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Factors Affecting the Likelihood of Dogs and Cats Returning to Their Owners at a Municipal Animal Shelter in the United States

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Abstract

***Introduction*:** Animal shelters consider return-to-owner (RTO) as an ideal outcome for animals, owners, and shelters. Methods to increase RTO likelihood are frequently discussed by shelter professionals nationwide. Some of these methods are evidence-based, while others are anecdotally successful. This retrospective study aimed to provide evidence for commonly suggested methods, as well as identify additional factors influencing RTO likelihood.
***Methods*:** Data from 5,960 dog and 3,489 cat impounds were obtained from a large municipal animal shelter in Utah, USA. Directed acyclic graphs were developed to visualize causal assumptions, which were used to identify confounders for adjustment in the logistic regression while modeling the associations between study variables and RTO outcomes for both dogs and cats.
***Results*:** Dogs and cats with microchips, older animals, healthy animals, neutered animals, and animals brought to the shelter via another public agency were more likely to return to their owners. Animal sex and season of impound did not affect either dogs' or cats' RTO likelihood.
***Conclusion*:** The characteristics influencing RTO likelihood were similar for both dogs and cats. These influences provide support for existing shelter practices, such as facilitating widespread microchipping and waiving reclamation fees, while also encouraging implementation of new practices, such as modifying stray hold periods based on source type or health status. Limitations of the study included the presence of incomplete information in the database and concerns with the generalizability of results to other shelters.

Keywords: *return to owner*; *reclaim*; *RTO*; *directed acyclic graphs*; *DAGs*; *microchip*

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An estimated 4.4 million animals enter United States (US) animal shelters each year.[1] These animals enter for various reasons: An estimated 23.7% are relinquished by owners, 11.9% are transferred from other shelters, and 8.3% are brought in for euthanasia. Most (54.2%), however, come to shelters as stray animals.[1] Animals become stray for many reasons, but in the US, many stray dogs and cats are lost or escaped pets.[2] When these pets enter a shelter, returning them to their owners is an ideal outcome.[3]

Return to owner (RTO) is a metric used by animal shelters to measure how many animals who enter the shelter are subsequently reunited with their owners. Many resources aimed at improving RTO programs exist,[4,5,a,b] and improving RTO likelihood is a frequent topic in animal welfare discussions and blogs.[c,d] Ideas frequently shared in these resources include microchipping and neutering animals, reducing impound fees, and encouraging owners to use pet identification tags. These suggestions are based on previous studies that identified the presence of a microchip,[2,6–12] the animal's age and purebred status,[13] and presence of collars or tags[2,7,14] affected RTO likelihood. Additional studies looking at lost animals that were not taken to a shelter found other factors influencing RTO likelihood, such as sex,[7] neuter status,[7,11] animal behavior,[7] and coat characteristics.[7,11] However, many of these studies occurred outside of the US.[7–11] Even within the US, RTO likelihood can vary greatly between regions,[6,12] so factors affecting RTO likelihood may vary as well. Additionally, most of these studies looked only at

a. Return to Home Challenge Resources. Maddie's Fund. Accessed August 8, 2023. https://www.maddiesfund.org/return-to-home-challenge-resources.htm

b. Lost Pet Reunification. Human Animal Support Services. Accessed August 8, 2023. https://www.humananimalsupportservices.org/toolkit/lost-pet-reunification/

c. Maddie's Fund Weekly Community Conversations. Accessed October 10, 2023. https://forum.maddiesfund.org/communityconversations

d. The Latest from HASS. Human-Animal Support Services. Accessed October 10, 2023. https://www.humananimalsupportservices.org/blog

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dogs (only three studies[6,8,11] included cats in their analyses). Feline RTO likelihood typically lags far behind canine RTO likelihood,[1] and although many cats entering shelters are community cats without owners,[15] shelters must know how they can best help owned stray cats return to their owners, so more information about cat RTO factors is needed.

This study described the characteristics of dogs and cats entering one US animal shelter and tested the association between these characteristics and RTO with the goal of strengthening evidence that methods used in existing RTO programs are beneficial, as well as testing new characteristics that shelters can use to increase RTO likelihood for both dogs and cats. Although the findings from this singular study may not be applicable to all shelters, these findings may still inform practices as well as inspire further research.

Methods

This study received approval by the University of British Columbia's Behavioral Research Ethics Board (ID: H21-01115). A retrospective study was performed using data collected by Salt Lake County Animal Services (SLCoAS), a large municipal animal shelter in Utah, USA. SLCoAS uses ShelterBuddy (RSPCA Queensland, Version 3) to maintain record of their animal population. Data were obtained from ShelterBuddy's pre-existing 'Incoming Detail List' report and exported to Microsoft Excel 2019 (Microsoft Corporation, Version 1808, 2020). The selected date range was December 15, 2020 through October 31, 2022.

Only impounds of dogs and cats were included in this study. All other species were removed from the database. The data were split into dog impounds and cat impounds, organized, and cleaned using Excel.

Study criteria

Initially, 6,902 dog impound records were identified. Dogs considered ineligible for RTO, such as those deceased at intake, those relinquished by owners, and adoption returns were removed from the dataset, resulting in 6,056 impounds. All dogs less than 2 months of age were removed from the dataset. This was done because most dogs in the US are not adopted or purchased until at least 2 months of age,[16] so these puppies were very unlikely to have owners. The final dog dataset had 5,960 impounds.

Initially, 9,484 cat records were identified. Cats ineligible for RTO, such as those deceased at intake and those relinquished by owners, were removed from the dataset, resulting in 8,074 records. Cats in the shelter's Trap-Neuter-Release (TNR) and Return-to-Field (RTF) programs were also removed, as cats in these programs are community cats who, by definition, do not have owners. This left 5,097 records. Like dogs, all cats less than 2 months of age were removed from the dataset. Thus, the final cat dataset had 3,489 impounds.

Definition of variables

All impounds were assigned one of two outcomes: RTO (RTOs performed at the shelter and those performed in the field by animal control officers [ACOs]), and not RTO (all other outcomes: adoption, transfer out, euthanasia, died in care, and escaped).

Dog and cat datasets also contained the following variables: month of impound (further grouped into summer months for dogs and kitten season for cats), age group, sex, neuter status, microchip, source type, health status, breed group, color group, income, and distance. The dog dataset also had the variable of size group. Definitions for selected variables follow.

Season of impound

Month of impound was further grouped into summer months (April–September) for dogs, and kitten season (March–August) for cats. This was done because the circumstances and conditions, such as health conditions and desire to roam, of dogs and cats can vary greatly between seasons.[17–19] Additionally, because cats are seasonal breeders, they give birth in spring and summer months, so kittens enter shelters at much higher numbers in summer than winter months.[20]

Age group

Age groups were created based on the American Animal Hospital Association's (AAHA) Canine Life Stage Guidelines[21] and using an average lifespan of 10 years.[22] Because young puppies are often managed differently than older puppies in shelters, the puppy group was further divided. Thus, the five age groups for dogs were Puppy (8 weeks–6 months), Older Puppy (6 months–1 year), Young Adult (1 year–3.5 years), Mature Adult (3.5 years–7.5 years), and Senior (>7.5 years). Age groups for felines were created based on AAHA/American Association of Feline Practitioner Feline Life Stage Guidelines.[23] Like puppies, young kittens are managed differently in shelters than older kittens, so the kitten group was split. The five age groups for cats were Kitten (8 weeks–6 months), Older Kitten (6 months–1 year), Young Adult (1–6 years), Mature Adult (7–10 years), and Senior (>10 years).

Source type

Source type indicated the circumstances under which the animal was impounded. Four options existed: Abandoned, Field, Agency Assist, and Over the Counter (OTC). Abandoned represented animals who were found in an abandoned residence, such as empty apartments or vacant hotel rooms. Field represented animals impounded by an ACO, such as stray animals contained by ACOs. Agency Assist included animals impounded by ACOs responding to requests from another public agency, such as paramedics requesting ACOs retrieve the pet of a

hospitalized owner, or police requesting help with the pet of an arrested owner. OTC represented animals brought to the shelter by the public claiming they were strays.

Health status

A health status was assigned to the animal at the time of impound by shelter staff. Options included Normal, Injured, Malnourished, Poor, Pregnant, and Sick. Staff assigned categories at their discretion with no definitions provided by shelter management. Because of the low number of impounds in some options, researchers further condensed health statuses into two categories: healthy (= Normal) or unhealthy (= all other options).

Income

Income was defined as the 2020 median household income for the zip code where the animal was found. Zip codes were obtained from the addresses in the dataset. Some impounds did not have an address or zip code, but all impounds had a city. In these cases, the zip code of the city was used. For cities containing multiple zip codes, zip codes were randomly assigned to impound records in proportion with the proportion of human population living in each zip code for that city. The human population proportions were determined using an online database.[24] Income for each zip code was determined using the same database.

Distance

Distance was defined as the driving distance in miles from the center of the zip code where the animal was found to the shelter's physical address. Exact found addresses were not used. This distance was calculated by entering each zip code and the shelter's address into Google Maps (Google, 2023). Driving directions were obtained and the distance in miles for the top result was recorded.

Breed group

Each animal was categorized into a breed group based on the primary breed listed in the dataset. The 18 canine breed groups and four feline breed groups chosen by researchers were similar to groups used in other shelter-based studies.[25,26] Appendix A lists specific breeds included in each group.

Color group

Animals were assigned a color group based on their listed primary and secondary colors in the dataset. The 11 canine color groups and 10 feline color groups chosen by researchers were similar to color groups used in other shelter-based studies.[25–27]

Size group

Five size groups were created based on each dog's weight at impound. For dogs without a recorded weight, weight was estimated by using their primary breed and the median weight for that breed as listed by the American Kennel Club.[28] Weight and size were not investigated in cats because of the lack of variation in weights of most adult cats.

Directed acyclic graphs

Relationships between study variables were hypothesized by researchers. These hypotheses were based on results of previously-published studies which identified some variables correlated with RTO likelihood,[2,6–13] as well as widely-held assumptions among animal welfare professionals and researchers' own experience. The main purpose of hypothesizing these causal relationships was to use these assumptions in confounding evaluation. These relationships were presented using directed acyclic graphs (DAGs[29]; Fig. 1). Arrows between two variables represented an assumed direct causal relationship. For example, researchers assumed that an animal's age directly affected their neuter status (older animals are more likely to be neutered than young animals[30]) but did not affect that animal's sex. Variables (such as breed, color, and size) assumed to not affect RTO likelihood or other study variables were not included in the DAGs. The DAGs were created using DAGitty (dagitty.net[31], Textor, Version 3, 2019).

Data analysis

The study DAGs were analyzed to identify confounders for adjustment using DAGitty's built-in algorithm (i.e. d-separation). The association between each study variable (designated as an exposure) and RTO (designated as the outcome) was specified, and DAGitty selected a set of confounders for that specified variable from all other variables in the DAG. The confounding evaluations were performed for each of the study variables.

Logistic regression (IBM SPSS Statistics for Windows, IBM Corporation, Version 28.0, 2021) was used to model the relationship between each study variable and RTO while adjusting for the identified confounders. Adjusted odds ratio (OR) and 95% confidence interval (CI) were reported.

Results

Characteristics of study population

A total of 5,960 dog impounds and 3,489 cat impounds, mostly via field service (dogs 68.6%, cats 59.6%), were included in the study (Appendix B). Almost half (n = 2,904, 48.7%) of all dogs impounded came from just four breed groups: Pit Bulls, Sled Dogs, Lap Dogs, and Labradors, while most cats (n = 2,473, 70.9%) were domestic shorthair (DSH). Kittens made up 17.1% (n = 596) of cat impounds, whereas puppies made up only 5.5% of dog impounds (n = 328). One-third of impounded dogs had a microchip

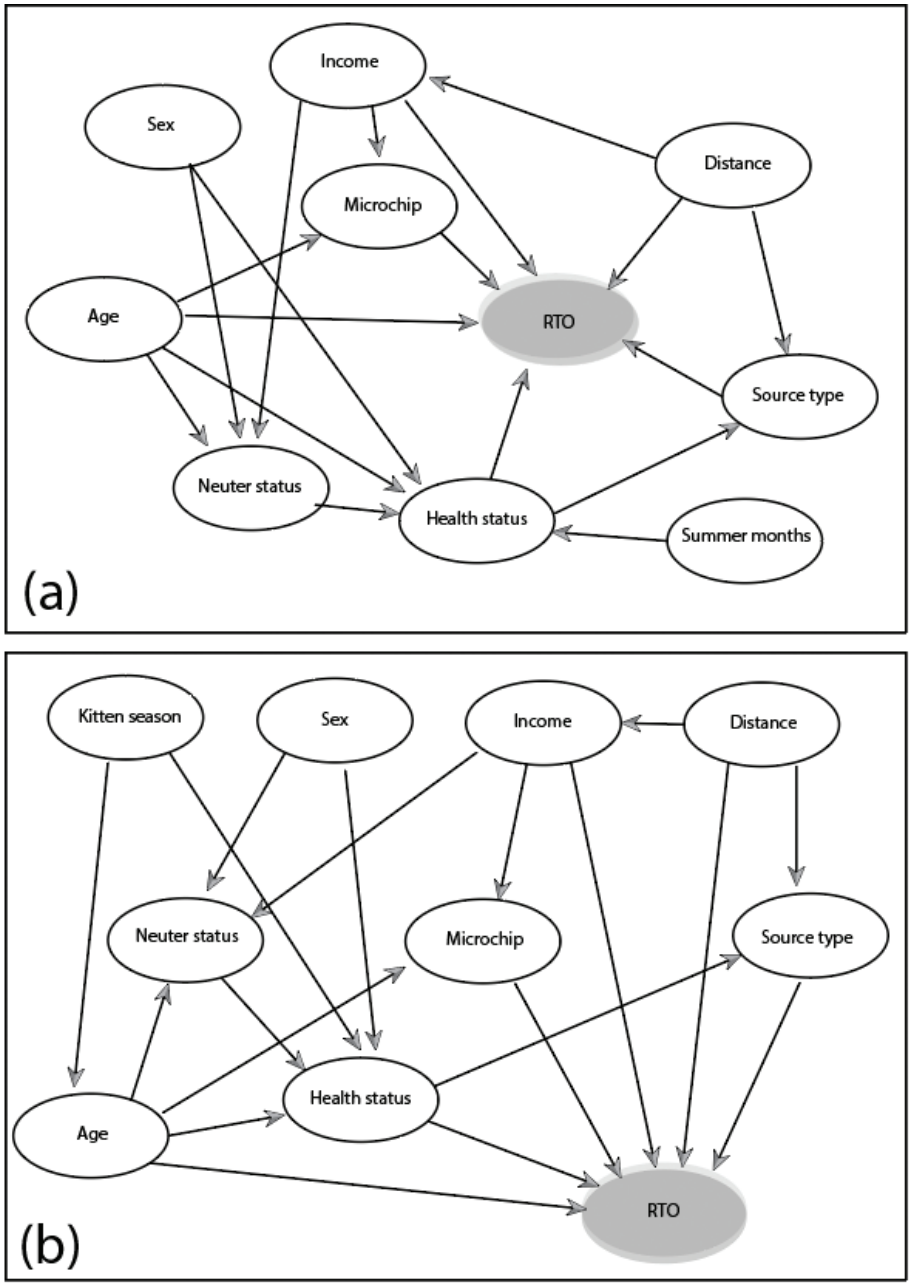

Fig. 1. Directed acyclic graphs (DAGs) depicting relationships between study variables and their associations with return to owner (RTO) in impounded dogs (a) and cats (b).

(n = 2,002, 33.6%) while only 13.2% (n = 459) of cats were microchipped. Among all impounds, 61.1% of dogs (n = 3,641) and 15.2% of cats (n = 529) experienced RTO.

Factors influencing RTO

Table 1 summarizes the study variables, their hypothesized causal relationships with RTO, and the corresponding sets of confounders for adjustment identified from the analysis of the DAGs (Fig. 1). The distribution of these variables in the two RTO groups as well as the adjusted OR and 95% CI are presented in Tables 2 and 3.

The results identified several factors that impacted RTO likelihood of both dogs and cats over the study period at this shelter.

The odds of experiencing RTO for cats with microchips were 5.5 times (95% CI 4.4–6.9) higher than cats without microchips when adjusted for age and income. Odds were 2.3 times (95% CI 2.0–2.6) higher for microchipped dogs than un-microchipped dogs when adjusting for age and income.

Compared to kittens, the odds of experiencing RTO were 4.9 times (95% CI 3.3–7.3) higher for senior cats, 3.6

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Table 1. Animal-related factors, their causal paths to return to owner (RTO), and the sets of confounders for adjustment, identified according to the analysis of the directed acyclic graphs (DAGs) depicting the study's causal assumptions (Fig. 1)

Factors	Causal paths	Confounders for adjustment
Dogs		
Microchip	Direct	Age, Income
Health status	Direct and Indirect (via Source type)	Age, Neuter status, Sex
Age	Direct and Indirect (via Microchip, Neuter status, Health status, and Source type)	None
Sex	Indirect (via Neuter status, Health status, and Source type)	None
Neuter status	Indirect (via Health status and Source type)	Age, Income, Sex
Source type	Direct	Distance, Health status
Summer months	Indirect (via Health status and Source type)	None
Income	Direct and Indirect (via Microchip, Neuter status, Health status, and Source type)	Distance
Distance	Direct and Indirect (via Source type, Income, Microchip, Neuter status, Health status, and Source type)	None
Cats		
Microchip	Direct	Age, Income
Health status	Direct and Indirect (via Source type)	Age, Neuter status, Sex
Age	Direct and Indirect (via Microchip, Neuter status, Health status, and Source type)	None
Sex	Indirect (via Neuter status, Health status, and Source type)	None
Neuter status	Indirect (via Health status and Source type)	Age, Income, Sex
Source type	Direct	Distance, Health status
Kitten season	Indirect (via Age, Neuter status, Microchip, Health status and Source type)	None
Income	Direct and Indirect (via Microchip, Neuter status, Health status, and Source type)	Distance
Distance	Direct and Indirect (via Source type, Income, Microchip, Neuter status, Health status, and Source type)	None

times (95% CI 2.2–5.8) higher for mature adults, 3.0 times (95% CI 2.1–4.2) higher for young adults, and 2.6 times (95% CI 1.6–4.1) higher for older kittens. Compared to puppies, the odds of experiencing RTO were 5.1 times (95% CI 3.4–7.6) higher for senior dogs, 3.3 times (95% CI 2.3–4.9) higher for mature adults, 2.5 times (95% CI 1.7–3.6) higher for young adults, and 2.0 times (95% CI 1.3–3.0) higher for older puppies.

For both dogs and cats, unhealthy animals had 1/2 the odds (OR 0.52, 95% CI 0.41–0.67 and OR 0.55, 95% CI 0.42–0.72, respectively) of experiencing RTO than healthy animals when adjusted for age, neuter status, and sex.

When adjusted for age, income, and sex, the odds of experiencing RTO for neutered cats were 5.2 times (95% CI 4.0–6.6) higher than intact cats, while the odds were 2.1 times (95% CI 1.8–2.5) higher for neutered dogs than intact dogs.

Compared to OTC and when adjusting for distance and health status, dogs with the source type Agency Assist had 2.3 higher odds (95% CI 1.6–3.3) of experiencing RTO, while Abandoned dogs had about 1/4 lower (OR = 0.27, 95% CI 0.10–0.70) odds of experiencing RTO. Agency Assist cats had 3.6 higher odds (95% CI 2.2–5.9) of experiencing RTO than OTC cats.

Sex and season were not found to affect the odds of experiencing RTO.

Discussion

This study's objective was to describe characteristics of dogs and cats impounded at an animal shelter and test their associations with RTO outcomes. The study successfully identified several actionable factors that influenced the likelihood of RTO, measured by adjusted ORs.

Microchips

For both dogs and cats, microchipped animals were much more likely to experience RTO than un-microchipped animals. This is consistent with the findings of many other studies.[2,6–12] When microchip information is correctly used and maintained,[8] microchips provide an excellent way to reunite stray animals with owners.

However, presence of a microchip did not increase odds of RTO for dogs as much as it did for cats (OR = 2.3 vs 5.5). Because many people with lost cats do not look for them at shelters[2] while people with lost dogs do,[2] it is possible that many un-microchipped dogs are still reclaimed from shelters while most cats get reclaimed only if they are microchipped.

Because of the huge effect microchipping has on RTO likelihood, shelters should strive to microchip as many dogs and cats as possible. Many shelters already microchip all animals prior to adoption. However, shelters could further improve microchip coverage by targeting owned animals that were not adopted from the shelter. SLCoAS, for example, offers free microchips to all owned dogs and cats in the

Table 2. Distribution of the animal-related factors by RTO status in dogs (N = 5,960) impounded at the participating Shelter between December 15, 2020 and October 31, 2022

Factor	Category	RTO		Not RTO		Odds ratio (95% CI)
		N	%	*N*	%	
Microchip	No	2,128	53.8	1,830	46.2	Ref
	Yes	1,513	75.6	489	24.4	2.3 (2.0–2.6)
Health status	Healthy	3,349	62.2	2,034	37.8	Ref
	Unhealthy	248	49.8	250	50.2	0.52 (0.41–0.67)
	Unknown	44	55.7	35	44.3	0.65 (0.37–1.1)
Age	Puppy	116	35.4	212	64.6	Ref
	Older puppy	363	52.5	329	47.5	2.0 (1.3–3.0)
	Young adult	1,294	57.6	951	42.4	2.5 (1.7–3.6)
	Mature adult	857	64.6	469	35.4	3.3 (2.3–4.9)
	Senior	731	73.5	263	26.5	5.1 (3.4–7.6)
	Unknown	280	74.7	95	25.3	2.5 (1.7–3.6)
Sex	Female	1,476	59.4	1,010	40.6	Ref
	Male	2,152	62.4	1,299	37.6	1.1 (1.0–1.3)
Neuter status	Intact	1,593	50.6	1,558	49.4	Ref
	Sterilized	1,731	72.2	667	27.8	2.1 (1.8–2.5)
	Unknown	317	77.1	94	22.9	3.2 (2.3–4.4)
Source type	OTC	684	52.2	626	47.8	Ref
	Field	2,591	63.4	1,497	36.6	1.6 (1.4–2.0)
	Agency assist	266	71.5	106	28.5	2.3 (1.6–3.3)
	Abandoned	11	22.4	38	77.6	0.27 (0.10–0.70)
	Unknown	89	63.1	52	36.9	2.0 (1.1–3.9)
Summer months	April–September	1,887	60.9	1,213	39.1	0.98 (0.88–1.1)
	October–March	1,754	61.3	1,106	38.7	Ref
Income (in 10,000 USD)		5.4 (4.2–6.1)[a]		4.9 (3.8–5.6)[a]		1.1 (1.1–1.2)[b]
Distance (in mile)		7.7 (6.2–13.5)[a]		8.4 (6.2–14.9)[a]		1.0 (0.99–1.0)[c]
Distance (in km)		12.4 (10.0–21.7)[a]		13.5 (10.0–24.0)[a]		1.0 (0.99–1.0)[c]

CI: confidence interval; Ref: reference; USD: United States dollar; RTO: return-to-owner; OTC: Over the Counter.
[a]Median and interquartile range are reported.
[b]Odds ratio for every 10,000 dollars increase in income.
[c]Odds ratio for every 1 mile (1.6 km) increase in distance to study shelter.

area.[e] Another shelter steeply discounts licensing fees for microchipped animals,[f] while others bundle microchipping with neuter or vaccination services.[g,h]

Age

In both dogs and cats, older animals (especially seniors) had higher odds of experiencing RTO than younger animals. As illustrated in the DAGs, researchers assumed that age affects not just RTO directly (younger animals are probably less likely to have owners than older animals), but also variables like neuter status (younger animals are less likely to be neutered than older animals[30]), presence of a microchip (younger animals are less likely to be microchipped[32]), or health status (younger animals are more susceptible to disease[33,34] and therefore more likely to enter a shelter sick or injured) that affected RTO.

Shelters can use this knowledge to alter shelter management practices no matter the animals' ages. For example, shelters could implement a shorter stray hold period for younger animals.[12] As older animals are not adopted as quickly as younger animals,[25] shelters may

e. Clinic Services. Salt Lake County Animal Services. Accessed August 6, 2023. https://slco.org/animal-services/clinic-services/

f. Pet Licensing. City of Port Lucie Animal Control. Accessed August 13, 2023. https://www.cityofpsl.com/government/departments/police/animal-control/pet-licensing

g. Spay and Neuter Programs. Foothills Humane Society. Accessed August 6, 2023. https://foothillshumanesociety.org/services/spay-and-neuter-programs/

h. Spay/Neuter Services. The Humane Society of Greater Kansas City. Accessed August 13, 2023. https://hsgkc.org/spay-neuter-services/

Table 3. Distribution of the animal-related factors by RTO status in cats (N = 3,489) impounded at the participating Shelter between December 15, 2020 and October 31, 2022

Factor	Category	RTO		Not RTO		Odds ratio (95% CI)
		N	%	*N*	%	
Microchip	No	326	10.8	2,704	89.2	Ref
	Yes	203	44.2	256	55.8	5.5 (4.4–6.9)
Health status	Healthy	436	16.4	2,227	83.6	Ref
	Unhealthy	93	11.3	733	88.7	0.55 (0.42–0.72)
Age	Kitten	42	7.0	554	93.0	Ref
	Older kitten	41	16.3	210	83.7	2.6 (1.6–4.1)
	Young adult	263	18.4	1,165	81.6	3.0 (2.1–4.2)
	Mature adult	37	21.3	137	78.7	3.6 (2.2–5.8)
	Senior	88	27.2	236	72.8	4.9 (3.3–7.3)
	Unknown	58	8.1	658	91.9	1.2 (0.77–1.8)
Sex	Female	213	14.0	1,311	86.0	Ref
	Male	300	19.1	1,270	80.9	1.5 (1.2–1.8)
	Unknown	16	4.1	379	95.9	0.26 (0.15–0.44)
Neuter status	Intact	132	7.6	1,605	92.4	Ref
	Sterilized	365	29.9	856	70.1	5.2 (4.0–6.6)
	Unknown	32	6.1	495	93.9	1.6 (0.96–2.6)
Source type	OTC	156	12.5	1,091	87.5	Ref
	Field	335	16.1	1,745	83.9	1.4 (1.2–1.8)
	Agency assist	29	33.3	58	66.7	3.6 (2.2–5.9)
	Abandoned	9	12.0	66	88.0	0.93 (0.45–1.9)
Kitten season	March–August	278	14.9	1,584	85.1	0.96 (0.80–1.2)
	September–February	251	15.4	1,376	84.6	Ref
Income (in 10,000 USD)		5.0 (4.2–5.6)[a]		4.6 (4.2–5.6)[a]		1.1 (0.98–1.1)[b]
Distance (in miles)		7.7 (6.2–13.5)[a]		7.7 (4.5–13.5)[a]		1.0 (0.98–1.0)[c]
Distance (in km)		12.4 (10.0–21.7)[a]		12.4 (7.2–21.7)[a]		1.0 (0.98–1.0)[c]

CI: confidence interval; Ref: reference; USD: United States dollar; RTO: return-to-owner; OTC: Over the Counter.
[a]Median and interquartile range are reported.
[b]Odds ratio for every 10,000 dollars increase in income.
[c]Odds ratio for every 1 mile (1.6 km) increase in distance to study shelter.

prioritize RTO over adoption for older animals, perhaps by highlighting older animals on lost/found notices. Shelters hesitant to practice open selection may be more willing to start on younger animals, knowing those are the least likely to experience RTO and most likely to be quickly adopted.

Health status

Both healthy dogs and cats had slightly increased odds of RTO than unhealthy animals. The study shelter frequently charged reclaiming owners for any medication and procedures done on their animals while they were housed at the shelter. It is possible that owners who discover their unhealthy animal is at a shelter may be too embarrassed to reclaim them or unable to pay additional fees associated with treating their health conditions. Further, in this study, the category of Unhealthy was defined in part by health statuses such as Malnourished and Poor. These statuses may imply that there is no owner caring for the animal, so animals entering the shelter as Unhealthy may be more likely to not have an owner compared to Healthy animals.

Knowing that unhealthy animals have lower odds of experiencing RTO may encourage shelters to offer more prompt or aggressive medical care to animals in their stray hold period without fear of reclaiming owners complaining about what was done to their pets. Waiving reclamation fees, including charges incurred for health reasons, may also encourage owners to reclaim their animals[35] and can be bundled with mandatory microchipping or neutering to increase odds of reunification if that animal becomes lost again. Although limited research has been conducted to show if waiving fees increases RTO likelihood, fee-waived adoptions can decrease length of stay and overpopulation in shelters,[35,36] so a similar effect may be true for RTO outcomes.

Neuter status

Neutered dogs and cats had higher odds of experiencing RTO than those intact, which is consistent with previous studies' findings.[7,11] Owners likely do not reclaim their pet based solely on whether or not the animal was neutered. Rather, neuter status may reflect which animals had owners in the first place (owned cats are probably more likely to be neutered than unowned community cats) or what role those animals play in their owners' lives (e.g. a neutered animal is more likely kept for companionship than an unneutered animal[37]).

Additionally, the barriers that prevent people from neutering their pets, such as transportation, finances, and socioeconomic factors[38] may also be barriers to reclaiming lost pets.

More research is needed to further explore the relationship between neutering and RTO likelihood. Meanwhile, because neutered dogs and cats do have higher odds of experiencing RTO, shelters should continue to advocate for widespread neutering through low-cost spay/neuter outreach.

Data showed that animals of unknown neuter status also had a higher RTO likelihood than intact animals. This was likely because in the study shelter, the neuter status of many animals was not determined until the animal was made available for adoption. If an animal experienced a different outcome prior to that time (RTO, euthanasia, or transfer out), their neuter status remained marked as unknown.

Source type

The source type also affected RTO likelihood of both dogs and cats. Abandoned animals were least likely to experience RTO, while Agency Assist animals were most likely. Indeed, Abandoned animals were likely abandoned because their owners no longer wanted them, while Agency Assist animals frequently had owners who still wanted them, were temporarily unable to care for them, and reclaimed them once the situation improved. Still, this finding may alter shelter practices and policies. For example, shelters could institute shorter holds or quickly plan pathways besides RTO for abandoned animals as it is unlikely their owner will return for them.

This study chose not to include cats in the shelter's RTF program in the pool of RTO candidates because it focused on cats suspected of being owned. Including community cats in this pool, however, could have significant effects on the results. For example, presumably very few cats in RTF programs have microchips; if these cats were counted as a successful RTO event it could lessen the otherwise strong effect of microchips on RTO likelihood found in this study while increasing overall RTO likelihood. Evidence also suggests that when shelters institute RTF programs, their feline RTO likelihoods increase, even when RTF and RTO are considered different outcomes.[39]

Season of impound

Much can also be learned from findings that were not statistically significant. Season of impound had no influence on RTO when controlled for the confounders of age and health status. Indeed, someone would not be more likely to reclaim their animal just because it is summer or winter. Excluding cats and dogs younger than 2 months from the study population may have also lessened the effect season of impound had on the results.

Sex

Animal's sex also had limited effect on RTO. For dogs, no change in RTO likelihood was found. For cats, males had a slightly higher likelihood than females (OR = 1.5). According to researchers' assumptions as illustrated by the DAGs, sex was associated with RTO only through other variables. This complicated indirect causal relationship might explain the weak association between sex of cats and RTO outcomes. However, more research into this relationship is warranted. Cats of unknown sex had almost four-fold fewer odds of experiencing RTO compared to intact cats (OR = 0.26). This was probably because at the study shelter, many cats with unknown sex experienced an outcome very quickly after entering the shelter, such as injured cats requiring euthanasia or kittens transferring to a different shelter. The sex of these cats was rarely updated in ShelterBuddy; most cats staying at the shelter long enough to have a chance of RTO had their sex correctly entered into the software.

Income and distance

Both income and distance were not found to affect RTO likelihood for dogs or cats. This contrasts with other studies that found distance[40,41] and socioeconomic factors such as income[42,43] impact other shelter intake and outcomes. However, because this study used zip codes rather than smaller geographic measurements like census tracts or exact addresses to calculate income and distance, neither variable had a large range (95% of all incomes were between $23,250 and $78,532), making it difficult to draw conclusions.

Limitations

There were multiple limitations of this study. First, there were a fairly large number of animals with unknown values for variables such as age, sex, and neuter status. Although these impounds could have been removed prior to analysis, researchers thought they might provide interesting insights. Even so, the presence of these values potentially introduced biased results due to uncontrollable confounding.

Like many studies, the generalizability of this study may not be widespread. All data came from a single well-resourced urban municipal shelter with a substantial budget;

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robust foster, TNR/RTF, and fundraising programs; and multiple veterinarians on staff. Data from other shelters in different locations with different resources or organizational models may not replicate these results, especially the findings such as health status' or source type's relationship with RTO that have not been seen in previous studies.

Additionally, the identification of confounders relied on the researchers' assumptions about how the variables were causally associated, as illustrated by the DAGs. For example, purebred status was associated with RTO in one study.[13] However, in this current study, researchers assumed breed does not have a causal relationship with the other study variables (e.g. age, sex, owner income, RTO) and thus did not include it in the DAG model. The study presented and analyzed one set of causal assumptions; different assumptions might lead to different variables being included, which might lead to different results. Regardless, causal assumptions are inherent and necessary for making inferences in non-randomized studies[44] like the current study. DAGs were used to explicitly communicate researchers' causal assumptions and to justify the modeling strategy.

Conclusion

Although RTO likelihood differed between dogs and cats, many of the variables influencing RTO were the same, including the presence of a microchip, animal age, and animal neuter status. While previous studies have identified these factors in dogs, this study shows that they are also influential in cats. These findings lend credence to the practices many shelters already employ.

This study also tested new factors for their associations with RTO for both dogs and cats and found that health status and source type also influenced RTO. Shelters should account for these factors in their policies and procedures. Other factors such animal sex and season of impound did not influence RTO likelihood at this shelter.

Although these results only reflect the reality of the study shelter, other shelters may find benefits using these findings to hone their shelter policies and RTO endeavors.

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