medicine, University of Florida, Gainesville, FL, USA; [3]Veterinary Community Outreach Program, Department of Small Animal Clinical Sciences, University of Florida College of Veterinary Medicine, Gainesville, FL, USA; [4]Maddie's Shelter Medicine Program, Department of Small Animal Clinical Sciences, University of Florida College of Veterinary Medicine, Gainesville, FL, USA; [5]Department of Large Animal Clinical Sciences, University of Florida College of Veterinary Medicine, Gainesville, FL, USA

Abstract

***Introduction*:** The prevalence of intestinal parasites, notably zoonotic ascarids and hookworms, is higher in shelter dogs, compared to dogs in homes, making parasite control within shelter facilities a public health priority.
***Objective*:** The objective of the study reported here was to measure and compare the frequency of dogs infected with zoonotic or non-zoonotic intestinal parasites at admission and before discharge at a shelter facility.
***Methods*:** Ninety-two dogs were tested for diagnosis of intestinal parasites at admission and before discharge.
***Results*:** At admission, 50/92 (54%) dogs were diagnosed with intestinal parasites. Most dogs (43/50) were diagnosed with mono-infections with *Ancylostoma* spp., or co-infections with *Ancylostoma* spp. and *Toxocara* sp. or non-zoonotic parasites. Sixty-five dogs had a complete fecal study performed, which included an intake and exit sample analyzed for presence of parasite ova. Among the 65 study dogs, the frequency of dogs with intestinal parasites was lower before discharge (23 or 35%), compared to that at admission (33 or 50%) ($P = 0.02$). Fifty-one of 65 (78%) dogs were adopted, transferred to an outside rescue facility, or returned to their owners. Of these 51 dogs that left the shelter during the study period, 16/51 (31%) dogs were infected with intestinal parasites, and 8 of the 16 infected dogs were diagnosed with zoonotic parasites. Finally, among 37 dogs that tested negative and 28 that tested positive to zoonotic parasites at admission and re-tested later, four (11%) and six (21%) dogs, respectively, tested positive to zoonotic parasites when tested later.
***Conclusion*:** The frequency of shelter dogs infected with intestinal parasites at admission and before discharge was high (≥35%), and most infections were caused by *Ancylostoma* spp., an intestinal parasite in dogs that can be transmitted to humans, particularly children. We offer health policy options that shelter veterinarians/managers and local policymakers can consider for possible implementation and evaluation.

Keywords: *intestinal parasite*; *zoonotic parasite*; *dog, shelter*; *Toxocara*; *Ancylostoma*

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Correspondence
*Heather D. S. Walden
1945 SW 16th Avenue
Gainesville, FL 32610
Tel.: (352) 294-4125
Email: hdstockdale@ufl.edu

Reviewers
Sarah Hefferan
Sara White

Approximately 3.1 million dogs enter shelter facilities each year.[1] The prevalence of intestinal parasites, notably zoonotic ascarids and hookworms, is higher in shelter dogs, compared to dogs in homes[2,3] making parasite control within shelter facilities a public health priority. The higher burden of intestinal parasites in shelter facilities can be attributed to admission of free-roaming dogs with no prior veterinary care, confinement, and close contact between dogs in crowded environments; however, the burden can be mitigated by use of anti-helminthic treatments, sanitation procedures, and shelter management protocols.[4–6] Following Association of Shelter Veterinarians Guidelines for Standards of Care in Animal Shelters,[7] animals should receive parasite prevention on entry and regularly throughout their shelter stay to

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prevent environmental contamination and minimize risk to people in the shelter. At minimum, because of the public health significance, all dogs and cats must be de-wormed for roundworms and hookworms before leaving the shelter.[7]

Public knowledge about the risk of zoonotic infections from companion animals is low, and many pet owners are unaware of the potential for infection, as well as the methods of detection and prevention.[8] The most common helminthic zoonotic parasites carried by dogs include ascarids, *Toxocara canis*, and hookworms, *Ancylostoma* species.[2] *Toxocara canis* is the most widespread public health and economically important zoonoses humans share with dogs, and while Toxocariasis is generally more prevalent in the tropics and sub-tropics, it does occur in industrialized nations, especially in children.[9–11] *Ancylostoma* spp. are similarly common among dogs. Human infection with this parasite causes a dermatological disease known as cutaneous larva migrans (CLM) but can also cause an eosinophilic enteritis.[9,12,13] To our knowledge, the burden of intestinal parasites in U.S. shelter dogs both at admission and before discharge has not been reported. The objective of the study reported here was to measure and compare the frequency of dogs infected with zoonotic and non-zoonotic intestinal parasites at admission and before discharge at a shelter facility. The frequency of dogs infected with zoonotic or non-zoonotic parasites before discharge was reported by outcome (i.e., adopted, transferred to an outside rescue facility, or returned to their owners).

Materials and Methods

Ethics Statement

The sample collection and evaluation used in this study were approved and performed under the guidelines set forth by the Institutional Animal Care and Use Committee at the University of Florida (Protocols #201609597, 201709712).

Study Site

This study was conducted at a municipal shelter facility in north central Florida from June to August 2017. In 2017, a total of 2,705 dogs entered the shelter facility: 1,007 (37%) were adopted; 823 (30%) were transferred to an outside rescue facility; 630 (23%) were returned to their owners; and 212 (8%) were humanely euthanized. In compliance with the Association of Shelter Veterinarians Guidelines for Standards of Care in Animal Shelters,[7] the shelter protocol for processing new dogs at intake included administration of a DA2PP vaccine, a topical flea and tick medication (fipronil), and oral pyrantel pamoate (50 mg/mL) at a dose of 5 mL per 10 pounds of body weight (11 mg/lb, or 5 mg/kg). Additional treatments and timing of treatments beyond intake were dictated by the attending shelter veterinary staff.

Study Dogs

Ninety-seven dogs ≥ 6 months old admitted into the shelter facility from June 9, 2017 until July 11, 2017 were initially considered for inclusion. Study dogs required a fecal sample (≥ 1 gm) collected prior to administration of their intake dose of pyrantel pamoate and prior to morning cleaning, or during walks. Five dogs were excluded because a fecal sample was not collected at admission. The final study enrollment was 92 dogs, 6-months old to 12-years old.

Study Design

This investigation was designed as an observational study. The shelter study dogs were sampled and tested for diagnosis of intestinal parasites at admission and before discharge. The frequency of dogs infected with zoonotic intestinal parasites before discharge was quantified and reported by outcome groups (i.e., adoption, transfer to an outside rescue facility, returned to owner).

Collection of Fecal Samples

Samples were collected free-catch from concrete kennel floors and transferred to fecal tubes or were retrieved using dog waste bags; in either case, samples were then placed inside a Ziploc bag and labeled with sample date, study number, and shelter animal ID number. Samples were transported to the University of Florida's College of Veterinary Medicine for processing and analysis. Once intake fecal samples were collected, dogs were administered the first dose of pyrantel pamoate by mouth (5 mg/kg) and monitored as study participants. No other changes were made to the dogs' treatments or medical care. Fecal samples were collected in a similar manner at 2 weeks and/or 4 weeks after the administration of the intake dose of pyrantel pamoate, if the dog was still in the shelter. For dogs that exited the shelter during or prior to this time, an exit sample was collected if available.

Diagnosis of Intestinal Parasites

Fecal samples were analyzed at the Parasitology Laboratory at the University of Florida College of Veterinary Medicine. Samples were analyzed using a minimum of 1 gram of feces and fecal flotation by centrifugation[14] with Sheather's solution (specific gravity 1.27). Sample results were recorded for presence and type of parasitic ova, cysts, or oocysts.

Outcomes

The main outcomes of interest were dogs infected with zoonotic or non-zoonotic intestinal parasites at admission and before discharge, and dogs diagnosed with

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intestinal parasites before discharge by outcome group (e.g., adopted, transferred to an outside rescue facility, or returned to their owners).

Data Collection

The following data were collected from each study dog: dog ID number, age (years), sex (male, female), spayed/neutered (yes, no), admission date (mm/dd/yyyy), discharge date (mm/dd/yyyy), length of stay at the shelter facility (days), number of fecal samples collected and tested for diagnosis of intestinal parasites, number of anthelminthic treatments during shelter stay, and outcome (remained at shelter, adoption, transfer to an outside rescue facility, returned to owner, euthanasia).

Data Analysis

The proportions of dogs infected with intestinal parasites at admission and before discharge were calculated by dividing the number of dogs with a positive diagnosis of intestinal parasites by the total number of dogs tested; 95% confidence intervals (95% CI) were calculated for each point estimate by using free software (http://epitools.ausvet.com.au). The associations between a positive diagnosis of intestinal parasites at admission and spay/neuter status (yes, no), sex (male, female) and age (years) (<1 years, 1–2 years, 3–12 years) were examined by using a chi-square test. Dogs were assigned into one of three age-groups to identify dogs less than 1 year, young dogs (1–2 years) and adult dogs (3–12 years). Duration of stay (days) and number of deworming treatments were compared between dogs with a positive or negative diagnosis of intestinal parasites by using the Wilcoxon rank sum test. The null hypothesis that proportions of dogs diagnosed with intestinal parasites were not different at admission and before discharge was tested by the McNemar's chi-square test. In all analyses, values of $P < 0.05$ were considered statistically significant.

Results

The study sample included 92 dogs. Fifty-four (59%) dogs were male, 61 (66%) were not spayed/neutered, and median age was 2 years old (Table 1). The average length of stay in the shelter was 17.7 days, ranging from 1 to 77 days, with a median of 12 days.

Dogs With Intestinal Parasites at Admission

At admission, 50 of 92 (54%; 95% CI = 44%, 64%) dogs were diagnosed with intestinal parasites (Table 2). Most dogs (43/50) were diagnosed with mono-infections with *Ancylostoma* spp., or co-infections with *Ancylostoma* spp. and *Toxocara* sp. or other non-zoonotic parasites. A positive diagnosis of intestinal parasites at admission was not different between spayed (52%) and intact (56%) dogs ($P = 0.70$), male (50%) and female (61%) dogs ($P = 0.31$), or less than 1 year old (60%), 1–2 years old (48%), and 3–12 years old (62%) dogs ($P = 0.45$).

Table 1. Study dogs sampled and tested for diagnosis of intestinal parasites at admission ($n = 92$ dogs) into the shelter facility and at admission and before discharge ($n = 65$ dogs)

Variable	Category	Frequency of all dogs at admission $n = 92$ (100%)	Frequency of dogs with paired samples collected and tested at admission and before discharge $n = 65$ (100%)
Sex	Male	54 (59)	31 (48)
	Female	38 (41)	34 (52)
Spayed/Neutered	No	61 (66)	44 (68)
	Yes	31 (34)	21 (32)
Number of deworming treatments	1	69 (75)	45 (69)
	2	22 (24)	19 (30)
	3	1 (1)	1 (1)
Outcome	Remained at shelter	10 (10)	10 (15)
	Adoption	43 (47)	30 (46)
	Transferred to an outside rescue	23 (25)	15 (23)
	Retained by owner	10 (11)	6 (10)
	Euthanasia	6 (7)	4 (6)
Age (years)*		2 (1, 3)	2 (1, 3)
Duration (days) of stay at shelter*		12 (7, 24)	16 (8, 30)

*Data are reported as median (first, third quartiles).

Table 2. Frequency of dogs infected with intestinal parasites at admission to a shelter facility (n = 92 dogs)[1]

Diagnosis	All n = 87	Owner surrender n = 18	Stray n = 60	Abandoned n = 9
Parasites observed by flotation				
No	39 (45)	10 (56)	26 (43)	3 (33)
Yes	48 (55)	8 (44)	34 (57)	6 (67)
Zoonotic parasites, all	43 (49)	7 (39)	28 (47)	6 (67)
Ancylostoma spp	28 (32)	6 (33)	18 (30)	4 (44)
Ancylostoma spp. + *Toxocara* sp.	2 (2)	0	1 (2)	1 (11)
Ancylostoma spp. + *Trichuris* sp.	7 (8)	0	7 (12)	0
Ancylostoma spp. + *Cystoisospora* spp.	3 (3)	1 (6)	1 (2)	1 (11)
Ancylostoma spp. + *Trichuris* sp. + *Cystoisospora* spp.	1 (1)	0	1 (2)	0
Non-zoonotic parasites, all	7 (8)	1 (6)	6 (10)	0
Trichuris sp.	5 (5)	1 (6)	4 (7)	0
Cystoisospora spp.	1 (1)	0	1 (2)	0
Trichuris sp. + *Cystoisospora* spp.	1 (1)	0	1 (2)	0

[1]Data are reported as n (%); 87/92 dogs offered a fecal sample.

Dogs With Intestinal Parasites Before Discharge

Among 65 dogs with fecal samples at admission and before discharge, 23 (35%; 95% CI = 25%, 48%) were diagnosed with intestinal parasites before discharge (Table 3). Fifty-one of the 65 dogs were adopted, transferred to an outside rescue facility, or returned to their owners; 16/51 (31%) dogs were infected with intestinal parasites, and 8 of the 16 infected dogs were diagnosed with zoonotic parasites.

Duration of stay was longer in 23 dogs with intestinal parasites (median = 27 days) than in 42 dogs with no intestinal parasites (13) (P = 0.03) (Table 4). Number of deworming treatments was not different between dogs with (median = 1) or without parasites (1) before discharge (P = 0.98).

The frequency of dogs with intestinal parasites was lower before discharge (23/65 or 35%), compared to that at admission (33/65 or 50%) (P = 0.02).

Dogs With or Without Zoonotic Parasites at Admission That Were Re-Tested After Admission

Among 37 dogs that tested negative to zoonotic parasites at admission, median number of days to second test = 16 (minimum = 4, maximum = 69). Twenty-five of 37 (68%) dogs had one dewormer dose and 12 (32%) had two doses. Four (11%) dogs tested positive to intestinal parasites, when re-tested after admission.

Among 28 dogs that tested positive to zoonotic parasites at admission, median number of days to second test = 19 (minimum = 1, maximum = 77). Twenty of 28 (71%) dogs had one dewormer dose, seven (25%) had two doses, and one (4%) had three doses. Ten (36%) dogs tested positive to intestinal parasites, when re-tested after admission.

Discussion

This study provides new information on the burden of intestinal parasite infections in dogs at admission and before discharge at a shelter facility. A strength of this investigation is that study dogs were sampled and tested for detection of zoonotic and non-zoonotic intestinal parasites at admission and before discharge. In addition, we offer health policy options that shelter veterinarians/managers and local policy makers can consider for possible implementation.

Dogs With Intestinal Parasites at Admission

Fifty of 92 (54%) dogs were diagnosed with intestinal parasites at admission, and most were zoonotic parasites. In our study sample, a positive diagnosis of intestinal parasites at admission was not associated with spay/neuter status, sex, or age. In a previous study conducted in 547 private veterinary hospitals in 44 US states during 2003–2006,[15] the burden of dogs infected with intestinal parasites was higher in young dogs (less than 6 months old) and intact dogs. In that study, a higher prevalence of *Toxocara* and *Ancylostoma* infections was expected in young dogs because of the possibility of transplacental and transmammary infection with those two parasites and the likelihood of age-associated immunity. Neutering can be a surrogate marker for routine veterinary care, including deworming. Comparison of study results between our study and that by Mohamed et al.[15] is difficult because the target population, sampling methods and study sample were different.

In this study, most dogs were infected at admission with zoonotic parasites *Ancylostoma* and there were limited instances of *Toxocara*. This is consistent with

Table 3. Frequency of dogs diagnosed with intestinal parasites before discharge by outcome group (*n* = 65 dogs)[1]

Diagnosis	All *n* = 65	Shelter[2] *n* = 10	Adoption *n* = 30	Transfer[3] *n* = 15	Returned[4] n = 6	Euthanasia *n* = 4
Parasites observed by flotation						
No	42 (65)	4 (40)	18 (60)	12 (80)	5 (83)	3 (75)
Yes	23 (35)	6 (60)	12 (40)	3 (20)	1 (17)	1 (25)
Zoonotic parasites, all						
Ancylostoma spp	14 (22)	5 (50)	7 (23)	0	1 (17)	1 (25)
Ancylostoma spp. + *Toxocara* sp.	8 (12)	3 (30)	5 (17)	0	0	0
Ancylostoma spp. + *Trichuris* sp.	1 (2)	0	0	0	1 (17)	0
Ancylostoma spp. +	2 (3)	1 (10)	1 (3)	0	0	0
Cystoisospora spp.	3 (5)	1 (10)	1 (3)	0	0	1 (25)
Non-zoonotic parasites, all	9 (14)	1 (10)	5 (17)	3 (20)	0	0
Trichuris sp.	5 (7)	0	3 (10)	2 (13)	0	0
Cystoisospora spp.	4 (6)	1 (10)	2 (7)	1 (7)	0	0

[1]Data are reported a *n* (%); [2]Shelter = remained at shelter; [3]Transfer = transferred to an outside rescue facility; [4]Returned = returned to owner.

Table 4. Duration of stay and number of deworming treatments in dogs infected or non-infected with intestinal parasites before discharge (*n* = 65 dogs)[1]

Variable	Intestinal parasites No *N* = 42	Intestinal parasites Yes *N* = 23	*P*
Duration of stay (days)	13 (7, 24)	27 (13, 35)	0.03
Number of deworming treatments	1 (1, 2)	1 (1, 2)	0.98

[1]Data are reported as median (first, third quartiles).

other studies that have indicated the most common helminthic zoonotic parasites carried by dogs in the United States include the *Toxocara* species of ascarids and the *Ancylostoma* species of hookworms.[2] A recent review suggests similar results worldwide.[9] Toxocariasis can occur when people accidentally ingest the infective larvated *Toxocara* eggs[16]; this is most common in children, either from geophagia or pica.[17,18] This infection is implicated in hundreds of cases of ocular disease in children each year, including permanent unilateral blindness.[19] As previously mentioned, *Ancylostoma* species, or hookworms, infecting humans causes a CLM, and rarely eosinophilic enteritis,[9,12,13] which may be marked by weight loss, abdominal pain, diarrhea, and rectal bleeding.[12] Unlike toxocariasis, which requires ingestion of *Toxocara* sp. larvated egg, human infection with *Ancylostoma* spp. can occur via skin penetration – similar to method of transmission in animals.[13,20]

Dogs With Intestinal Parasites Before Discharge

The frequency of dogs with intestinal parasites was lower before discharge (23/65 or 35%), compared to that at admission (51%). It is possible that oral treatment of pyrantel pamoate (50 mg/mL) given at intake had a positive effect on parasite infections in some dogs. However, as there was no difference in the number of treatments between dogs with and without parasites before discharge, the relationship between pyrantel pamoate and parasite infection is unclear. Additionally, the true effectiveness of a single pyrantel dose is unknown in dogs when a discharge fecal is examined soon after the admission fecal. Fecal results at discharge may be false negative due to the life cycle stage of the parasite (i.e. still in the prepatent stage) or length of time between treatment and sample collection. Of the 28 dogs with zoonotic parasites at intake, eight were in the shelter for 1 week or less. Of these eight, only one remained positive for zoonotic parasites between intake and discharge. This dog was in the shelter for 2 days. Additionally, samples could still be positive due to drug resistance or reinfection from the shelter environment.

Among 51 dogs that were adopted, transferred to an outside rescue facility, or returned to their owners, 16 dogs were infected with intestinal parasites, and 8 of the 16 infected dogs were diagnosed with zoonotic parasites. Because adopted dogs infected with zoonotic parasites without intervention can pose a health hazard to the new adoptive family, a health policy that has been adopted in shelter facilities is to advise new owners to seek out a veterinarian of their choice for an initial exam and continued medical care of their adopted dog. In this study, unfortunately, it was not feasible to determine how many dog owners followed through with a veterinarian after adoption. To our knowledge, no other studies have reported the burden of dogs infected with zoonotic intestinal parasites at discharge, when adopted, transferred to an outside rescue facility, or returned to their owners.

Dogs Without Zoonotic Parasites at Admission That Were Re-Tested After Admission

Among 37 dogs that tested negative to zoonotic parasites at admission, one of 17 (6%) dogs tested positive for zoonotic parasites when re-tested ≤ 14 days later and 3/20 (15%) did when re-tested ≥ 15 days later. Explanations for the occurrence of new cases of dogs with a positive diagnosis of intestinal parasites when re-tested are that length of stay was about two times longer in dogs diagnosed with intestinal parasites (median = 27 days), compared to dogs with no parasites observed (13 days) or the prepatent period of the parasites. These data further support the possibility of a new infection picked up at the shelter, or because the initial test occurred during the prepatent period of the parasite. In this case, diagnostic stages such as eggs or oocysts would not yet be detected, delaying the diagnosis until the discharge exam.[13,20]

Study Limitations

First, study results are based on a convenience sample of 92 dogs admitted to a municipal shelter facility during a 4-week period in June–July 2017; thus, the study results cannot be extrapolated to other shelter facilities in Florida or other states. Second, limited time and resources to complete the study did prevent us from sampling and testing more dogs for diagnosis of intestinal parasites at admission and before discharge in other months of the year. Thus, the study results apply to the sample of dogs during the 4-week period. Third, 65 of 92 (71%) study dogs sampled and tested at admission also provided a fecal sample before discharge. A higher proportion of dogs sampled and tested before discharge could have provided more validity and precision to our study results. As mentioned, dogs received pyrantel pamoate by study personnel only at intake. No other medical changes or treatments were provided by study personnel. Shelter veterinary staff offered additional treatments at their discretion, which were recorded by study personnel. Confounding variables within our study animal population, such as age, immunocompetency, general health status, breed, previous ownership status, exposure to play yards or play groups, and size/weight, may affect parasite status and control efforts. Additionally, drug resistance, specifically with pyrantel, in *Ancylostoma caninum* in dogs, could also alter the results of this study.[21]

Conclusion

In this study, frequency of shelter dogs infected with intestinal parasites at admission and before discharge was high (≥ 35%), and most infections were caused by *Ancylostoma* spp., an intestinal parasite in dogs that can be transmitted to humans, particularly children. Among dogs that were adopted, transferred to an outside rescue facility, or returned to their owners, one third were infected with intestinal parasites (and half of these dogs were infected with zoonotic parasites).

Policy Options

Policy options can be feasible and acceptable, or feasible but not acceptable by stakeholders or policy makers due to financial or human resources available. Decision makers in selected shelter disease management frameworks can decide which option presented to them is (or is not) considered feasible and acceptable for possible implementation (after taking into consideration the consequences of acting or failing to act on selected policy options). Study results reported here can justify a revision of current management plans in shelter facilities to further mitigate the risk of zoonotic parasitic infections in adoptive families. Three health policy options that shelter veterinarians/managers and local policymakers can consider for possible implementation and evaluation are: (1) a do nothing (business as usual) approach which does not require intervention costs, but it might lead to transmission of zoonotic prasite infections from infected dogs to susceptible humans, particularly children; (2) testing dogs before discharge for diagnosis of intestinal parasites; (3) treatment of dogs against intestinal parasites at intake and before discharge, as determined by the attending veterinarian; (4) environmental control by cleaning and disinfection of shelter facilities, periodically or when there is evidence of high burden of parasitic environmental contamination; or (5) to inform potential new dog owners the status of intestinal parasite infection in dogs for adoption, and offer options such as a complimentary veterinary visit with a local veterinarian for examination and fecal evaluation. The last four options can prevent/control intestinal parasite infections in family and community dogs and potential zoonotic infections in adoptive families and their communities. A return on investment analysis is beyond the scope of this study, but it could help shelter veterinarians/managers and local policymakers make an informed decision.

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Author Credit Statement

Conceptualization, investigation, data and sample collection and analysis: DNC; data analysis, resources: LNG; conceptualization, data analysis, supervision: JAH; conceptualization, data analysis, funding acquisition: PCC; methodology, supervision, resources: HDSW. Writing, reviewing and editing draft: DNC, HDSW, LNG, PCC, JAH.

Conflict of Interest Statement

The authors declare no potential conflicts of interest.

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