REIMAGINING ANIMAL SHELTERING: SUPPORT SERVICES AND COMMUNITY-DRIVEN SHELTERING METHODS

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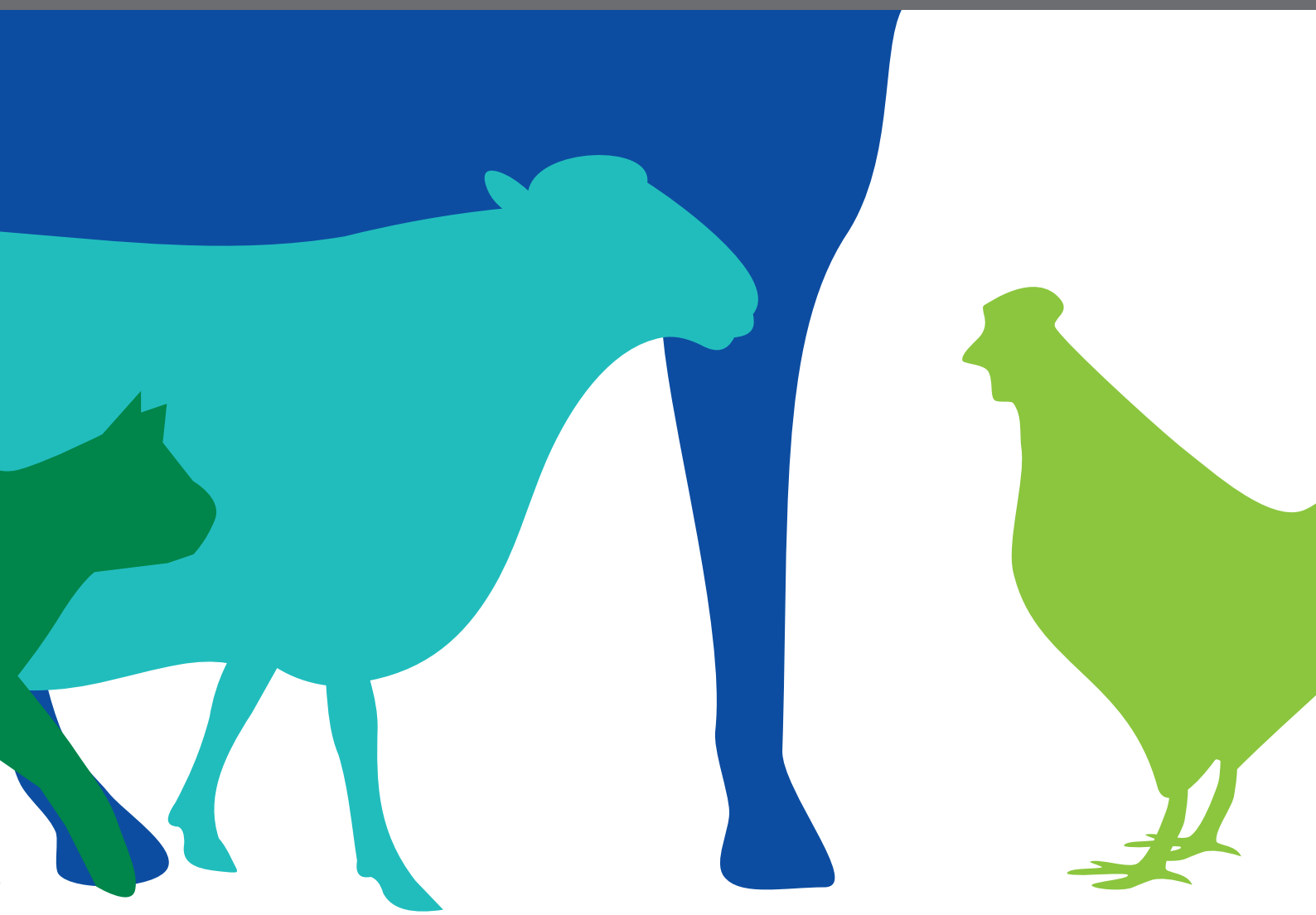

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REIMAGINING ANIMAL SHELTERING: SUPPORT SERVICES AND COMMUNITY-DRIVEN SHELTERING METHODS

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Table of Contents

05 ***Editorial: Reimagining Animal Sheltering: Support Services and Community-Driven Sheltering Methods***
Peter Joseph Wolf, Julie Levy, E. Susan Amirian and Kevin Horecka

09 ***Exploring the Relationship Between Human Social Deprivation and Animal Surrender to Shelters in British Columbia, Canada***
Lexis H. Ly, Emilia Gordon and Alexandra Protopopova

27 ***Social Enterprise as a Model to Improve Live Release and Euthanasia Rates in Animal Shelters***
Jennifer Thomsen, Bastian Thomsen, Kellen Copeland, Sarah Coose, Sean Blackwell and Vitoria Dante

36 ***A New Web-Based Tool for RTO-Focused Animal Shelter Data Analysis***
Tom Kremer

48 ***Workplace Relations and Opportunities for Career Development Impact the Retention of Veterinarians in Shelter Medicine***
Lauren Powell, Chelsea L. Reinhard, James Serpell and Brittany Watson

59 ***Effect of COVID-19 on Pet Food Bank Servicing: Quantifying Numbers of Clients Serviced in the Vancouver Downtown Eastside, British Columbia, Canada***
Marina Schor and Alexandra Protopopova

67 ***Free-Roaming Dog Surveys in Quito, Ecuador: Experiences, Lessons Learned, and Future Work***
Max Cárdenas, C. Jaime Grijalva and Stella de la Torre

73 ***Pet-Friendly for Whom? An Analysis of Pet Fees in Texas Rental Housing***
Jennifer W. Applebaum, Kevin Horecka, Lauren Loney and Taryn M. Graham

86 ***Inequitable Flow of Animals in and Out of Shelters: Comparison of Community-Level Vulnerability for Owner-Surrendered and Subsequently Adopted Animals***
Lexis H. Ly, Emilia Gordon and Alexandra Protopopova

103 ***Characterizing Pet Acquisition and Retention During the COVID-19 Pandemic***
Christy L. Hoffman, Melissa Thibault and Julie Hong

114 ***Measuring Changes in Perceptions of Access to Pet Support Care in Underserved Communities***
Sloane M. Hawes, Tess M. Hupe, Jordan Winczewski, Kaitlyn Elting, Amanda Arrington, Sandra Newbury and Kevin N. Morris

128 ***Where Are We on the Animal Welfare Map? Using GIS to Assess Stakeholder Diversity and Inclusion***
Kevin C. Roberts, Tegan L. Buckingham, Kyrsten J. Janke and Linda S. Jacobson

145 ***"State of the Mewnion": Practices of Feral Cat Care and Advocacy Organizations in the United States***
Sabrina Aeluro, Jennifer M. Buchanan, John D. Boone and Peter M. Rabinowitz

159 ***Corrigendum: "State of the Mewnion": Practices of Feral Cat Care and Advocacy Organizations in the United States***
Sabrina Aeluro, Jennifer M. Buchanan, John D. Boone and Peter M. Rabinowitz

161 ***Decolonizing Animal Welfare Through a Social Justice Framework***
Johnny L. Jenkins Jr. and Mueni L. Rudd

165 ***The Evolving Role of Triage and Appointment-Based Admission to Improve Service, Care and Outcomes in Animal Shelters***
Kate F. Hurley

170 ***Rethinking the Animal Shelter's Role in Free-Roaming Cat Management***
Kate F. Hurley and Julie K. Levy

181 ***Critical Problems for Research in Animal Sheltering, a Conceptual Analysis***
Kevin Horecka and Sue Neal

193 ***Emergency Fostering of Dogs From Animal Shelters During the COVID-19 Pandemic: Shelter Practices, Foster Caregiver Engagement, and Dog Outcomes***
Lisa M. Gunter, Rachel J. Gilchrist, Emily M. Blade, Jenifer L. Reed, Lindsay T. Isernia, Rebecca T. Barber, Amanda M. Foster, Erica N. Feuerbacher and Clive D. L. Wynne

210 ***Direct and Indirect Factors Influencing Cat Outcomes at an Animal Shelter***
R. J. Kilgour and D. T. T. Flockhart

222 ***Trends in Intake and Outcome Data From U.S. Animal Shelters From 2016 to 2020***
Jeffrey R. Rodriguez, Jon Davis, Samantha Hill, Peter J. Wolf, Sloane M. Hawes and Kevin N. Morris

234 ***The Impact of Incorporating Multiple Best Practices on Live Outcomes for a Municipal Animal Shelter in Memphis, TN***
Rachael E. Kreisler, Alexis A. Pugh, Katie Pemberton and Sara Pizano

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Editorial: Reimagining animal sheltering: Support services and community-driven sheltering methods

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Editorial on the Research Topic
Reimagining animal sheltering: Support services and community-driven sheltering methods

In the original call for submissions to this Research Topic, we highlighted the relative lack of research into various aspects of community-based animal sheltering, a set of sheltering principles and methods grounded in the belief that domesticated (and especially companion) animals are part of a larger system of people, animals, and the environment (often referred to as One Health) whose sustainability, stability, and health are dependent upon more direct participation of the community in animal-related services. In effect, community-based animal sheltering seeks to disperse programs and practices that would normally be housed in, and restricted to, a brick-and-mortar shelter facility throughout the geography and demography of a city, and to understand the connections between the socio-cultural structures of a society and its animal residents.

Because such a holistic approach invites—perhaps necessitates—innovative methods and novel measures of success, we anticipated that community-based animal sheltering would be a topic of considerable interest to researchers and animal sheltering practitioners. We were not disappointed, therefore, to see no fewer than 20 articles published in this volume.

Each article illuminates a particular aspect of community-based animal sheltering, a broad topic and one that is new enough to resist any easy definition. Some focus their attention squarely at the intersection of "traditional" animal services and community engagement (e.g., emergency fostering of dogs during the COVID-19 pandemic), while the focus of others is mostly **one** or the other. Similarly, some articles report on conditions "as they are" in shelters and the communities they serve (e.g., free-roaming dog populations), while others report on operational

or programming outcomes (e.g., an increased live release rate as the result of community cat programming). The diversity of research questions addressed, and methods employed, is a testimony to the complexity of this Research Topic.

Horecka and Neal's conceptual analysis sets the stage, providing a big-picture view of "critical problems for research in animal sheltering" broken down into seven key areas, each with its own potential impacts. The authors' analysis combines input from more than 300 animal sheltering professionals and an extensive review of the relevant literature. They note that many of the key areas they have identified "are being actively worked upon by various research institutions (i.e., significant work in animal diseases has occurred), but some have received little attention yet (i.e., operations research)." Their fellow contributors to this Research Topic have helped fill in at least some such gaps.

Shelter operations and programs

Using a "qualitative, comparative ethnographic study that included semi-structured interviews, participant observation, and archival research," Thomsen et al. examined the potential role of social entrepreneurship in improving shelter outcomes. Their findings describe some of the ways animal shelters are adopting more business-like practices (e.g., professionalizing shelter management, creating a welcoming retail experience for visitors), resulting in changes that can benefit staff, volunteers, and—ultimately—the animals in their care.

Hurley discusses the trend toward "triage and appointment-based services" in animal shelters and their positive results. Whereas triage "is a well-developed strategy in human general practice medicine," animal shelters have typically permitted the "unscheduled admission of any animal presented during open hours… regardless of shelter capacity or animal needs." However, recent changes in admission policies and practices, prompted in many cases by restrictions related to the COVID-19 pandemic, have revealed numerous benefits (e.g., reduced euthanasia, more predictable workflow, reduced disease transmission). *Ad hoc* shelter admissions of cats, in particular, has often led to euthanasia. "In North America alone," explain Hurley and Levy, "hundreds of millions of cats have been impounded and euthanized and billions of dollars invested in such programs." The authors compare this "traditional" method with **two** alternatives: a shelter-based trap-neuter-return (TNR) program, and "leaving cats in place with or without referral to mitigation strategies or services provided by other agencies."

Among the many shelters to implement appointment-based admissions and shelter-based TNR is Memphis Animal Services, in Memphis, Tennessee. Their adoption was part of a larger shift toward improved lifesaving that began in 2017. Kreisler et al. examined the results of this shift, reporting, for example, that the shelter's live release rate for cats increased from 62% in 2016 to a median of 92% post-intervention. Improvements for canine live release rate were more modest, from roughly 75% in 2016 to "just below 90% for 2017 through 2021." Post-intervention, euthanasia numbers were no longer closely correlated with admission numbers for either species.

Community-based programs and services

Measuring the effectiveness of community-based programs and services is critical to their success. Hawes et al. employed six questions from the One Health Community Assessment to "measure perceptions of access to pet care in two urban and two rural zip codes." Residents of one urban and one rural zip code received community-based animal welfare services (e.g., low- or no-cost veterinary services, pet food delivery, collars and leashes), while residents of the other zip codes did not. In the urban communities, residents who received community-based services reported "a higher overall measure of access to pet care" than their urban counterparts who received no such services. This was not true among the rural residents, however.

Using 2013–2020 pet food bank records from the British Columbia Society for the Prevention of Cruelty to Animals, Schor and Protopopova examined temporal trends, paying particular attention to any potential impacts of the COVID-19 pandemic. Among their findings, some were anticipated (e.g., the number of clients receiving services in 2020 was significantly less than in previous years), while others were not (e.g., cat owners received the largest share of services).

Programs and services at the intersection of shelter and community

As more shelters come to recognize the potential impact of community-based programs and services, they are beginning to let go of more "traditional" sheltering practices. During the early months of the COVID-19 pandemic, media accounts reported on the surge in foster caregiving (1–3). Gunter et al. examined the phenomenon at 19 US shelters, finding that foster caregiving increased during the first 2 months but settled back to initial levels by June 2020. Nearly 40% of caregivers had no prior experience fostering dogs for their local shelter. Shelters with fewer resources tended to rely on known foster caregivers and transfer dogs to other agencies, whereas more highly resourced shelters tended to recruit new fosters and place dogs with adopters in their communities.

Kremer developed a web-based tool designed to improve canine return-to-owner (RTO) rates, using geographical data from Dallas (Texas) Animal Services to demonstrate its usefulness. The subsequent analysis showed that 70% of stray

dogs reunited with their owners were at most 1 mile from their home, while 42% were within a block of their home. The RTO rate for adult dogs with microchips was 71%, compared to 39% for those without microchips.

Using the Canadian Index of Multiple Deprivation (CIMD), Ly et al. "compared the 'flow' of surrendered animals between originating communities (incoming) and communities where they were adopted (outgoing)." Their results reveal a flow that is often unbalanced, with animals moving from more vulnerable to less vulnerable communities. The authors' findings "provide a basis for understanding potential inequities in the use of shelter services to surrender or adopt an animal" and the development of interventions that can better balance the flow between communities.

Shelter conditions

Rodriguez et al. examined intake and outcome data from 1,373 US animal shelters over a five-year period (2016–2020). Their analysis shows that intake and euthanasia significantly decreased over this period, for both dogs and cats. Meanwhile, live release rates increased significantly for both species. A number of live outcome categories—adoptions, return-to-owner, return-to-field, and transfers to other agencies (for cats), each as a proportion of total intake—showed significant increases as well.

Although 51.1% of US shelter admissions during 2020 were dogs, cats made up 68.4% of the animals "unnecessarily dying" there (4). Using structural equation modeling, Kilgour and Flockhart predicted that cat outcomes at a Washington, DC, animal shelter could be predicted on the basis of four interrelated factors: characteristics of the cats (e.g., sex, coat pattern and color, health status); where the cat came from, the date and type of intake (owner-surrendered, stray), and the cat's length of stay in the shelter. "Consistent with other studies," the authors report that, "intake type, potentially indicating degree of ownership, and physical attributes of cats are both important components of the system relating to outcomes."

One topic of increasing interest in recent years has been the difficulties associated with shelters recruiting and retaining veterinary professionals (5, 6). Powell et al. surveyed 52 shelter veterinarians, along with 39 former shelter veterinarians and 130 veterinarians working in private practice, in their investigation of the "characteristics of employment in shelter medicine relative to turnover or retention of shelter veterinarians." The authors report that veterinarians who "participate in decision-making for patients and shelter management procedures" are more likely to be retained by shelters than their colleagues who aren't offered such opportunities.

Community context

To better understand the potential for community-based animal sheltering, it is important to examine conditions in the communities currently served by "traditional" animal shelters. Again, Ly et al. used the CIMD, this time to predict the risk of British Columbia residents surrendering their pets to local shelters. The authors found some similarities across parts of the city (e.g., "Situational Vulnerability predicting increased odds of surrendering pit bull-labeled dogs vs. all other dog breeds") and some differences, "suggesting that provision of animal services, such as veterinary care, for vulnerable groups may be specific to location."

Using adoption, owner-surrender, volunteer, foster caregiver, and public veterinary service client data from a four-year period (2015–2019), Roberts et al. performed a hot spot analysis across neighborhoods served by the Toronto Humane Society (THS). The authors found that some parts of the city were better served than others, specifically that residents located farther from THS were less likely to utilize the organization's services. Their results provide a framework for developing "strategies to reach under-served demographics."

According to a 2021 report from the Pet-Inclusive Housing Initiative, 72% of US residents consider pet-friendly housing "hard to find" (7). Combining rental property listings for the 20 most populous cities in Texas with corresponding census tract data, Applebaum et al. examined the issue in greater detail. Their results show that less expensive pet-friendly properties were more likely to charge additional pet fees than were properties that charged higher rents. Moreover, "low-income communities and communities of color were more likely than higher income and predominantly White communities to pay disproportionately higher fees to keep pets in their homes."

Hoffman et al. report on the results of a May 2021 survey of US households regarding pet ownership and acquisition during the first 14 months of the COVID-19 pandemic. Despite media accounts reporting a dramatic increase in pet acquisition (8, 9), the authors found no significant increase in pet ownership over the study period. In addition, the authors found that pets being rehomed during this period were typically "placed with friends, family members, and neighbors more frequently than they were relinquished to animal shelters and rescues."

Cárdenas et al. compared two methods for surveying free-roaming dog populations across eight urban and eight rural parishes in Quito, Ecuador: capture-recapture surveys and distance sampling surveys. Each had its limitations—difficulty in identifying individual dogs from photographs, for example, in the case of capture-recapture surveys, difficulties in estimating "animal-observer distances and angles" in the case of distance sampling surveys. As a result, the authors recommend that future studies be conducted *via* "direct observations of dog abundance (number of free-roaming dogs/km) during street

counts, complemented with capture-recapture surveys every 5 years."

To better understand real-world management of free-roaming cats, Aeluro et al. surveyed 567 "feral cat care and advocacy organizations" from across the US. Their findings suggest that many of these organizations have adopted very similar policies and practices (e.g., a minimum weight of 2.0 lbs. for sterilization, left-side ear-tips to indicate sterilization, and less than one quarter engaging in routine feline immunodeficiency virus and feline leukemia virus testing). However, the authors also noted that most of the organizations surveyed lacked clearly defined goals and measures of success.

Conditions at the intersection of shelter and communityc

As some of the articles included in this Research Topic have highlighted, not all communities served by an animal shelter receive the same level of service (e.g., Ly et al., Roberts et al.). Jenkins and Rudd explore this more deeply, offering a way forward that might be informed by the disability, environmental, gender and sexual diversity, and racial justice movements, among others. The authors finish with a clear call to action: "animal welfare must build authentic relationships with intersectional [Black, Indigenous, and other people of color] communities to holistically address the challenges that impact these communities and their pets. In essence, this work requires the disruption of the status quo within animal welfare to benefit pets within marginalized communities."

Conclusions

The original intention of this Research Topic was "to assemble evidence for or against critical concepts, programs, and methods related to community-based animal sheltering and support services" in the hopes that such evidence might "shape the future of animal services." Specifically, we had in mind a future in which "the interconnectedness of human, animal, and environmental health and welfare outcomes" better inform animal services so that these agencies can "serve their communities in a fair, just, inclusive, and equitable manner." Again, we have not been disappointed. Indeed, the articles published here represent a notable contribution to the animal welfare literature and—perhaps more importantly—help point the way forward for community-based animal sheltering and support services.

Author contributions

PW drafted the editorial, which was reviewed, revised, and accepted by all co-authors. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Exploring the Relationship Between Human Social Deprivation and Animal Surrender to Shelters in British Columbia, Canada

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Previous studies identify owner-related issues, such as cost and housing, as common reasons for relinquishment of companion animals to animal shelters. It is likely that the burden of surrendering for owner-related reasons falls on those who are socially vulnerable (e.g., low income, unemployed); however, very few studies have assessed social determinants as a predictor of animal relinquishment. The present study used the Canadian Index of Multiple Deprivation (CIMD), which uses four factors of social vulnerability (Ethnocultural Composition, Economic Dependency, Residential Instability, and Situational Vulnerability) to predict risk of surrender for various reasons, of various species and breeds, and of various health statuses across British Columbia, Canada (n = 29,236). We found that CIMD factors predicted increased risk of surrender across many shelter variables. For further understanding of differences between areas in the province, the present study also analyzed the relationship between CIMD factors and animal surrender variables in two areas of interest: Metro Vancouver (n = 3,445) and Kamloops (n = 2,665), and plotted these relationships on a geospatial scale. We found that there were some similarities across areas, such as Situational Vulnerability predicting increased odds of surrendering pit bull-labeled dogs vs. all other dog breeds. There were also differences in predictors of animal surrender variables, suggesting that provision of animal services, such as veterinary care, for vulnerable groups may be specific to location. For example, whereas Ethnocultural Composition predicted increased risk of owner surrender for multiple owner-related reasons in Metro Vancouver, these same reasons for surrender were predicted by Residential Instability in Kamloops, indicating demographic differences that affect animal shelter service use. The results of this research validate the use of geospatial analysis to understand relationships between human vulnerability and animal welfare, but also highlight the need for further interventions in marginalized populations to increase retention of animals.

Keywords: animal shelter, relinquishment, animal welfare, one welfare, social determinants, social vulnerability

INTRODUCTION

The close relationship of humans and companion animals means that the two populations often share similar physical and social conditions (1); however, human and animal services, such as shelters for humans and animals experiencing homelessness, often remain segregated (2). Recently, the One Health framework—which reflects the interconnected nature of the health of humans, animals, and the environment—has become more popular, although it typically focuses on threats to the health of the three aforementioned facets, such as zoonotic diseases or antimicrobial resistance (3). In response, the One Welfare framework was created as a unifying concept to include both physical and psychosocial impacts of human animal relationships, and how improvement of one can ultimately benefit the other (4). Pet ownership falls under the One Welfare framework, as previous studies report various physical and mental health benefits to owning a companion animal (5–7).

Pet ownership is not equal across human groups. Previous studies have found pet ownership to be associated with social factors such as housing type, house ownership, income, education, family composition, and urban vs. rural residency, among others (8–10). Studies report owner-related issues (including housing issues, owner health issues, cost) as a major reason for surrender [for a review on dog surrender, see (11)]. Miller et al. (12) reported 87.2% of cat surrenders in an Australian shelter being due to owner-related reasons. The significance of owner-related reasons for surrender indicates that animal relinquishment may be a One Welfare issue as well, as owner factors (such as poor health, housing issues, and low socioeconomic status) may create greater risk of relinquishing their animal. Previous research found that areas of high social vulnerability predicted both dog "hot spots" —areas from which high amounts of dogs were relinquished—and indicated higher intake of dogs with health issues and social neglect (1). Another study found that areas of high intake of stray dogs overlapped with areas of child maltreatment, which may indicate that such communities face multiple human and animal related challenges that may be driven by social deprivation (13).

Whereas, the aforementioned studies all identified relationships between human social determinants and animal shelter-related variables, none of these studies have more broadly analyzed community-level social determinants with various aspects of relinquishment, such as the species surrendered, the reason for surrender, or the health status of the animal. Given the prevalence of owner-related reasons for surrender, the relationship between human deprivation and risk of surrender across the given reasons for surrender are an area of interest. Additionally, pet ownership and surrender has been studied extensively in dogs and cats, although the growing popularity of small animals, rabbits, and exotic pets in North America warrants investigation (14, 15). Geospatial analysis lends itself well to comparisons of various geographic areas; however, previous studies in animal welfare often study one location of interest (1, 13). The aim of the present study was to explore the relationship between community-level social deprivation and owner surrender characteristics to animal shelters in British Columbia, Canada. The analysis took place on a province-wide scale across British Columbia, as well as a focused analysis of two demographically different areas of the province: Metro Vancouver and Kamloops. We utilized data from the British Columbia Society for the Prevention of Cruelty of Animals (BC SPCA), which has 36 animal shelter locations across the province. We used statistical analysis of data from the Canadian Index of Multiple Deprivation (CIMD), as well as geospatial analysis to demonstrate the relationship between social determinants and animal relinquishment.

MATERIALS AND METHODS

Data

This study protocol was reviewed and approved by the University of British Columbia's Behavioral Research Ethics Board (H20-02704). Permission for data collection was received by the BC SPCA. This retrospective study utilized the publicly available CIMD, which uses various measures of social well-being categorized into four factors to create nation-wide and region-specific scales (16). The CIMD uses Canadian census data to determine deprivation based on dissemination area. A dissemination area is a unit of area used by the Canadian census that contains around 400–700 people; it is made up of one or more dissemination blocks [a unit of area that is bound by standard geographic areas such as roads or boundaries; (16)]. The data exists in both raw numeric scores and quintile scores. A higher score indicates greater deprivation based on the indicators for each particular dimension (16). The four dimensions of the CIMD are Ethnocultural Composition (EC), Situational Vulnerability (SV), Economic Dependency (ED), and Residential Instability (RI). **Table 1** shows corresponding indicators for each of the four dimensions for British Columbia.

In order to link the person's postal code with the Statistics Canada's standard geographic areas for which the CIMD factors are measured, the Postal Code Conversion File (PCCF) was used (17). In some rural, low-population areas of British Columbia, there are some postal codes which span a large area and a few cases where the postal code spans multiple dissemination areas. To simplify the data, the first dissemination area corresponding with these postal codes was used. To verify the use of the chosen dissemination area score, we calculated the Pearson correlation coefficient (for raw numeric scores) and weighted Cohen's Kappa (for quintile scores) between the chosen score and the mean scores across each CIMD factor (Ethnocultural Composition $R = 0.99$, Kappa $= 0.98$; Economic Dependency $R = 0.99$, Kappa $= 0.97$; Situational Vulnerability $R = 0.98$, Kappa $= 0.97$; Residential Instability $R = 0.99$, Kappa $= 0.97$).

Incoming animal data were requested from all 36 animal shelter branches of the British Columbia Society for the Prevention of Cruelty of Animals from September 1, 2016 to August 31, 2020. The first animal shelter variable of interest was the reason for surrender, which were grouped into 10 distinct categories by the shelter data collection software: Personal Issues (including divorce, pregnancy/recent birth, or jail), No

TABLE 1 | The four dimensions of multiple deprivation and corresponding indicators for British Columbia (2016).

Ethnocultural composition	Situational vulnerability	Economic dependency	Residential instability
Proportion of population who self-identify as a visible minority	Proportion of population that identifies as aboriginal	Proportion of population participating in the labor force (>15yrs)*	Proportion of dwellings that are apartment buildings
Proportion of population that is foreign-born	Proportion of population aged 25–64 without a high school diploma	Proportion of population aged 65+	Proportion of persons living alone
Proportion of population with no knowledge of either official language (linguistic isolation)	Proportion of dwellings needing major repairs	Ratio of employment to population*	Proportion of dwellings that are owned*
Proportion of population who are recent immigrants (arrived in 5 years prior to Census)	Proportion of population that is low-income	Dependency ratio (population 0–14 and 65+ divided by population 15–64)	Proportion of population who moved within the past 5 years
	Proportion of single parent families		

**Indicates reverse-coded measures. Data is taken from the 2016 Census of Population by Statistics Canada.*

Longer Wanted (the animal was a gift or is unwanted), Housing Issues (including eviction, complaints from neighbors, being unable to find pet-friendly housing), Guardian Health (including owner sickness or injury, allergies to pet, death of owner), Feral/Free-roaming (surrender of a feral or free-roaming animal), Can't Afford (including being unable to pay for veterinary costs, maintenance costs, or impound fees), Behavior (including animal behavioral issues such as aggression, digging/chewing, house training issues), Animal Health (including animal injuries, sickness, or animal pregnancy), Abandoned (by a friend, relative, or tenant), and Too Many (including unwanted litters, and having too many animals in the home), which was used as the reference category. The reference category in each shelter variable is used as a category of comparison for the rest of the categories. The reference category for each shelter variable is the most commonly reported category. Another shelter variable of interest was species, which was grouped into six categories: small animal, rabbit, puppy, kitten, exotic, dog, and cat (which was used as a reference category). Finally, the last multi-category variable of interest was the animals' physical and behavioral health status upon intake, which was recorded based on the Asilomar Accords (18) and includes Healthy (which was used as the reference category), Treatable-Manageable, Treatable-Rehabilitatable, and Unhealthy-Untreatable. Binary variables of interest included whether the animal was spayed/neutered upon entering the shelter (compared to sexually intact animals), which was analyzed for cats, dogs, kittens, and puppies only, and whether or not the animal was a pit bull-labeled dog (compared to all other labeled dog breeds), which was analyzed for dogs and puppies only. We had a particular interest in pit bull-labeled dogs due to long-debated links between this breed type, race, and poverty (19). The term "pit bull-labeled" rather than "pit bull type" is used because of previous literature which shows that shelter staff frequently misidentify dogs belonging to this group (20).

The raw shelter data files contained 76,991 observations (2016–2017: $n = 22{,}791$; 2017–2018: $n = 22{,}245$; 2018–2019: $n = 21{,}254$; 2019–2020: $n = 16{,}646$). In order to assess the data geospatially within the province, all entries with postal codes outside of British Columbia were excluded. Observations were also removed if they did not have any location data, as they could not be related to the CIMD scale. Data were subset into the method of intake (Owner Surrender, Stray, and Humane Officer Seized/Surrendered). For owner surrendered animals, shelter-related variables of interest included reason for surrender, species, spay/neuter status upon intake and dog pit bull label.

Analysis

For shelter variables which had two possible categories (spay/neuter upon intake, pit bull label), a logistic regression was performed to examine the relation between the four dimensions of the CIMD and the shelter variable. Relationships between the categorical shelter variables (reason for surrender, species, health status) and CIMD dimensions were assessed through a multinomial logistic regression. Relationships were considered statistically significant at $p < 0.05$. Due to the exploratory nature of this study, no formal adjustment for multiplicity of testing was included in order to allow for subsequent studies to confirm or refute possible connections (21). All statistical analysis was undertaken in R Studio.

Coordinates of the owner addresses given at intake were plotted onto a map of British Columbia's dissemination areas. Because the area of British Columbia is so large, we chose to focus on two regions of the province to demonstrate spatial relationships (Metro Vancouver, and Kamloops and its surrounding area). Results from the statistical analysis across all of British Columbia were used to discuss which relationships between CIMD factors and shelter-related data. For the Metro Vancouver and Kamloops analysis, several statistically significant results were plotted geospatially for descriptive purposes in order to visually demonstrate differences between locations within the province. Metro Vancouver was selected because it is the most populous location in BC. As a comparison to Vancouver, Kamloops was selected because of its lower population, differing Ethnocultural Composition, and a more rural environment. Additionally, Kamloops is one of three BC municipalities where the BC SPCA is conducting focused community assessments thus allowing for the practical application of collected data.

Study Locations

In 2016, the population of British Columbia was ∼4.6 million people. The majority of the population (64%) are white, followed by East and Southeast Asians (18%, 18). The reported Indigenous

population in 2016 was ∼300,000 people. The majority of immigrants to British Columbia moved to the province within the past 30 years. Since 1981, the most common birthplace of immigrants to British Columbia was China, followed by India and the Philippines (22).

Metro Vancouver is a metropolitan area, which consists of a large urban area (the City of Vancouver) and surrounding "urban fringes" (23). In 2016, the reported population of Metro Vancouver was ∼2.5 million people (24). The City of Vancouver is located on the homelands of the Musqueam, Squamish, and Tsleil-Waututh First Nations (25). In 2016, 2.5% of the Metro Vancouver population reported Indigenous ancestry, and Indigenous population has seen a net growth since 1996 (24). The largest pan-ethnic groups in Metro Vancouver are white (49%) followed by East Asian (23%). Under Statistics Canada's definition of "visible minority" (neither white nor Indigenous), the population of visible minorities in Metro Vancouver grew by 110% between 1996 and 2016 (24). Across Metro Vancouver, 36% of households are reported as rentals, although this proportion increases to 53% of households when looking specifically at the City of Vancouver (25).

Kamloops is a city located in the south-central area of British Columbia that reported an estimated population of 100,000 in 2016 (26). The proportion of visible minorities is significantly smaller compared to Metro Vancouver, with the total visible minority population reported as 8% in 2016, with South Asians making up 36% of the visible minority population. Kamloops has a higher proportion of Indigenous residents (10%) compared to Metro Vancouver (26). Unlike Metro Vancouver, the largest influx of immigrants to Kamloops was prior to 1981. Kamloops also has a lower proportion of renters compared to Metro Vancouver [28%; (21)].

RESULTS

British Columbia

After the data cleaning, the total number of observations for Owner Surrender data for all of British Columbia (2016–2020) was $n = 29{,}236$. Results of the multinomial logistic regression models showed that there were various associations between the CIMD factors and owner surrender variables, as seen in **Figure 1**.

Ethnocultural Composition

Ethnocultural Composition predicted risk of surrendering for various owner-related reasons for surrender. A one-unit increase in Ethnocultural Composition increased risk of surrendering for personal issues by 1.54 times (95% CI, 1.43–1.66), housing issues by 1.61 times (95% CI, 1.51–1.72), guardian health by 1.79 times (95% CI, 1.67–1.93) and being unable to afford the animal by 1.31 times (95% CI, 1.20–1.42) in comparison to surrendering for having too many animals. Increase in Ethnocultural Composition predicted increased risk of surrendering for animal-related reasons such as the animals' behavior (RR = 1.25, 95% CI, 1.14–1.36), but predicted decreased risk of surrendering for reasons of the animal being feral/free-roaming (RR = 0.66, 95% CI, 0.53–0.82). Ethnocultural Composition also predicted the greatest increase in risk of surrendering for reasons of no longer wanting the animal (RR = 1.96, 95% CI, 1.71–2.25) across all four CIMD factors.

In comparison to surrendering cats, an increase in Ethnocultural Composition increased risk of surrendering rabbits and small animals by 1.54 (95% CI, 1.38–1.74) and 1.71 (95% CI, 1.61–1.81) times, respectively. Increase in Ethnocultural Composition predicted decreased risk of surrendering kittens and puppies in comparison to cats (kitten RR = 0.61, 95% CI, 0.57–0.66; puppy RR = 0.61, 95% CI, 0.54–0.70). Ethnocultural Composition predicted decreased risk of surrendering animals which were Unhealthy-Untreatable or Treatable-Rehabilitatable compared to those considered Healthy (Unhealthy-Untreatable RR = 0.84, 95% CI, 0.76–0.94; Treatable-Rehabilitatable RR = 0.74, 95% CI, 0.71–0.78). The odds of surrendering an animal that is spayed or neutered (relative to not spayed or unneutered) were 1.33–1 for every unit increase in Ethnocultural Composition (95% CI, 1.26–1.40), and odds of surrendering a pit bull-labeled dog compared to all other dogs was decreased (OR = 0.70, 95% CI, 0.58–0.84).

Situational Vulnerability

An increase in Situational Vulnerability did not predict increased risk of any reasons for surrender compared to surrendering for having too many animals. Increase in Situational Vulnerability lowered risk of surrendering for reasons of animal behavior (RR = 0.71, 95% CI, 0.67–0.75), guardian health issues (RR = 0.58, 95% CI, 0.54–0.62), housing issues (RR = 0.72, 95% CI, 0.69–0.75), no longer wanting the animal (RR = 0.62, 95% CI, 0.64–0.85), and for personal issues (RR = 0.77, 95% CI, 0.73–0.82) in comparison to surrendering for having too many animals. A one-unit increase of Situational Vulnerability increased risk of surrendering kittens and puppies by 1.37 (95% CI, 1.32–1.42) and 1.78 (95% CI, 1.69–1.86) times, respectively, in comparison to cat surrenders. Among dogs and puppies, for each one-unit increase in Situational Vulnerability, odds of surrendering a pit bull-labeled dog were 1.13 times larger than surrendering any other dog breed (95% CI, 1.06–1.21).

Economic Dependency

A one-unit increase in Economic Dependency increased risk of surrender due to the animal being feral/free-roaming by 1.15 times (95% CI, 1.07–1.23). Increase in Economic Dependency reduced risk of surrendering for reasons of animal behavior (RR = 0.89, 95% CI, 0.85–0.94), being unable to afford pet ownership (RR = 0.88, 95% CI, 0.84–0.92), guardian health issues (RR = 0.91, 95% CI, 0.87–0.95), housing issues (RR = 0.94, 95% CI, 0.91–0.98), and for personal issues (RR = 0.75, 95% CI, 0.72–0.79) in comparison to surrendering for having too many animals. There was reduced risk of surrendering small animals (RR = 0.93, 95% CI, 0.89–0.97), puppies (RR = 0.86, 95% CI, 0.81–0.92), exotic animals (RR = 0.89, 95% CI, 0.81–0.97), and dogs (RR = 0.90, 95% CI, 0.86–0.93), but increased risk of surrendering kittens (RR = 1.05, 95% CI, 1.01–1.08) in comparison to cats.

Regarding health, an increase in Economic Dependency increased risk of surrendering Treatable-Rehabilitatable or Treatable-Manageable animals as opposed to Healthy animals

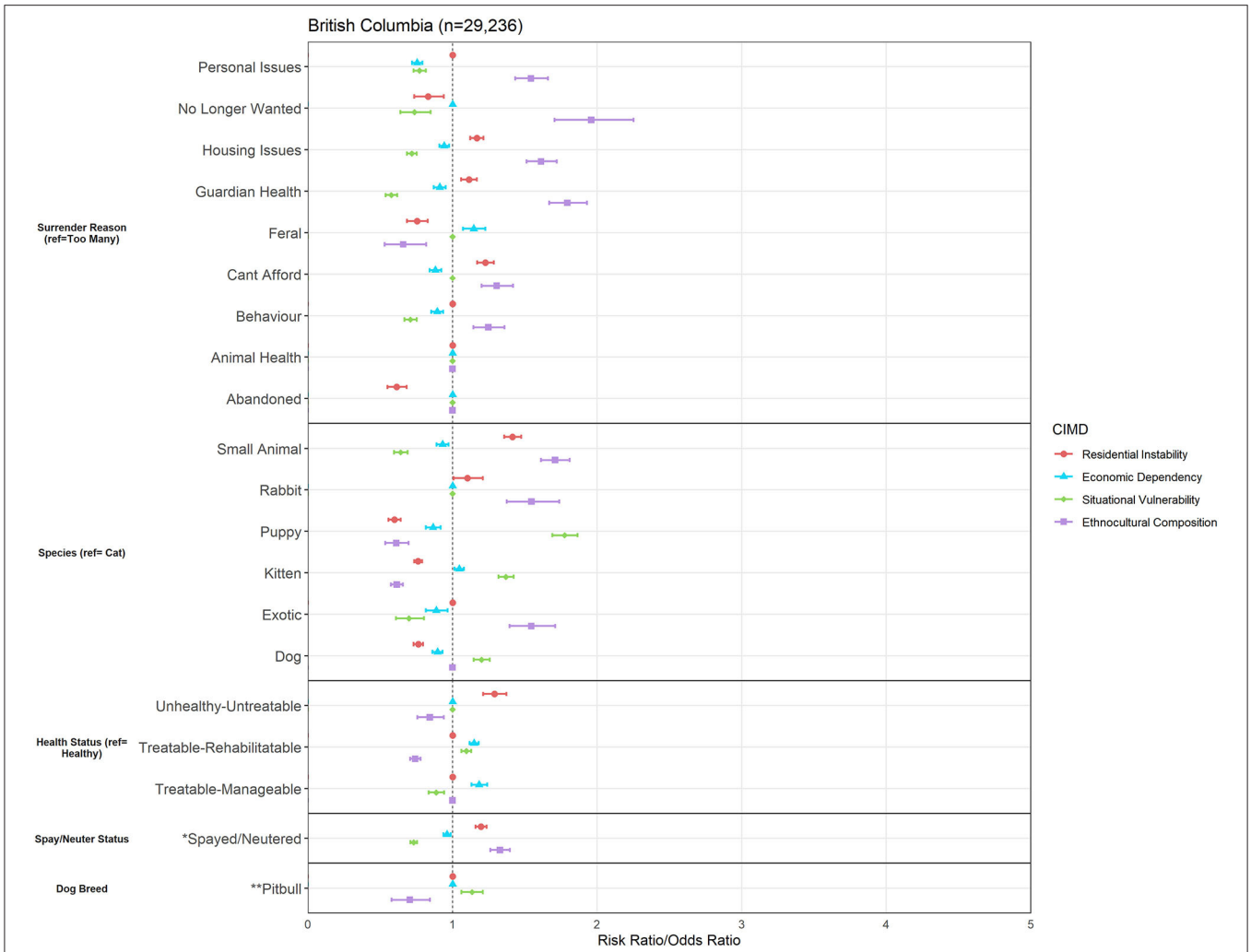

FIGURE 1 | Association between Canadian Index of Multiple Deprivation (CIMD) factors and owner surrender variables across British Columbia ($n = 29,236$). Results of logistic regression models for shelter variables by increasing CIMD factor scores are shown. Data are presented by risk ratios and their 95% confidence interval (bars); $p < 0.05$ when 95% confidence interval does not cross the vertical dotted line. Non-significant results are represented by a risk ratio of 1 with no CI. A risk ratio >1 suggests an increased risk of that shelter variable category as you increase in deprivation, while a risk ratio <1 suggests a reduced risk. *denotes data from dogs, cats, kittens, and puppies only ($n = 25, 075$) and is represented in odds ratios (and 95% CI). **Denotes data from dogs and puppies only ($n = 6,516$) and is represented in odds ratios (and 95% CI).

by 1.14 (95% CI, 1.12–0.98) and 1.18 (95% CI, 1.13–1.24), respectively. This factor also predicted slightly decreased odds of surrendering an animal that is spayed/neutered upon intake (OR = 0.96, 95% CI, 0.94–0.99).

Residential Instability

A one-unit increase in Residential Instability increased risk of surrender for housing issues by 1.17 times (95% CI, 1.12–1.21) compared to surrendering for having too many animals. Residential Instability also increased risk of surrender for guardian health issues (RR = 1.13, 95% CI, 1.05–1.17), and being unable to afford pet ownership (RR = 1.23, 95% CI, 1.17–1.28) compared to surrendering for having too many animals. Areas higher in Residential Instability predicted increased risk of surrendering small animals and rabbits (small animals RR = 1.41, 95% CI, 1.36–1.47; rabbits RR = 1.10, 95% CI, 1.01–1.21), but decreased risk of surrendering puppies (RR = 0.60, 95% CI, 0.56–0.64), kittens (RR = 0.76, 95% CI, 0.73–0.79), and dogs (RR = 0.76, 95% CI, 0.73–0.80) compared to cats.

Residential Instability was the only CIMD factor that predicted increased risk of surrendering an animal which was Unhealthy-Untreatable compared to Healthy (RR = 1.29 95% CI, 1.21–1.37). However, it was one of two factors that predicted increased risk of surrendering animals that are spayed or neutered compared to not (OR = 1.20, 95% CI, 1.16–1.23).

Metro Vancouver

The Metro Vancouver area was subset to include any owner address that fell in between latitudes of 49.00 to 49.33 and longitudes of −123.31 to −122.46. This area includes the City of

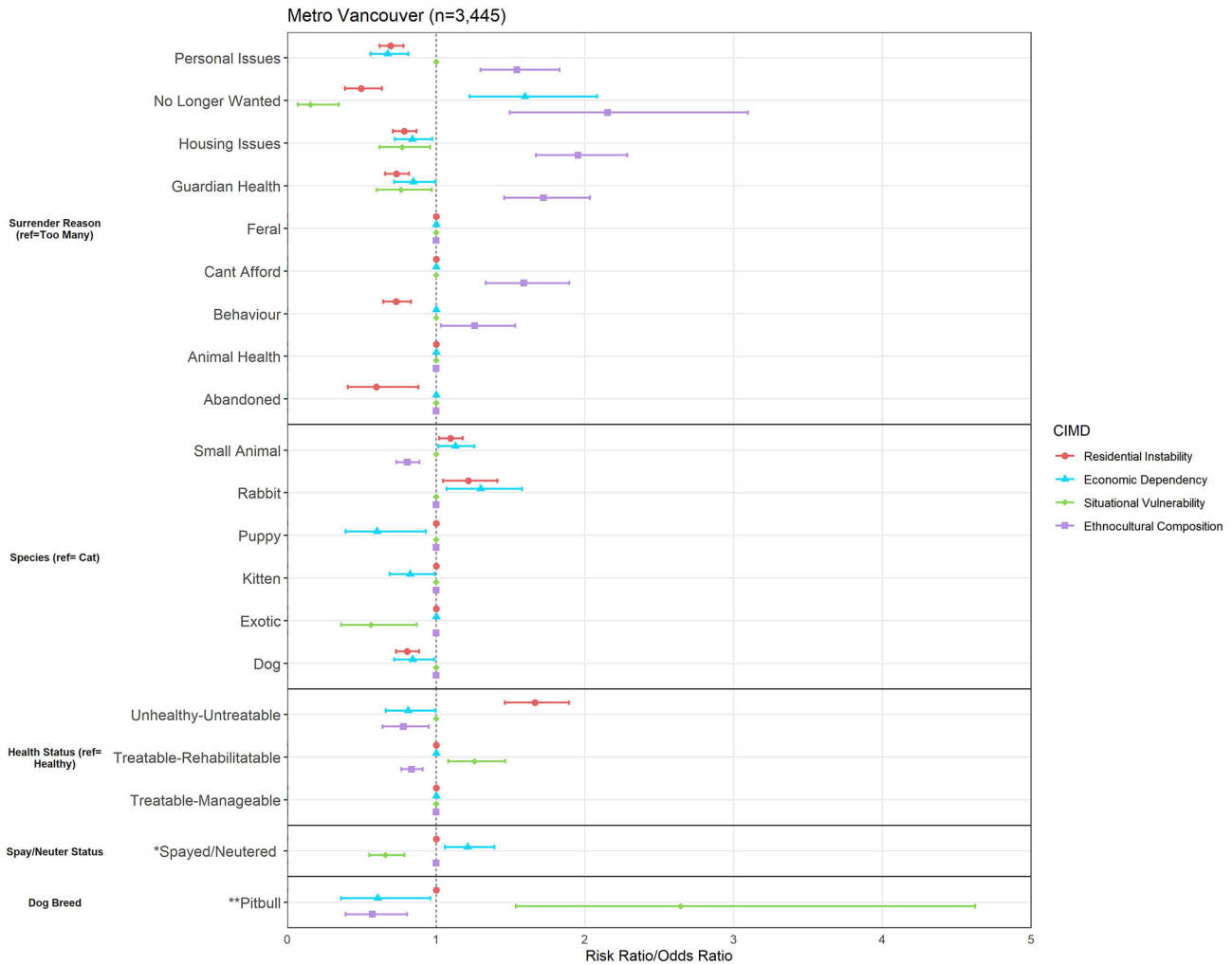

FIGURE 2 | Association between Canadian Index of Multiple Deprivation (CIMD) factors and owner surrender variables across the Metro Vancouver area ($n = 3,445$). Results of logistic regression models for shelter variables by increasing CIMD factors are shown. Data are presented by risk ratios and their 95% confidence interval (bars); $p < 0.05$ when 95% confidence interval does not cross the vertical dotted line. Non-significant results are represented by a risk ratio of 1 with no CI. A risk ratio >1 suggests an increased risk of that shelter variable category as you increase in deprivation, while a risk ratio <1 suggests a reduced risk. *denotes data from dogs, cats, kittens, and puppies only ($n = 2,128$) and is represented in odds ratios (and 95% CI). **denotes data from dogs and puppies only ($n = 609$) and is represented in odds ratios (and 95% CI).

Vancouver, as well as surrounding cities and municipalities. The total number of surrenders from the Metro Vancouver area was $n = 3,445$. Results of the logistic regression models are outlined in **Figure 2**, which demonstrates both similarities and differences from the results of the British Columbia region. Below, we discuss relationships of interest to demonstrate descriptive examples on a geospatial scale.

There were both similarities and differences between the relationships of CIMD and shelter variables for British Columbia and the Metro Vancouver areas. Similar to British Columbia, Ethnocultural Composition predicted increased risk of surrender for various owner related reasons such as being unable to afford the animal (RR = 1.46, 95% CI, 1.26–1.70), issues with guardian health (RR = 1.59, 95% CI, 1.39–1.83), housing issues (RR = 1.70, 95% CI, 1.50–1.93), and personal issues (RR = 1.22, 95% CI, 1.07–1.40). Owner-related reasons for surrender are plotted on a map for all of Metro Vancouver in **Figure 3**.

Similar to all of British Columbia, a relationship was seen between Ethnocultural Composition and decreased risk of surrender of kittens and puppies by 0.82 (95% CI, 0.69–0.99) and 0.60 (95% CI, 0.39 and 0.93) times, respectively. While increased small animal and rabbit surrender was related to Ethnocultural Composition across all of British Columbia, in Metro Vancouver, increased risk of surrender was predicted by increase in Economic Dependency for rabbits by 1.30 times (95% CI, 1.07–1.58) and small animals by 1.13 times (95% CI, 1.01–1.26) in comparison to cat surrender. Increase in small animal and rabbit surrender was also predicted by increased Residential Instability (small animal RR = 1.09, 95% CI, 1.02–1.18; rabbit RR = 1.22, 95% CI, 1.05–1.41), as seen in **Figure 4**.

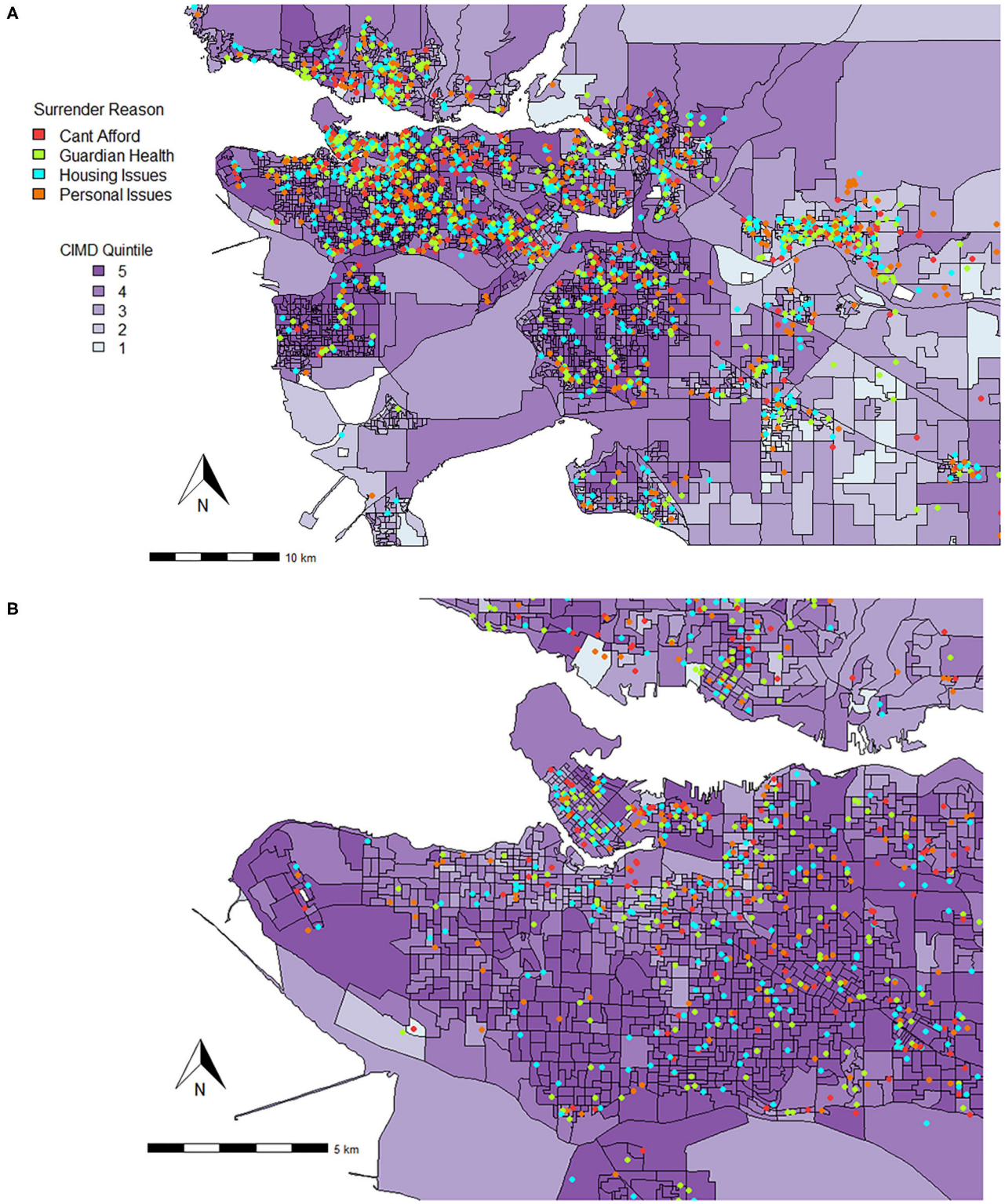

FIGURE 3 | Locations where animals were surrendered for various owner-related reasons for surrender in **(A)** Metro Vancouver and **(B)** the City of Vancouver (September 1, 2016 to August 31, 2020) plotted on top of quintiles for Ethnocultural Composition (1 = least composition, 5 = most composition). The Ethnocultural Composition factor of the CIMD includes indicators such as the proportion of self-identified visible minorities; the proportion of foreign-born population; proportion of recent immigrants; and proportion of linguistically isolated population (no knowledge of either official language). While each point shows the dissemination area of origin, it does not represent the true address.

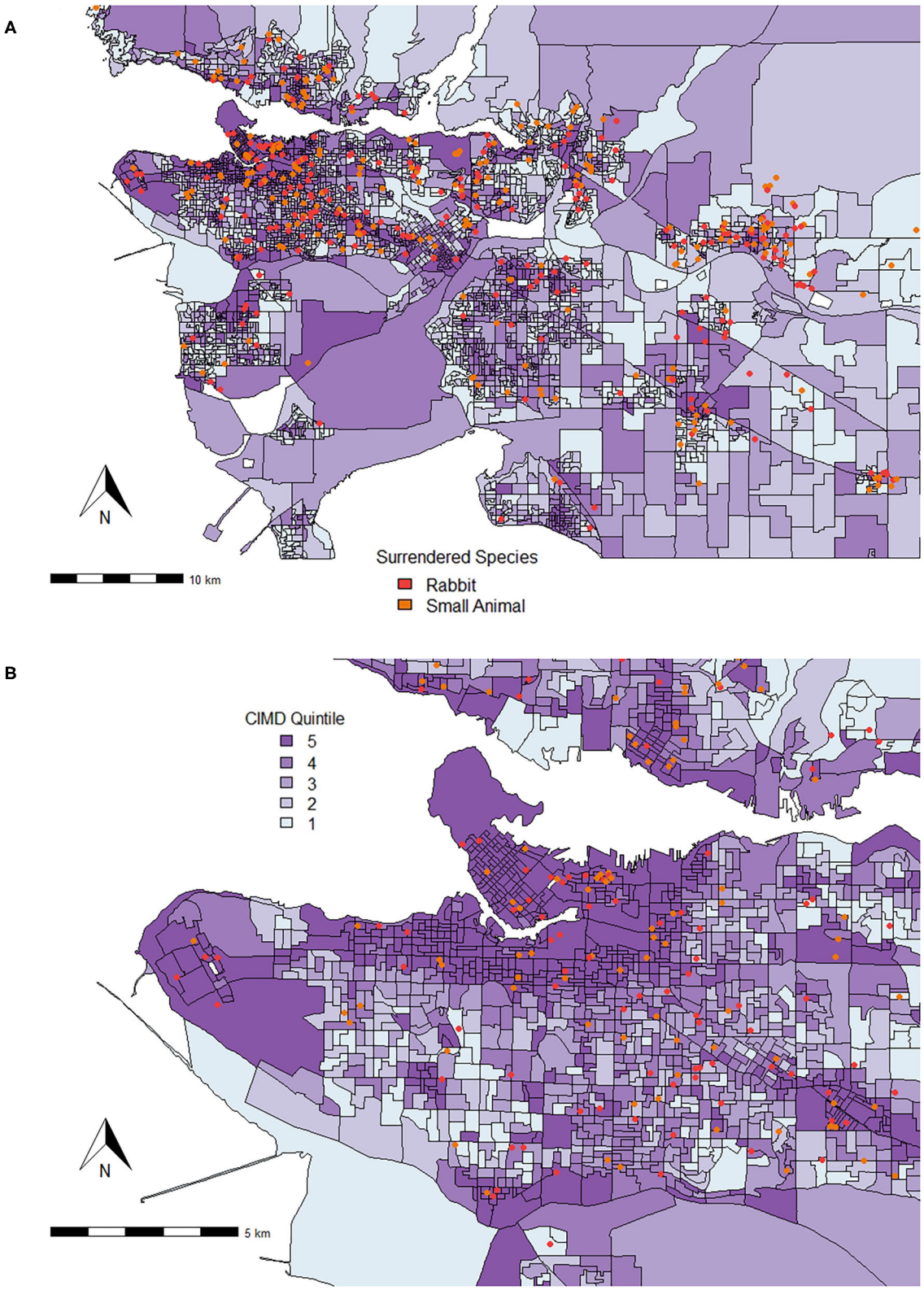

FIGURE 4 | Locations where small animals and rabbits were surrendered from in **(A)** Metro Vancouver and **(B)** the City of Vancouver (September 1, 2016 to August 31, 2020) plotted on top of quintiles for Residential Instability (1 = least instable, 5 = most instablr). The Residential Instability factor of the CIMD includes indicators such as the proportion of apartment dwellings; the proportion of persons living alone; the proportion of rented dwellings; and the proportion of population that has moved in the last 5 years. While each point shows the dissemination area of origin, it does not represent the true address.

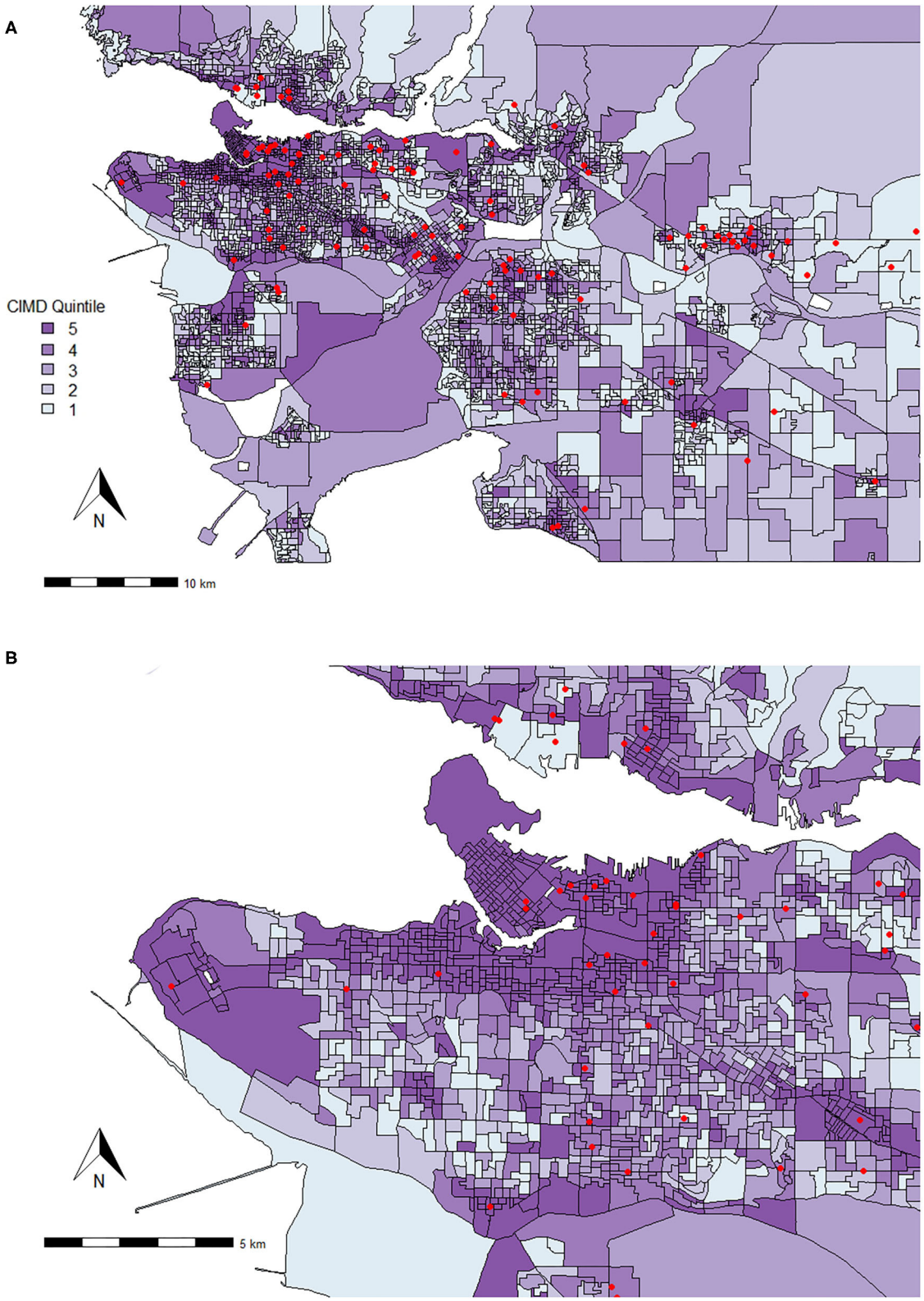

FIGURE 5 | Red dots represent locations where animals scored Unhealthy-Untreatable were surrendered from in **(A)** Metro Vancouver and **(B)** the City of Vancouver (September 1, 2016 to August 31, 2020) plotted on top of quintiles for Residential Instability (1 = least instable, 5 = most instable). The Residential Instability factor of the CIMD includes indicators such as the proportion of apartment dwellings; the proportion of persons living alone; the proportion of rented dwellings; and the proportion of population that has moved in the last 5 years. While each point shows the dissemination area of origin, it does not represent the true address.

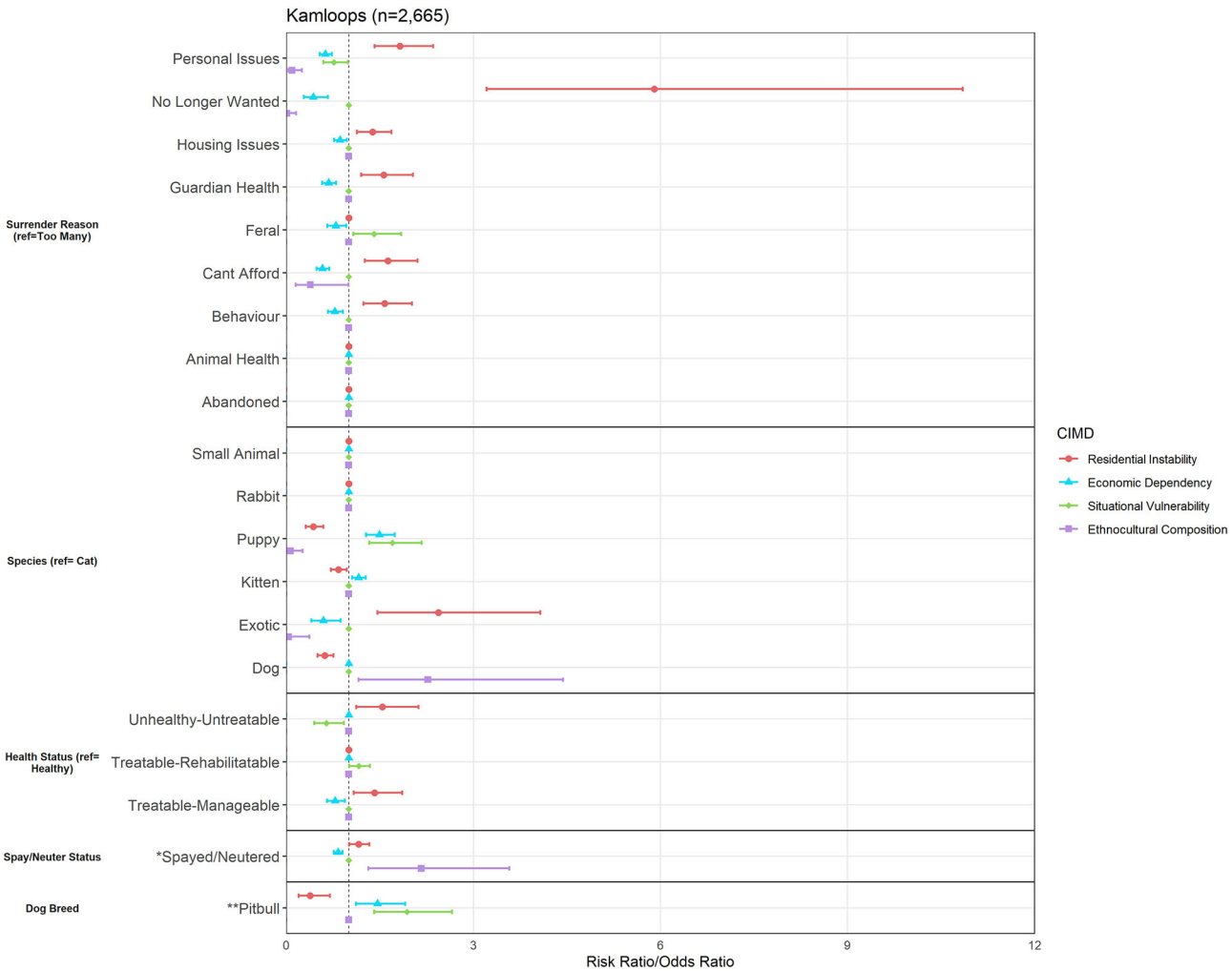

FIGURE 6 | Association between Canadian Index of Multiple Deprivation (CIMD) factors and owner surrender variables across the city of Kamloops and surrounding area ($n = 2,665$). Results of logistic regression models for shelter variables by increasing CIMD factors are shown. Data are presented by risk ratios and their 95% confidence interval (bars); $p < 0.05$ when 95% confidence interval does not cross the vertical dotted line. Non-significant results are represented by a risk ratio of 1 with no CI. A risk ratio >1 suggests an increased risk of that shelter variable category as you increase in deprivation, while a risk ratio <1 suggests a reduced risk. *denotes data from dogs, cats, kittens, and puppies only ($n = 2,548$) and is represented in odds ratios (and 95% CI). **denotes data from dogs and puppies only ($n = 657$) and is represented in odds ratios (and 95% CI).

Notably, a one-unit increase in Residential Instability increased risk of surrendering an animal with an Asilomar Accords category of Unhealthy-Untreatable compared to healthy by 1.66 times (95% CI, 1.46–1.89), which is shown geospatially across Metro Vancouver in **Figure 5**.

Lastly, in Metro Vancouver, a one-unit increase in Situational Vulnerability increased odds of surrendering a pit bull-labeled dog by 2.6-fold (95% CI, 1.54–4.63). However, this relationship had too few points to be meaningfully visualized on a geospatial scale.

Kamloops

The Kamloops area was subset to include any owner address that fell in between latitudes of 50.20–51.00 and longitudes of −121.50 to −119.00. This area includes the city of Kamloops, as well as surrounding municipalities. Across all 4 years, the total number of surrenders from the Kamloops area was $n = 2,665$. **Figure 6** outlines the results of the logistic regression models from the Kamloops area. Below, we discuss relationships of interest to demonstrate descriptive examples on a geospatial scale.

Again, our analysis found both similarities and differences between the Kamloops area and the previously described areas of interest. In Kamloops, Residential Instability was the factor most related to various owner-related reasons for surrender, as it predicted increased risk of surrendering animals for personal issues by 1.82 times (95% CI, 1.41–2.35), housing-related issues by 1.38 times (95% CI, 1.13–1.69), being unable to afford the animal by 1.63 times (95% CI, 1.26–2.10), and guardian health issues by 1.56 times (95% CI, 1.20–2.03), in comparison to the reason of having too many animals. These owner-related

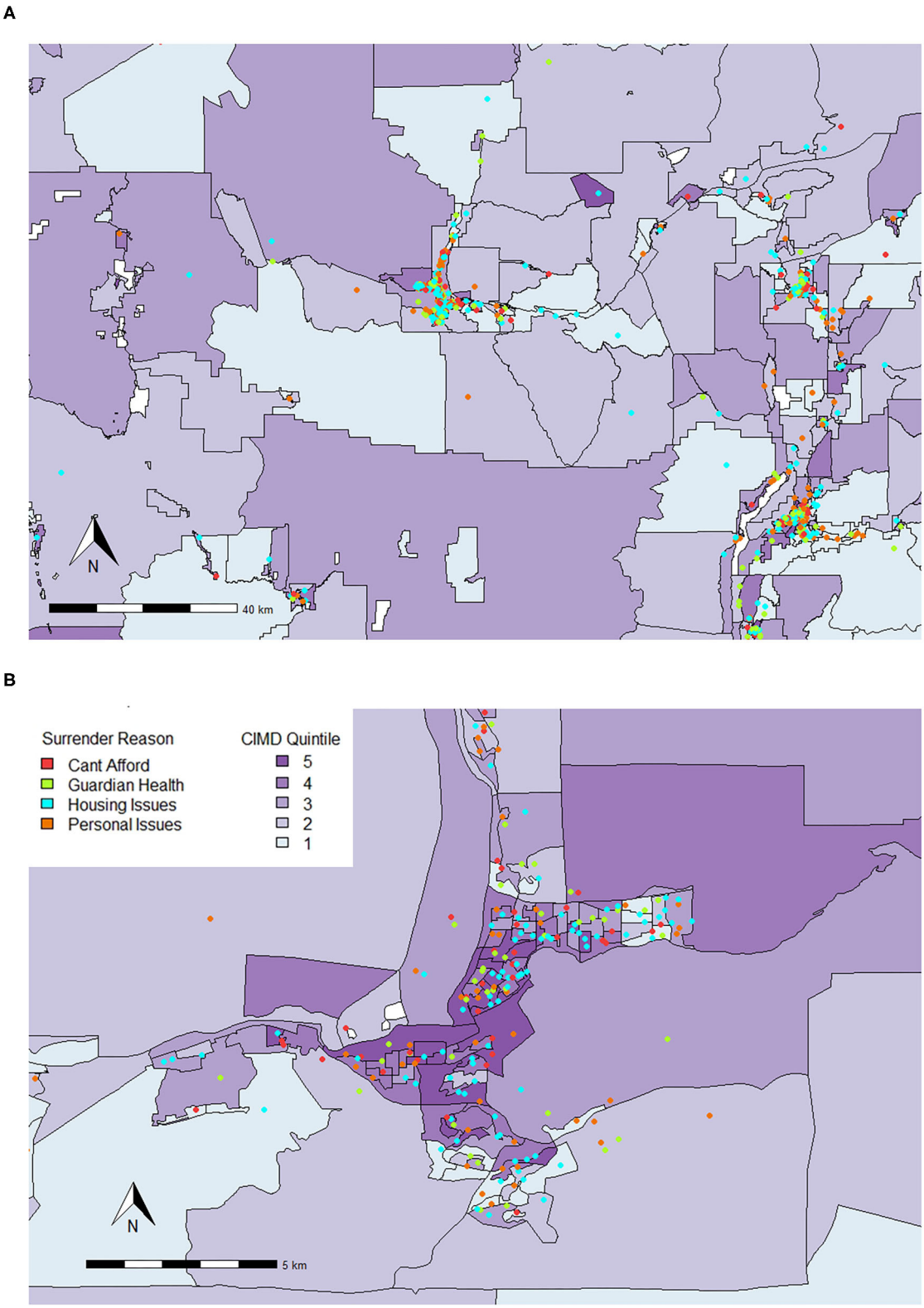

FIGURE 7 | Locations where animals were surrendered for various owner-related reasons for surrender in **(A)** Kamloops and the surrounding area and **(B)** the City of Kamloops (September 1, 2016 to August 31, 2020) plotted on top of quintiles for Residential Instability (1 = least instable, 5 = most instable). The Residential Instability factor of the CIMD includes indicators such as the proportion of apartment dwellings; the proportion of persons living alone; the proportion of rented dwellings; and the proportion of population that has moved in the last 5 years. While each point shows the dissemination area of origin, it does not represent the true address.

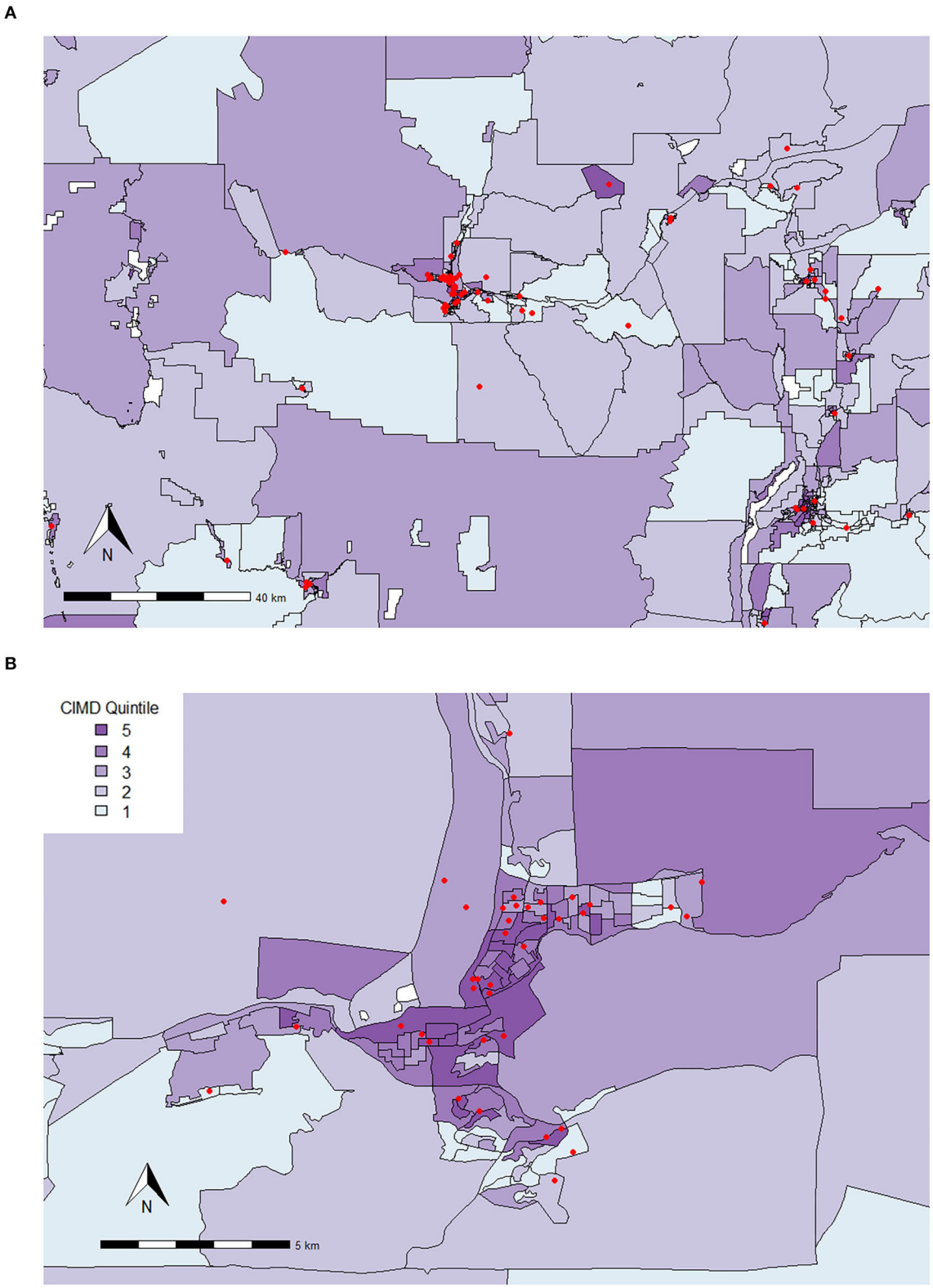

FIGURE 8 | Red dots represent locations where animals scored Unhealthy-Untreatable were surrendered from in **(A)** Kamloops and surrounding areas and **(B)** the City of Kamloops (September 1, 2016 to August 31, 2020) plotted on top of quintiles for Residential Instability (1 = least instable, 5 = most instable). The Residential Instability factor of the CIMD includes indicators such as the proportion of apartment dwellings; the proportion of persons living alone; the proportion of rented dwellings; and the proportion of population that has moved in the last 5 years. While each point shows the dissemination area of origin, it does not represent the true address.

reasons are plotted geospatially across the Kamloops area in **Figure 7**.

Unlike British Columbia and Metro Vancouver, there was no relationship between any of the CIMD factors and risk of surrendering small animals and rabbits. Both Situational Vulnerability and Economic Dependency predicted increased risk of surrendering puppies by 1.70 (95% CI, 1.33–2.17) times and 1.49 (95% CI, 1.28–1.74) times, respectively (in comparison to cats). Residential Instability predicted decreased surrender of puppies (RR = 0.43, 95% CI, 0.31–0.60) and kittens (RR = 0.83, 95% CI, 0.71–0.97), but increased risk of surrendering exotic animals by almost 2.5 times (RR = 2.43, 95% CI, 1.46–4.07).

Similar to Metro Vancouver, a one-unit increase in Residential Instability predicted increased surrender of Unhealthy-Untreatable animals by 1.54 times (95% CI, 1.12–2.11) compared to surrender of Healthy animals. For comparison with the Metro Vancouver area, this relationship is plotted across the Kamloops area in **Figure 8**.

Another similarity between Kamloops and Metro Vancouver was related to pit bull-labeled dogs. A one-unit increase in Situational Vulnerability increased odds of surrendering a pit bull-labeled dog by almost 2-fold (OR = 1.94, 95% CI, 1.41–2.66). As with Vancouver, there were too few points to represent this meaningfully on a geospatial scale.

DISCUSSION

Our study found multiple relationships between human deprivation and animal relinquishment across British Columbia. Exploratory analysis of multiple human and animal related factors allowed us to assess social determinants impacting animal relinquishments on a broad scale, which can be used to inform further research in areas of human and animal welfare. The present study is among the first to explore owner surrender data based on human vulnerability, and part of the growing literature using geospatial analysis to visualize these relationships on a community scale.

Our study found that higher Ethnocultural Composition scores predicted increased surrender for multiple owner related reasons, including guardian health issues, housing issues, personal issues, and being unable to afford the pet. Racialized and immigrant populations have been previously linked to these reasons for surrender. The term racialized is used in Canada to replace terms such as "visible minority," in recognition that race is a social (not biological) construct and that in some parts of the country, former "minority" populations now comprise a majority (27). For example, Canadians that identify as an ethnic minority are shown to be at higher risk of various poor physical and mental health variables (28, 29). Immigrants to British Columbia report difficulties in finding housing due to unfamiliarity with the Canadian housing system and unexpectedly high costs (30). Vancouver neighborhoods with more homogenous minority populations were found to have higher prices (31), which possibly puts racialized populations at higher risk of housing-related surrender issues. Indeed, racialized and immigrant populations may face adversities that increase risk of companion animal surrender for owner-related issues.

Furthermore, while previous studies often investigated surrender of dogs or cats, our results indicate that further investigation is needed among all species and age groups. Greater Ethnocultural Composition increased risk of surrendering kittens, puppies, rabbits, and small animals compared to adult cats. Studies surrounding differences in race or ethnicity and animal ownership are lacking, particularly with different species of companion animals. Applebaum et al. (32) reported 70.4% of White Americans owned pets compared to 29.0% of African Americans, 60.0% of Latin Americans, and 33.0% of all other races/ethnicities. Previous studies have found variation in attitudes toward animals and animal ownership based on cultural or ethnic group membership (33, 34). A Dutch study found that self-identified ethnic minorities kept pets less frequently, and owned atypical companion animals such as fish and birds more frequently (35). However, it would be relevant to further investigate cultural differences of pet ownership in Canada, since differences in deprivation are expected based on different composition of the ethnic populations compared to the United States [such as lower population of Latin Americans in Canada; (36)]. While pet ownership occurs in virtually all cultures globally, it is relevant to explore the differences in experienced barriers between cultures in order to better understand relinquishment of animals from racialized households and provide useful support.

The Situational Vulnerability dimension of the CIMD represents variation in socio-demographic conditions across education, income, and housing. In British Columbia, indicators that contribute to Situational Vulnerability included low educational attainment; low income; single parent families; housing needing major repair; and proportion of Indigenous population. Previous studies have assessed the relationship between income and pet ownership. For example, a Brazilian survey found that higher income households were more likely to own dogs compared to lower income households, but there was no difference in likelihood of cat ownership or number of animals owned (37). A study in the Netherlands found that animal owners tended to have higher incomes than non-owners (38). Our study found that Situational Vulnerability in British Columbia was related to various risks, such as surrendering litters (kittens or puppies). The relationship between income and unwanted litters has previously been investigated, and has led to the creation of low-cost spay/neuter clinics (39).

The Situational Vulnerability factor also includes the proportion of Indigenous peoples in a dissemination area. Indigenous peoples face higher rates of social and health deprivation including increased poor health variables, poverty, inadequate housing, and discrimination (40). Research shows that companion animals are culturally important for Indigenous communities, and pet ownership plays an important role in the social facilitation of Indigenous youth in Canada (41). However, underserved Indigenous communities are also at higher risk of zoonotic diseases from domestic dogs, and many struggle with dog population management due to rural locations and lack of access to veterinary care (42). There are some Indigenous groups

for which veterinary medical procedures (e.g., surgically altering dogs, vaccination, and deworming) are not culturally acceptable (42). As well, Indigenous communities are not homogenous in nature with relation to animal ownership (43). An estimated 44% of Canada's Indigenous population resides in urban areas (44). Therefore, it is possible that issues with access to veterinary services are not always geospatial, but perhaps temporal or financial, as examples. Issues with Indigenous access to care may have been reflected in our study, as Situational Vulnerability was associated with population issues such as surrendering for having too many animals, surrendering litters, and surrendering sexually intact animals.

The Economic Dependency dimension is related to dependence on sources of non-employment income. This includes measures such as the proportion of population aged 65 and older, unable to work (<15 years old), and the proportion of the population that is unemployed. Economic dependency also indicates presence of two possible age groups—adolescents and seniors. From a health perspective, pet ownership in adolescence has been shown to improve psychosocial development [for a review, see (10)]. In seniors, pet ownership can improve loneliness, social engagement and physical activity, among other benefits [for a review, see (45)]. The aging population also faces unique difficulties with pet ownership, such as being unable to bring their pet to care homes or having to find care for the pet while dealing with health issues (46). However, our study was not congruent with previous findings, as Economic Dependency reduced risk of surrendering for owner-related reasons compared to having Too Many animals.

Although the Economic Dependency dimension deals with mainly employment-related measures, increase in Economic Dependency predicted *decreased* risk of surrendering for reasons of being unable to afford the pet. However, across British Columbia, an increase in Economic Dependency predicted increased risk of animals that were not considered healthy under the Asilomar Accords (Treatable- Rehabilitatable and Treatable-Manageable) and also predicted increased risk of surrendering intact animals. Risk of poor health status and sexually intact animals may also be related to cost, as price/cost has been cited as a reason animal owners do not seek more frequent veterinary care (47).

The Residential Instability dimension encompasses neighborhood fluctuations in terms of both housing and familial factors. Residential Instability predicted increased risk of surrender due to housing issues, which has been cited as a common issue motivating animal relinquishment (11), including with animals other than dogs and cats [e.g., rabbits; (48)]. Factors of Residential Instability have previously been identified as issues in pet ownership [such as being a renter; (49)]. The rising cost of home ownership has led to increased numbers of renters, and in many areas, landlords have significant control of the type, number or size of animals in rental units (50). Accommodating pets when renting means that some owners choose lower quality or higher priced rentals, or even keep pets without approval (51). Housing-related worries, such as living in unsuitable accommodations for a pet, living in an unsafe neighborhood for a pet, or living in a no-pets building, are reported as some of the most significant reasons of non-ownership of pets (8, 52). Indeed, because many pet owners see their animals as "family" (53), the issues of housing and pet ownership are inextricably linked to each other.

Analysis of the Vancouver and Kamloops regions shows that there are geographic differences in the predictive nature of human deprivation on owner surrender factors. These geographic differences are reflected in different CIMD scores between locations. For example, Ethnocultural Composition may differ significantly based on the area. While immigrants prefer to settle in major metropolitan cities (such as Vancouver), this has led immigration policies to encourage immigrants to settle in smaller cities [such as Kamloops; (30)]. This was reflected in our study as Vancouver showed high Ethnocultural Composition scores across most dissemination areas. Metro Vancouver is more urban compared to the area of Kamloops, and pet ownership is greater in rural areas compared to urban (8).

There are also differences between Vancouver and Kamloops that are not directly captured by the CIMD, but may impact pet ownership and surrender. One example of this is the built environment of the cities. In Canada, municipal governments are generally responsible for jurisdiction of park development, including dog parks (54). Previous studies in Canada have found that proximity of off-leash dog parks in a neighborhood impacts dog-walking behavior, which can impact health status of both the owner and the dog (55, 56). However, research shows that built environments of neighborhoods are linked to deprivation factors such as socioeconomic status and racial or ethnic composition (57, 58), so this is likely captured by a similar relationship to CIMD factors.

Our results also showed factors which similarly predicted shelter surrender variables between all three areas of interest. For example, Situational Vulnerability predicted increased odds of surrendering pit bull-labeled dogs compared to all other dog breeds. The term "pit bull" does not correlate to a recognized breed, but instead is a term applied to a heterogeneous group of purebred and mixed breed dogs, although the use of pit bull as a descriptor varies according to observers (59), and dogs are often mislabeled in shelters (20). Despite common visual misidentification, many provinces and states impose Breed Specific Legislation (BSL) that restricts the ownership of pit bull-labeled dogs based on fear of injury to humans (60). Pit bull-labeled dogs have long been associated with racialized populations and poverty (19). Media often shows pit bull-type dogs in relation to aggression and dog fighting (61). While dog fighting originated in Britain, the image of dog fighting in the United States is associated predominantly with low-income Black men (62). The animal welfare field has long had suspicions that BSL is more linked to racism rather than public safety through the transfer of racial stereotypes and stigma [c.f. (63, 64)]. Our findings provide support for the relationship between the relinquishment of pit bull-labeled dogs and socioeconomic status, as Situational Vulnerability was associated with increased risk of surrender for dogs labeled this way by shelter staff.

Companion animal ownership is common, and research has explored the mental and physical health benefits in humans who own companion animals. Several studies compare

health variables for companion animal owners and non-owners and find that those with companion animals have improved health variables such as decreased mental health issues (65), lower risk of heart disease (66) and increase in positive health behaviors (67). Research has found particular benefits of pet ownership in vulnerable populations. For example, youth experiencing homelessness reported fewer symptoms of depression if they owned a companion animal (68). Furthermore, animal relinquishment is a difficult and emotional decision for animal owners (69). Because vulnerable populations may be more at risk of surrendering animals, addressing deprivation could reduce surrender of animals from populations whose health may benefit greatly from pet ownership, as well as reduce the stress associated with the decision to relinquish animals among this population.

The results in our study also indicate that deprivation may be related to lack of access or other barriers in seeking services for companion animals. All four factors were related to risk of either not spaying/neutering the animal or the animal having a health status other than Healthy upon intake. This is in line with previous research in Great Britain, which found that dogs and cats belonging to owners in more deprived areas were less likely to have preventative health care interventions such as being spayed/neutered and being microchipped (70). However, surrendering the animal for reasons of the animals' health was not related to any of the factors of CIMD, demonstrating that these barriers may be experienced but may not be the primary cause of surrender. Reasons such as cost or lack of a regular veterinarian may be barriers to seeking veterinary care (39). Indeed, improving access to veterinary care for low-income and other vulnerable pet owners has been identified as one of the main challenges of veterinarians in Canada (71). There is also an argument to improve access to veterinary care from a public health perspective, which is commonly argued from a One Welfare perspective. For example, zoonotic disease transmission via pets can cause health and economic costs for both humans and animals (72). Underserved communities are less likely to have regular visits with a veterinarian, and thus are less informed about zoonotic disease risks (73). The literature regarding access to veterinary care parallels the research in human healthcare, which perhaps indicates a One Welfare connection for families with companion animals. For example, increased risk of oral disease in children is associated with race (e.g., Black and Mexican Americans) and income (living below the poverty level) in the United States (74). The similarities between lack of access to veterinary care and health care demonstrate the impact of deprivation on human and non-human animal family members. Further research could investigate access to both human and animal services in communities to determine the impact of multiple deprivations on families.

Due to the relationships between human deprivation and lack of available animal-related services, the results of our study support improving provision of services to both humans and companion animals to decrease risk of surrendering for deprivation-related reasons. Examples of services which address both human and animal welfare have shown success. For example, households facing food insecurity reported highly valuing having pet food available in their food banks, and were reluctant to surrender animals if this food became unavailable, instead agreeing that they would share human food with their companion animals (75). As previously mentioned, the implementation of free or subsidized spay/neuter clinics both alleviates cost-related concerns of veterinary care (76), but can also improve welfare of the animal, as previous studies have found that spay/neuter clinics can reduce rates of intake in shelters (77). As well, the evidence of pet ownership and health benefits in aging adults has led to the development of programs like the TigerPlace Pet Initiative (TiPPI), a senior living facility that is pet-inclusive and provides veterinary care, foster care, and adoption services for the residents (78). Weiss et al. (79) found that dog owners reported that interventions such as low-cost dog support (e.g., training or veterinary care), temporary boarding, and pet-friendly housing may have helped them retain their pets. These initiatives follow principles of the One Welfare framework, as providing services for the animals ultimately improve human well-being through retention of a companion animal, reduction of stress related to costs of owning an animal, or reducing risk of zoonotic disease transmission (6). Our study also shows that owner-related deprivations increase risk of surrendering animals to shelters, indicating a need for owner-related interventions to keep pets in their homes. However, our study identified other human-related social issues in risk of relinquishment to shelters, such as ethnicity, housing insecurity, and Indigenous status which would benefit greatly from further research to identify appropriate support interventions.

There are some notable limitations to our study. The shelter data were limited to a single reason for surrender, although relinquishment of pets has been identified as a complex and multifaceted decision (80). Previous studies found that owners may misreport reasons for surrender when undergoing the difficult decision to relinquish their animal due to social desirability bias (81). For example, an owner may report a behavioral issue in the animal to avoid admitting being unable to take care of the animal. Similarly, shelter staff may report reasons for relinquishment differently based on location, based on internal bias of staff members, or based on differing definitions between the animal owner and staff. This limitation has been identified in previous literature (11, 81), although it may be more relevant as our data was taken across multiple shelter locations with varying staff.

One possible limitation of using the CIMD is that it reflects deprivation relative to the pet owners' location rather than the current status of the individual owner. However, some of the factors used to calculate individual dimensions, such as proportion of apartment dwellings, are characteristics of the dissemination areas that are calculated independent of individual socioeconomic status. Furthermore, the CIMD is calculated in the smallest unit of area for which all census data is collected, meaning this data is the most specific form of measurement of social vulnerability for geospatial comparison across the whole province. Thus, we believe that the CIMD is a valuable proxy to represent general socioeconomic status for the individuals, as it is

likely that individuals living in the same area share similar factors of deprivation (70).

Finally, although the CIMD represents social facets that are likely to relate to vulnerability of communities, some factors leave more room for interpretation than others. For example, the Economic Dependency factor uses indicators that include age demographic of an area, including those who are over 65. Economic Dependency could be high in retirement communities with a high population of over 65 residents (who may be affluent), or high in other communities with families that have children that are <15 years old. Our study found that, across British Columbia, Economic Dependency predicted decreased risk of surrender for multiple owner-related reasons for surrenders, which could be due to the indicators of this CIMD factor. For further research, it may be helpful to distill the more straightforward elements of the CIMD, or more specific census data of interest (e.g., income, rental housing) that have *a priori* predictions related to animal surrender.

CONCLUSION

Our analysis showed that, from 2016 to 2020, various dimensions of the Canadian Index of Multiple Deprivation (CIMD) were related to risk of animal relinquishment based on animal shelter variables such as owner-related reasons for surrender, species, health status, and breed, to the British Columbia Society for the Prevention of Cruelty to Animals. The use of geospatial analysis identified differences in deprivation and animal relinquishment risks for different geographic areas within the province of British Columbia. Identifying CIMD dimensions which are associated with shelter intake data does not necessarily imply a causal association. However, the results of this study can be used to inform shelter or community-based interventions. Viewed through a One Welfare lens, people experiencing vulnerability benefit from continued pet ownership—supporting retention of animals and understanding factors that lead to surrender is valuable at both the shelter and community level. To reduce relinquishment of animals to shelters and to keep animals with their owners, a focus on identifying and providing support for vulnerable populations is relevant.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of British Columbia Behavioral Research Ethics Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

LL, EG, and AP contributed to the conception of the study and subsequent study design. LL acquired and organized the database and wrote the first draft of the manuscript. LL and AP performed statistical analysis. All authors contributed to the manuscript, further revisions, and approved the final version of the manuscript for submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2021.656597/full#supplementary-material

Supplementary Data Sheet 1 | Ly et al. Code. Github link for access to R code used to analyze the relationship between human deprivation and animal surrender in British Columbia.

Supplementary Data Sheet 2 | Ly et al. Data File. Owner surrender to BC SPCA shelters from September 1, 2016 to August 31, 2020.

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Social Enterprise as a Model to Improve Live Release and Euthanasia Rates in Animal Shelters

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This paper explored the role that social entrepreneurship may play in helping to improve euthanasia and live release rates in animal shelters. This paper used a qualitative, comparative ethnographic study that included semi-structured interviews, participant observation, and archival research. It compared two large animal shelters from the U.S. and Australia. Collectively, 21 formal interviews, more than 30 informal interviews, and participant observation were conducted over a 6-month time frame between the two countries. Findings indicate that three main factors may contribute to the transformation of non-profit animals shelters and result in improved euthanasia and live release rates, as well as animal caregiver burnout. These include: (1) professionalizing shelter management, (2) engaging with non-profit social enterprise activities, and (3) improving the efficiency of daily operations. In this paper, we argue that by embracing non-profit social enterprise activities, animal shelters may improve anthropocentric animal shelter activities to positively affect human and non-human rights, welfare, and agency. We do not contend that non-profit animal shelters should sacrifice their stated mission or ethics to include business practices. Rather, by professionalizing management and operations that include self-sustaining diverse revenue streams, it may free up time and resources to make a greater effect in positive non-human animal welfare and outcomes.

Keywords: live release rate, euthanasia, animal shelters, social entrepreneurship, multispecies livelihoods, animal welfare, non-profit organizations/sector, human-animal studies

INTRODUCTION

Euthanasia rates of healthy adoptable dogs (*Canis lupus familiaris*) and cats (*Felis catus*) in the U.S. remain staggeringly high, with ∼670,000 dogs and 860,000 cats destroyed annually (1). However, over the past decade, an encouraging trend in companion animal Live Release Rate (LRR) statistics transpired in the United States and Australia (1, 2). "The Asilomar Accords defines LRR as the proportion of animals leaving the shelter alive among those that experience an outcome" [(3), p. 120]. The number of dogs and cats entering U.S. animal shelters each year significantly

declined over the last decade, with ∼6.5 million dogs and cats entering U.S. shelters in 2019, down 9.7% from an average of 7.2 million in 2011 in the U.S. (1). Similarly, U.S. euthanasia rates declined from ∼2.6 million in 2011 to 1.5 million in 2019.

Australia was chosen as a comparison for this study for its similar improvements in LRRs during the same time period (2011–2019), and for its even greater reduction in euthanasia rates. In Australia, the RSPCA is the largest provider of animal shelter care and reported an intake of only 85,033 dogs and cats in 2018–2019 (4), compared to 107,900 in 2011–2012. The result of a 21.2% decrease (5). In 2018–2019, dog euthanasia rates were 12.72% and cats of 22.94% (4), down from 25.6% for dogs and 47.1% for cats in 2011–2012 (5). This was largely credited to a decline in dog intake numbers, from 55,563 in 2011–2012 (5), to 33,863 in 2018–2019, though cat intakes in RSPCA shelters hovered above 50,000 annually (4).

Previous research suggests that these improvements occurred due to human education (6, 7), spay and neuter programs (8), and the transferring of non-human animals from shelters to rescue organizations that create more space and capacity to assist companion animals (9, 10). Other potential factors include improved data collection and sharing between the animal shelter and welfare groups (11), holding off-site adoption events (12), and a general improvement in positive attitudes toward non-human species in society over the past 40 plus years (13–15). In this paper, we contend that professionalizing shelter management, engaging with non-profit social enterprise activities that generate self-sustaining revenue by selling goods or services (e.g., retail operations, selling data software, etc.), and improving the efficiency of daily operations has contributed to more positive human perceptions of companion animals, decreased animal caregiver burnout, and improved LRRs at animal shelters. We first review the literature related to changing human perceptions of non-human animals, profiling animal shelter workers and caregiver burnout, and non-profit social enterprises related to animal shelters before describing our methods and findings from a cross-country comparison study of two large animal shelters, one from Australia and the other from the U.S.

LITERATURE REVIEW

Changing Human Perceptions of Non-human Animals

Human-animal studies have focused on the discontinuity of both humans and non-human animals in society, where discourse has shifted to concentrate on animals as mutually beneficial components for both human and non-human societies (16–21). Contemporary human-animal studies are most broadly understood as the examination of interactions among human and non-human animals, emphasizing the expression of non-human agency (22–24). In her seminal book, "*Animals in Society: An Introduction to Human-Animal Studies,*" DeMello (25) considers the conceptual construct of non-human animals within the Euro-American cultural context and the ways it reinforces and perpetuates hierarchical human relationships. Govindrajan (23) utilizes a multispecies ethnographic framework to deconstruct the entanglement of various theoretical concepts (e.g., interspecies relatedness), suggesting that non-human animals have a profound influence on shaping the relationship with human societies through agency, intention, and emotional capacity.

Applied ethology explores animal behavior and welfare of domesticated animals including companion animals (26). Findings center on positive and negative ramifications of human influences, with a strong argument against such concepts as behaviorism and operant conditioning due to their stresses on anthropomorphic hierarchical assumptions that neglect to view non-human animals as agents that co-create mutually beneficial relationships (27). However, in their study of wildlife-human perspectives in modernized countries, Manfredo et al. (15) contend that anthropomorphizing non-human animals, or seeing non-human animals as more human-like, has contributed to pro-non-human animal societal shifts due to power-based domination perspectives giving way to mutualism orientations, "Individuals with strong mutualism orientations would consider wildlife as part of their broader social community, deserving of rights and caring treatment" (p. 2).

Profiling, Animal Shelter Workers, and Caregiver Burnout

In an attempt to better understand adoption and euthanasia rates, multiple studies examined the potential variables causing certain dogs and cats to be adopted over others. Hill and Murphy (28) employed linear regression models to determine that "dog size, personality, behavior, and level of obedience training" contributed to individual adoption success. A similar study focusing on the length of stay at two "no-kill" animal shelters in New York, showed a direct correlation between the age of the animal and time spent at the facility, where positive outcomes are more likely for puppies than other animals (29). Leonard (30) conducted an ethnographic study at the Washington Humane Society on the cultural bias toward animals based on color associations and literary traditions in Western cultures. She explicitly described the role of "Big Black Dog Syndrome" (BBDS) where large black dogs of all breeds have a difficult time being adopted and are typically the most likely to be euthanized. However, Sinski et al. (31) tested BBDS for its efficacy and found that support for BBDS was mostly anecdotal or theoretical. Data from their study did not support BBDS theory but some shelters still implement strategies such as "applying brightly-colored collars, bows, or bandannas to dark-coated animals" (p. 640), which may suggest positive upticks in adoption rates by making dogs appear more attractive to humans.

Euthanasia affects animal shelter employees and volunteers, leading to burnout and turnover that further increases the costs associated with animal rescue efforts. Anderson et al. (32) surveyed 54 shelter managers across the U.S. where an average of 869 dogs and cats per shelter were euthanized each year. Shelter managers cited emotions of sadness, crying, anger, and depression, which contributed to a 74% employee burnout rate, and 24% turnover rate. "These findings confirm that performing

euthanasia can have serious and problematic ramifications for shelter staff and shelter operations" (p 569). Workers are also at risk of emotional or cognitive distress due to often limited resources (e.g., financial, medicinal, staff) that may hinder the quality of care (33).

Non-profit Social Enterprises

In the U.S., the animal shelter and rescue industry spend an estimated $3.3 to $3.5 billion U.S. dollars annually (34, 35). Research has been conducted in business and management studies on certain aspects of the global consumer pet and veterinarian industries [see McEachern and Cheetham (36), Song and Lim (37), Lemke et al. (38), and Muldowney (39)], but few studies have explored the animal shelter industry from a (non-profit) social entrepreneurship lens. This is perhaps surprising for such a large industry with deeply embedded cultural, emotional, and social ties (40). Globally, non-profits and non-governmental (NGOs) charitable organizations are increasingly affected by the reduction of private donations and government funding, as well as increasing competition from evolving market forces (33). In the U.K. alone, estimates conclude that non-profit funding was cut by $2.8B from 2010 to 2016, deeming it the "Great Recession" for charitable organizations (41–43).

In response, non-profits and NGOs are beginning to reshape the way they conduct business. Ko and Liu (43) emphasize three domains a non-profit can engage to become more financially sustainable and transform into a social enterprise: (1) enact commercial revenue streams, (2) create a professional organizational form, and (3) legitimize a social-commercial business model. Social entrepreneurship (SE) refers to "using social innovations that leverage entrepreneurship to create social value, in a sustainable and market-oriented triple-bottom-line approach" [(44), p. 202], that focuses on social, economic, and environmental justice. Social enterprises are predominantly identified within the non-profit sector [see Fowler (45), Taylor et al. (46), Anderson and Dees (47), Dees et al. (48), Pomerantz (49), and Nicholls (50)]. Non-profit animal shelters, like universities, often rely on government funding, donations, grants, and nominal (adoption) fees to persist. However, most universities operate as non-profit social enterprises by expanding beyond tuition and fee revenue to sell dining packages, merchandise, tickets to sporting events, housing, etc. Non-profit animal shelters must add revenue-generating activities where they sell a good or service such as operating a café to be considered a non-profit social enterprise.

"Mainstream" SE theory frames the literature toward innovative hybrid business models that consider mission-oriented organizations within a market-based dichotomy [see Alter (51)]. Austin and Seitanidi (52) emphasize cross-sector collaboration that strengthens long-term strategic alliances for non-profit social enterprises (NSEs). Bull and Ridley-Duff (53) contend that ethics should be emphasized in SE and proffer a rules-based framework to moral and political choices for entrepreneurs regarding decisions of economic exchange, legal form, and social value orientation. Non-profit SEs that are adapting to new methods of funding must not only consider what to commodify, but how that commodification ripples throughout society within associative, cooperative, and responsible forms of business (53). While Alters' (51) typology of social enterprises provides practitioners a method to analyze multiple models for market exchange and scalability, non-profit social enterprise animal shelters must also consider the non-human animals in their care.

The issue that then arises is how to commodify, professionalize, and account for organizational change activities within animal shelters without sacrificing the stated mission, or the rights, agency, and welfare of non-human animals (51, 54–56). In the complementary field of wildlife ecotourism (for its intersection of human livelihoods and non-human welfare), Thomsen et al. (57) contend that a multispecies livelihoods approach may help to balance human socioeconomic stressors with non-human animal welfare. They take a post-humanist approach to define multispecies livelihoods as "the right for human and non-human animal species to not only exist but to secure the necessities of life in a manner that does not infringe on another species' right to live except for sustenance hunting or legitimate safety concerns to foster optimal conditions for wildlife-human coexistence" (p. 4). We argue here that non-profit animal shelters can transform into social enterprises to remain financially solvent while staying true to their stated mission of rescuing and caring for non-human animals and improving LRRs.

METHODS

This comparative, qualitative study investigated how a large U.S. animal shelter and a similar-sized Australian animal shelter made significant improvements in their LRRs since 2011, and questioned how their relative successes could be replicated, if at all, and under what conditions. This study leveraged an inductive critical philosophical assumption that employed a bottom-up approach, imperative to understand the context that actors face (58). The study was conducted in an Intermountain West, U.S. city, where local governments contract out the largest non-profit animal shelter to assist with efforts in animal rescue, fight cruelty and abuse, run prison dog training programs, as well as manage daily operations to take care of homeless companion animals (59). They receive an average of 41 new animals daily totaling nearly 15,000 dogs and cats per year, in an area with a human population of fewer than 1,000,000 people. The humane society in Australia is also considered to be the largest in its state and handled more than 56,000 animals in the fiscal year 2017–2018, in an area with an estimated population of more than 6,000,000 people. From here forward, the U.S. Intermountain West humane society will be referred to as the U.S. Animal Shelter, and the Australian based one will be referred to as the Australian Animal Shelter.

Data Collection

Research was conducted in Australia by the first two authors, and in the U.S. by the first three authors. The two shelters were selected for comparison based on their similarities in terms of the shelter's size and inclusion of social enterprise activities. Other shelters could have been selected, but logistical access to conduct

the research was also a factor to make the study feasible for the researchers. Documents (online and internal publications shared with the authors) provided comparative insight. Over a 2-week period, 10 semi-structured interviews and brief participant observations were completed in Australia. Over the following 6 months, 11 interviews, along with participant observation (volunteering, job shadowing), took place in the US. For example, participant observation included the researchers volunteering on a marketing campaign for a major fundraising event in the U.S., observing volunteer coordinators as they performed daily tasks, cleaning out kennels and walking dogs while speaking with staff and volunteers, observing surgery, and assisting with light administrative duties. Though similar activities were conducted during the limited time in Australia, the researchers assisted the U.S. shelter two to three times per week over the 6 months. Field notes were handwritten at the end of each day, which provided the researchers an opportunity to reflect on past observations and perceptions during and after the study to help analyze the context of working in a shelter environment.

Each of the 21 formal interviewees were full-time paid employees, part of the administrative staff, and ranged in responsibility from volunteer coordinator to executive director. More than 30 additional informal interviews took place while volunteering and conducting participant observation with workers and volunteers at the shelters. Collective demographic information of the formal interviewees included age ranges from 27-64, where 15 were female and 6 were male. Nineteen had at least a bachelor's degree, 10 had a graduate degree, and all had been with their respective organizations between 2 and 12 years.

Data Analysis

All participants were anonymized to protect identities and foster candid responses. All interviews were digitally recorded and transcribed to ensure accuracy. All authors coded, categorized, and analyzed responses thematically resulting in three key themes, with saturation reached prior to the conclusion of interviews. The Central Queensland University Ethics Committee approved this study (Application Number 0000020941).

FINDINGS AND DISCUSSION

Three key themes emerged from the interviews and are presented in **Table 1** below. These themes include: (1) Professionalizing shelter management, (2) Engaging with non-profit social enterprise activities, and (3) Improving the efficiency of daily operations.

Key Findings Theme #1: Professionalizing Shelter Management

The Australian and U.S. Animal Shelters transformed their management approach to become more professional and efficient in daily operations. They embraced a non-profit social enterprise model to expand revenue streams such as selling products that included animal shelter tracking software, and pet food and supplies through retail stores, to not solely rely on fluctuating donations and grants. This was accomplished through targeted internal measures such as raising the quality of work expectations for current employees and targeting well-qualified hirees, with external measures of engaging stakeholders through community involvement activities, maintaining an active online social media presence, and building relationships. Other key changes included shifting executive and full-time staff compensation incentives from funds raised to mission-stated outcomes, holding regular employee evaluations, creating development and growth opportunities (personal and advancement) where employees could earn raises and bonuses, and hiring human resource managers with corporate experience to establish clear professional conduct and communication expectations.

In 2011–2012, both shelters proactively reorganized professional standards and expectations amongst current employees. Volunteers were previously managed by another volunteer, and there was little structure or oversight regarding volunteers' work, schedules, and expertise. Volunteer coordinators were hired into paid administrative roles to streamline volunteer operations, hold volunteers accountable, and generate increased in-kind and monetary donations. Each shelter developed a small fee training session for first-time volunteers in order to improve the quality of work and establish buy-in. Once a volunteer reached ∼80–100 h of time donated, they would be recruited to participate on more complicated projects such as working with shy dogs, training other volunteers, or helping to coordinate targeted high-donor outreach. The volunteer coordinators tracked more than 1,000 volunteers' hours and used these data to demonstrate improved outcomes to large donors, resulting in increased amounts and frequency. Volunteers who "stood out" were recognized in monthly newsletters, and even led to job opportunities for some. It no longer became acceptable to operate under conditions where a passion for animals solely drove decision making. At each shelter, human resource officers and executive leadership emphasized professional working criteria that included: opportunities for leadership positions, a safe work environment, accountability, performance reviews, and pathways for employees to build a career within the organization. Respondent #1 depicted the more efficient approach to hiring:

> We've got a talent management approach. So we try to invest in our best people. We profile the workforce around fit into different areas. Whether you're a high performer, a mediocre performer, poor performer, and you're treated in different ways based on how you slot into that organizational workforce profile. We invest in our really good people... I would say that there's no way you would have been able to bring a high-quality applicant into what we had previously. I just don't think they would have stuck around. But it's putting in place new leadership abilities, capabilities, and creating a work environment where high potential successful people can come and build a career with the organization, where previously, that wasn't the case.

Respondent #1 also shared that by increasing professional standards and opportunities for advancement, they were able to hire candidates with higher education and or more experience. Though this resulted in slightly higher salaries, they were able to meet market-based salaries by creating additional revenue

TABLE 1 | Overview of three key themes and related sub-themes.

Professionalizing shelter management	Engaging with non-profit social enterprise activities	Improving the efficiency of daily operations
Key Themes		
• Shelter employee tasks and goals were standardized, and performance standards were enhanced • Employees behave more professionally, improved professional communication, and built trust with stakeholders • Volunteer coordinators were hired to streamline in-kind and monetary donations • High performing employees were retained, and new employees had higher education and or more business experience	• Modern facilities and innovative space-use were integral to positive engagement and perceptions • Diversifying revenue streams was critical to financial sustainability • Retail operations provided a better customer experience resulting in better adoption rates and funds generated • Funds generated through ancillary revenue streams improved positive perceptions of the shelters	• Adaptive management focused on the professional development of staff and creation of leadership roles • Successful workplace culture linked goals of organization to performance • Innovation generated self-sustaining revenue streams to support non-profit efforts • Executive pay was tied to mission-oriented outcomes rather than cumulative donations

streams. Employees hired expressed gratitude that they were able to earn a livable wage while also being passionate about helping animals. This fostered a culture of employee satisfaction where multiple respondents felt empowered and valued in their roles.

Clear measures around engagement and leadership, variable pay, talent management approaches to human resources, maximal workforce output, and investments in a competitive talent pool reverberated within each organization for operational effectiveness. For example, leadership roles were created to invest in volunteers that saved an estimated ∼$2.5M in labor per year at the Australian Animal Shelter. Programs, databases, and targeted events were all shown to improve performance, which ensured support via donations and awareness. These activities included: improved volunteer onboarding training; paired volunteer mentoring where a volunteer with 80–100 plus h trained new volunteers; volunteer hours, expertise, and demographics were tracked at the individual level in excel databases that facilitated consistency on different annual projects or events as the same volunteer worked on the same project; and volunteers could be selected for different events such as gala fundraisers or community "5-km runs" based on the volunteer's interests and expertise. This also led to new organizational partnerships as active volunteers felt appreciated and expressed a desire to "do more," and facilitated discussions between local companies and the shelters that led to major sponsorships and donations. These activities also helped to improve organizational culture, as Respondent #3 articulated:

> One of the biggest problems was between volunteers and staff because of the inattentiveness of our volunteer coordinator at the time. If they [volunteers] had problems, they were going directly to the executive director. That scared staff away. The thinking or the advice was don't talk to volunteers. After the change, we targeted anybody that volunteered more than 80 h and invited them to a meeting to develop volunteer mentors and those groups helped develop our programs.

Organizational strategies were reevaluated, and it was determined that the shelters had to operate more like for-profit businesses to increase productivity, revenue, and trust. The U.S. Animal Shelter also reorganized in a similar fashion. Both shelters stabilized their previously rapid turnover within a couple of years with the hiring of well-educated and experienced employees.

The shelters raised public awareness of their improved shelter management through enhancing their online presence, resulting in public perceptions becoming more positive. Respondent #16 stated:

> We are professional, and we're transparent. And that is how you will keep the trust of other organizations and other businesses that might want to work with you, and also the public.

The shelters began communicating directly with potential adopters through improved social media activity and engagement such as prompt responses during business hours and posting more frequently, and increased adoption rates by providing professional pictures and biographical information about the adoptable pets online. Once at the shelter, the adoption interview and processing paperwork were streamlined to facilitate an easier, more retail-like adoption experience. The shelters also credit their professional transformation for building trust with stakeholders that resulted in improved LRRs and helped each shelter raise between $12 and 14 million U.S. dollars to build new retail-style adoption centers.

Key Findings Theme #2: Engaging With Non-profit Social Enterprise Activities

When the first two authors went to conduct interviews and participant observation at the Australian Animal Shelter, they had to emotionally prepare themselves as they expected to visit what they thought was commonplace shelter infrastructure of animals in cages, invoking images of a prison setting. Though they had heard about "best practices" and newer animal shelters emerging across the animal shelter industry, they had never personally experienced it. The first two authors volunteered in three shelters and visited another 15 over the previous 10 years in the South and Intermountain West regions of the U.S. After taking a tour of the facilities the first author reflected:

> I expected to see heart-wrenching dogs in concrete cages, barking incessantly and the look of fear in their eyes, but what we were

> met with was surprising, to say the least. While we waited for our contact, we were directed to the onsite retail cafe where felines were allowed to roam free and interact with guests while enjoying a beverage or snack in a very comfortable setting. After grabbing coffee, we were led to the back of the building and the differences between my expectations and reality became glaringly apparent. There were no poorly painted concrete walls or gray floors. No large rooms segmented by chain-link dividers. I saw no grungy dogs laying on the concrete or a poor excuse for a mat. We were exposed to something different.

The dogs were placed in brightly painted large rooms with all-glass walls, and each was outfitted with a nice bed, clean water, and a toy or two. The next thing that became obvious was how many employees interacted inside the rooms with the dogs. The shelter had a rotating schedule of volunteers and employees that would not only walk the dogs at set intervals but would come in and play or provide company for the dogs, and each dog had been recently bathed and brushed. Though this is a "best practice" in many shelters, the frequency and more than 4 h of daily enrichment activities astounded the researchers.

The waiting area for adoptions was nicely decorated and split into two sections. Adoptions were finalized on one side with easy access to veterinarians on the other. The final portion of the tour ended in a warehouse-style retail shop with everything a new or experienced dog parent could imagine, similar to a U.S. PetSmart, and at fair prices. Clear signs were posted throughout, indicating that profits from the store would be directly funneled back to support the shelter, providing consumers a sense of "doing even more good." The shelter had several convenient retail locations throughout the local community.

After touring the facilities, the second author described the experience as:

> It was a breath of fresh air-literally and metaphorically. From the very beginning, we were set at ease by watching the constant interactions with the animals housed at the shelter. Once in the holding area, we weren't overwhelmed by the common smell of urine and disinfectant. Everything was clean, the dogs appeared calmer and more excited rather than scared. The relaxing environment also led to the appearance of decreased fear-based behaviors in the dogs. There was less barking and cowering in corners or under beds.

Volunteers shared that this made it easier to predict the dog's behavior and how the prospective adopter may perceive the animal. This seemed to set the stage for a positive experience for the human without the excessive stress of seeing animals in more common cage-like settings. Respondent #7 shared:

> When I started, the average was like 2 weeks to find a home and then there would be those few dogs that we would get more concerned about because they would be here for months… I don't see that anymore. Now it's 4–7 days when they are on the adoption floor to find a home… and we just don't see these dogs that are here for months, and to be fair, very few cats are here for so long either.

In addition to the enhanced human and non-human shelter experience and retail operations, the Australian Animal Shelter invested in other revenue streams. These included shelter software, microchipping, thrift shops, crematoriums, puppy parties, and renting space to generate more stable income beyond traditional fundraising, grant writing, and philanthropic donations. The U.S. Animal Shelter was about to break ground on a similar retail-oriented shelter at the time of research and has since built similar operations.

Key Findings Theme #3: Improving Efficiency of Daily Operations

Improvements in daily operations can be attributed to three primary foci that are shaped by underlying factors of organizational change management: strategy, innovation(s), and workplace culture. They were driven by core competencies, nimble business philosophies, (iterative) process improvement, performance metrics, alignment, communications, relationship building, and leadership goals. Respondent #2 shared, "my role [as director] is obviously to make sure that board policy, overall, is introduced and followed, the mission is sustainable, legislative stuff as far as workplace health and safety, and particularly the mission to save lives."

In both shelters, significant emphasis was placed on adaptive management that integrates professional development and emotional capacities (often) associated with non-profit organizations (e.g., passion, intention, values). Respondent #5 represented this well:

> Traditionally, a lot of welfare groups have taken on people that turn up at an interview and say, "I love animals." That's great. We're all here because we love animals, but there's a bit more, too, that we need… We're constantly working with government about policy changes, and we often look to other agencies and welfare organizations' best practices. You can't get that without having people with the experience and background doing it.

A few procedures were intended to be strictly adhered to (e.g., evaluating animals and deciding which to go into adoption), but an organization's willingness and capability to adopt new practices are vital to resilience for social enterprises (60–62). Implementing innovative strategies toward non-human animal welfare and agency were key to the success of operations. Respondent #11 explained how animal rights and welfare were intrinsically linked to performance:

> We have six key organizational KPIs [key performance indicators]. Two of those are financial. If we hit the financial KPIs it opens up funds, a bonus type arrangement. Essentially, what we've decided to do as an organization is share the success of the organization with those people who determine whether we are going to be successful or not. It's not all about providing bonuses, it's making people more accountable and responsible for turning up and getting the job done.

In addition to tying KPIs such as LRRs to employee performance, other innovative strategies at each shelter included a rebranding of the shelter's image and reputation in the local community.

They were able to share improved adoption statistics, the improved living conditions of the animals in their care compared to their previous operations, increased volunteer engagement and appreciation, and an uptick in donations as proof that their efforts were targeted to improve animal welfare. The shift to become a non-profit social enterprise had considerable impacts on the outcomes of each establishment in organizational culture and overall operational efficiencies. These changes emerged throughout several aspects of each shelter, which influenced policy and procedure, technological-systems, (physical) facilities, organizational structure, human resources, and financials.

Positive Impacts on Human Perceptions, Live Release Rates, and Animal Caregiver Burnout

Clancy and Rowan (63) reviewed the historical record of companion animal demographics in the U.S. They contend that human perceptions of non-human animals have increasingly become more positive since the 1970s, when companion and feral animals were considered "overpopulated" due to a lack of legislation, desexing, and education. The U.S. and Australian Animal shelters previously faced large intake numbers of animals and not enough homes to adopt them out to, as Respondent #4 described:

> Twenty-five years ago, it was not so "hip" as it is now to adopt and there wasn't this adoption pride of where you got your animals… Pounds, including our own, [were] really high volume—a lot of euthanasias for time and space, and kind of icky places.

As public interest in animal rights and welfare increased, a cultural shift emerged in the way people view animals. Respondent #19 explained:

> Attitudes have changed, you know, people are more likely to sort of see animals as members of their family, which is a transition. I mean, it took a long time for a lot of people to realize, for example, you can't just chain a dog outside.

In response to this cultural shift, cramped, dark, and depressing shelters have been criticized as being inhumane, and pressures to improve the welfare and quality of life for animals within shelters have proliferated, resulting in improved LRRs (64). Innovative facilities were created in many locations, and programs designed to provide behavioral enrichment to the animals became more commonplace. This increased engagement with stakeholders, maximized adoption efficiency, and helped to reduce animal caregiver burnout. Respondent #10 at the Australian Animal Shelter shared that "the major positive changes have been around going from something like 50%, euthanasia, to 11%." This is a major improvement, but it should be noted that the LRRs are calculated slightly differently in Australia compared to the U.S. as the LRR includes non-health-related euthanasia for humane reasons.

The U.S. shelter also increased LRRs from an average of 83% to above 98%. Respondent #17 shared:

> We're quite open about euthanasia. And we will never say that we don't, but we do not euthanize animals for space, and we do not euthanize a rehomeable animal. When we euthanize dogs, if it's not because of health, it's because of behavior issues. And sometimes there's just no addressing them.

The two shelters in this study embraced a positive retail experience approach that improved the human and non-human experience and decreased time in shelter for animals. The positive retail experience approach transcended building aesthetics and offering products for sale. Shelter visitors were made to feel that they were "part of the solution," and that by adopting or purchasing a retail item they were also contributing to the shelter's mission to help save non-humans' lives. One of the volunteers at the Australian Animal shelter described how the visitors became a part of the "animal community" that stood for positive animal welfare. The first two researchers even noticed the transition in their own speech after conducting this study. The first author shared:

> When an acquaintance asks, "what kind of dogs do you have?," we respond that we have two *rescue* pups. We think that they are mostly border collies, but it doesn't matter. They're perfect for us.

When combined with the professionalization of shelter management and operations, as well as other non-profit social enterprise revenue-generating activities (i.e., retail store, software), an array of benefits emerged. Respondent #20 described that with improved volunteer coordination and a more welcoming environment, they were able to spend more time with the animals:

> In terms of live release rate and things like that, these animals out here can go crazy in a penned environment within a very short period of time. We can give each animal 4 h a day of enrichment. So that means getting out, sitting down, training them. My objectives here are to get the animals that don't make it to our adoption pens to an affiliate a rescue Group, a rescue partner, so that by doing that we raise our live release rate, and lower our euthanasia rate.

Several respondents reported that volunteer engagement increased and that both shelters were able to hire animal behavior experts to work with animals who would have previously been euthanized. In most cases, the respondents stated that with extra time and support, dog behavior improved, and it was rare that an individual could not be rehabilitated. At the U.S. shelter, dog adoption rates improved so greatly that they were able to collaborate with other non-profits who flew and trucked dogs in from high-kill shelters in other states to meet local demand for dogs. Every single respondent in the study expressed that morale and animal caregiver burnout had improved. Even though horrific animal cruelty cases persist, they described the general attitude and environment was more positive and hopeful. Respondents also stated that they felt they were making a positive difference for animals in their work.

CONCLUSION

The study is limited in its scope due to a relatively small sample size. Though the time for data collection was limited in Australia for logistical purposes, a longer period of participant observation would provide more data. Though the small sample size makes it challenging to generalize broad theoretical or practical approaches, these case studies showed that more research should be conducted on how animal shelters can apply non-profit social enterprise activities in their quotidian practices. Future studies should address these limitations and improve the diversity of the study by focusing on non-urban areas, and non-English (predominantly) speaking countries. The key findings indicated that non-profit animal shelters can, under certain conditions, successfully transition into a social enterprise by professionalizing shelter management, diversifying revenue streams, and enhancing operations. To accomplish this, non-profit animal shelters may need to sell a product or service (e.g., a pet retail store and animal shelter tracking software) and focus on two key factors. First, they must tie their executive compensation to mission-stated outcomes (e.g., live release rates) rather than revenue generation (e.g., large donations), and second, professionalize their daily operations (e.g., organizational structure, professional communication, human resource initiatives, etc.). The three key themes may contribute to alternative pathways for animal shelters to improve LRRs relatively quickly, and sustainably. If non-profit animal shelters can embrace these approaches then they may enhance independent financial solvency, promote multispecies welfare, while staying committed to their stated-missions.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Central Queensland University Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JT and BT collected data at both research sites. KC collected data at USA research site. All authors contributed to the data analysis and write-up.

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A New Web-Based Tool for RTO-Focused Animal Shelter Data Analysis

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Animal shelters are increasingly interested in reducing their intake and helping their communities keep and care for animals. Improving Return-to-Owner (RTO) rates of stray dogs is one path to save significant shelter space, time, and costs and keep animals with their caregivers and communities. Aggregating and visualizing RTO data spatially are useful for identifying trends and highlighting areas for potential interventions. Since shelters collect similar data, an interactive web application was developed to make such an analysis easily reproducible. This paper presents the tool's capabilities via a case study of 2019 data from the Dallas Animal Services shelter, covering the relationship between stray intake and RTO rate, the distances traveled from home by RTOed strays, microchip use across the city and its relationship with RTO rate, and the length of stay of RTOs and other outcome groups. Findings include showing that 70% of RTOed strays traveled at most 1 mile away from home and 42% up to block away, and that at-large, adult strays that had a microchip had a 71% RTO rate compared with 39% without one. The results affected the shelter's hold time for strays, highlighted target areas for microchip programs, and motivated neighborhood-based methods to locate found dogs' owners. Shelters are welcome to use the tool and participate in the development of new analytical lenses and visualizations that would best suit their needs.

Keywords: RTO, return to owner, data visualization, animal shelter, stray dogs, geographical/spatial analysis, web application, dog

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INTRODUCTION

Animal shelters take two approaches in measuring and evaluating their services. The first is looking at their outcomes, usually in terms of live release rate, and improving it through various programs (1–4). Many shelter-level studies conducted with academia and animal welfare organizations examine trends or interventions targeted at improving outcomes (2, 5). This should not come as a surprise, because a high live release rate is a helpful performance indicator for any shelter. The second path is to examine and reduce intakes rather than improve outcomes (6). This has been the focus, for example, of spay–neuter programs (7, 8).

This perspective can be framed within a broader re-evaluation of the shelter's role. Human Animal Support Services (HASS), a coalition of shelters and animal welfare organizations across the US, tries to rethink the role and structure of shelters by building programs that help keep animals within their community, with the shelter primarily functioning as an emergency medical care and short-term housing center for pets in urgent need (9).

An emphasis on understanding and reducing intakes is essential within this framework. However, even without such repurposing of the shelter, focusing on intake prevention supports shelter's interests [for an example with cat populations, see (10)].

One key activity that can promote this goal is to improve Return-to-Owner (RTO) rates. The rate refers to the fraction of stray intakes that are returned to their owners by field officers or after a short stay at the shelter (11). RTO has significant benefits: taking in a stray, desexing it (as mandated in most states), caring for it, and rehoming it is more costly and time-consuming than returning it to its owner, while in the meantime, it also takes shelter space, which means that the shelter can help fewer animals over time (12). Reuniting pets with their owners also relieves the distress caused by a lost pet and contributes to the trust in the shelter within its community (11).

Improving RTO rates has been recognized in the past as an underutilized means to decrease euthanasia rates, and a look at nation-wide shelter statistics suggests that there is a large room for improvement (6, 13). As could be expected, cats have much lower RTO rates than dogs, partly because many cats taken in have no homes to return to. While there is certainly room for improving cat RTOs, this study looked only at dogs, and thus so do all data, tables, and figures hereafter. Naturally, focusing on RTOs is relevant for shelters in which strays make up a significant portion of their intakes. For a rough estimate of the number of stray dogs and RTO rates across US shelters, **Table 1** summarizes this information based on 3,226 organizations that reported their 2019 calendar year data to Shelter Animal Counts (SAC) (13).

Overall, 46% of all reported dog intakes were strays (1.081 million out of a total intake of 2.292 million dogs), which was the leading intake type, followed by about 500,000 owner surrenders. Of these strays, the RTO rate across all reporting organizations was 39%. Looking at the subcategories of organizations as listed on SAC, RTO rates were 39% for governmental animal services, 44% for shelters or rescue with government contracts, and 30% for private shelters and rescues. These rates may be higher than the actual RTO rates, since they capture all RTOs and not only out of stray intakes, which includes confiscated dogs and owner surrenders. These data suggest that while the additional RTO potential might vary between organizations, there were at least 600,000 strays that were not returned to their owners.

TABLE 1 | Intakes, strays, RTOs (in thousands), and RTO rates as reported to SAC, 2019.

Organization type	Intakes	Strays	RTOs	RTO rate (RTOs/strays)
Government animal services ($n = 460$)	968.3	636.6	247.2	39%
Shelter/rescue, govt. contract ($n = 425$)	598.3	295.7	129.8	44%
Shelter/rescue, private ($n = 2{,}341$)	725.4	119.4	36.3	30%
Total ($n = 3{,}226$)	2,292	1,051.7	413.3	39%

Of course, some of these dogs could not be returned to their owners, because they were abandoned by them or did not have any. Another insight into the RTO gap can be drawn from a study conducted by Weiss et al. that surveyed owners on their lost pets (14). They estimated that 15% of dogs run away or get lost at least once, and that about 766,000 dogs are never reunited with their owners each year. Presumably, many of them end up in local shelters. Even if only half of the extra 600,000 intakes from 2019 are lost pets, when considering the cost, time, and shelter space taken for the care, desex, and rehoming of each animal, as well as the psychological and community-building benefits, the above estimates suggest that improving RTOs is a desirable goal for many shelters.

With this general motivation to study RTOs in mind, this research effort began by analyzing stray intake and RTO data from the Dallas Animal Services (DAS) shelter, aiming to illuminate questions that would support the shelter's effort to improve its RTO rates. In the fiscal year of 2019, 30,659 dogs were admitted into the shelter of which 20,738 (68%) were strays, and of these, 10,015 (48%) were RTOs. As suggested above, data about abandoned and free-roaming dogs would be relevant to assess the additional RTO potential in Dallas, i.e., how many of the 52% of strays not RTOed could be had the owner was found. Unfortunately, no such data were available. Physical condition could be one proxy for identifying whether an intake with no indication of an owner has RTO potential, but 95% of these intakes were similarly labeled as healthy. The DAS staff, through their communications with community members and local partners, assumed that they would have known of a large free-roaming dog population or recurring abandonments of pets; they believed that a meaningful part of the non-RTOed strays had owners to get back to who for a variety of reasons did not contact the shelter or provide their dogs with a form of identification. Thus, despite this imperfect knowledge, a dive into their data could help clarify how their intake and RTO patterns improve their RTO-related policies and programs.

The following questions were chosen with the shelter staff to guide this study:

1. What is the relationship between the number of strays and RTO rate per ZIP code?
2. How far do RTO strays travel away from home? Does that vary based on the stray's found location?
3. How long do strays stay before they are RTOed? Does length of stay (LOS) vary based on the owner's address?
4. What is the difference in RTO rate between strays found with or without a microchip? Were microchips uniformly present across the city?

As evident from these questions, a spatial analysis was appropriate to examine stray and RTO data. Mapping the data would allow the shelter staff to examine the summary statistics and trends in relation to different parts of the shelter's jurisdiction. While there are no previous spatial studies of stray dog intakes and RTOs specifically, several studies used Geographic Information Systems (GIS) to target interventions aimed at stray dog and cat population. Miller et al. used GIS to

select areas for intervention targeted at preventing euthanasia by reducing cat and pit bull intakes (15). They built maps on both ZIP level and Census tract levels that facilitated the selection of intervention areas for intake reduction and applied an intervention program made up of free spay/neuter surgeries, behavior trainings, vaccines, and retail gift cards, among others. They found that the spatial approach was valuable in selecting a target for intake reduction intervention as well as tracking its success. Spencer et al. used GIS to map the intake patterns of a shelter in Florida, identify areas with high stray dog intake, and investigate the reasons for the high intake through interviews with residents (16). Spindel et al. used intake locations of dogs identified with two types of canine viruses and their antibodies to target vaccination programs, and Sokolow et al. used GIS to track the spatial distributions of diarrheal disease among dogs in a northern California animal shelter (17, 18).

Other studies used GIS to characterize stray dog and cat population and study links between their pattern and sociodemographic indicators. One such study used geolocations of adoption outcomes from an animal shelter in Massachusetts on a Census-block level to investigate the link between adoption and both distance from the shelter and demographic indicators, such as median household income (19). In another study, cat intakes and deaths were geocoded and examined across Census tracts in Boston for their correlation with human premature death and socioeconomic indicators reflecting depravation (20). Outside the United States, one study mapped stray dog population in São Paulo, Brazil to evaluate the association of local sociodemographic and environmental factors with the population perception of the presence of free-roaming stray dogs (21). The researchers used districts as the geographic unit studied, spanning between 63 and 151 km^2, larger than Census tracts but smaller than ZIP codes. Similarly, Reading et al. identified clusters of owner addresses from which cats were surrendered to shelters (22). They were interested in specific addresses or blocks and, thus, used addresses to construct a density map and a clustering analysis. Aguilar and Farnworth studied stray cats in Auckland, New Zealand (23). They processed exact intake locations and identified high density areas with stray cats and reported their results in the neighborhood level around the Auckland region.

This study used ZIP codes as the main geographical hierarchy to characterize stray intake, as motivated in the Methods section, while also focusing on the spatial dimensions of RTO rates and microchip prevalence to explore a potential for program improvements.

The examination of RTO rates among microchipped and non-microchipped dogs builds upon several past studies. Lord et al. studied 3,425 stray dogs from 53 shelters, excluding Field RTOs for which no microchip data were available, and found that the median RTO rate across studied shelters for microchipped dogs was 52%, compared with an overall RTO rate of 22% (11). A similarly large study in Queensland, Australia examined microchip registration and RTO rates among 7,258 adult stray dogs and found an 80% RTO rate for microchipped dogs, including those with missing or faulty data, compared with 37% RTO rate for dogs without a microchip (24). A study in Czech Republic examined 10 years of shelter data, 5 years before and after a mandatory microchip decree was put in place in 2009 (25). In addition to finding that more dogs had microchips in the period after the decree, and that RTO among those with a microchip has slightly increased, their reported data showed that over the entire study period, microchipped dogs had a 77% RTO rate (1,056/1,379) compared with 42% (1,295/3,076) for non-microchipped dogs. Studies with smaller sample sizes (in the hundreds) in Spain and Serbia have also found similar differences in RTO rates (26, 27). This study builds upon these previous results by examining microchip presence across different areas of the shelter's jurisdiction. Furthermore, since microchip practices may differ between countries, this study provides an additional replication for the results of Lord et al. for a US-based shelter.

To enable more shelters to analyze their data based on the guiding questions identified above, a web-based interactive dashboard, temporarily named "Shelter Databoard," was built to visualize the results of the analysis. Information systems used by shelter do not natively offer this type of analysis, and since the data collected for this analysis are collected by many other shelters, the tool was built to take in a CSV file that any shelter could export from its information system.

In this paper, I will dive into the analysis of the DAS data as a case study to highlight the tool's capabilities and the insights that can arise from looking at shelter-level data this way. The Methods section provides additional context on DAS and goes through the data fed into the tool and the methods used to derive the different visualizations, which are then presented in the following Results section by the four research questions. I then discuss some of the tool's implications on DAS's practices and potential insights that may arise for different shelters and end with a brief overview of future directions, including the incorporation of Census tract data and an invitation for shelters to use the tool. A link to a live version of the tool with DAS data, courtesy of the shelter to share it, appears in the Future Research section.

METHODS

Dallas Animal Services

DAS is the government-operated municipal animal shelter for the city of Dallas, Texas and provides public safety and animal care services to residents of Dallas. It takes in any pet in need, regardless of space, and is located at ZIP code 75212. According to the US Census, the human population in Dallas in 2019, the year covered by the data, was 1,343,573 (28). Stray dogs are defined by DAS as any dog found in the field or brought in by a person who is not the dog's owner, as opposed, for example, to owner surrenders, incoming transfers, and dogs taken in for custody, quarantine, and following an eviction or cruelty. RTOs are accomplished in two ways: Field RTOs occur when the owner is found by a field officer, and Shelter RTOs occur when a dog was RTOed after it was brought into the shelter. References to RTO across the paper include both categories, unless explicitly mentioned; for example, the distance traveled by RTOs includes both categories, whereas LOS does not apply to Field RTOs.

A few additional details on RTO procedures in DAS can provide further helpful context. First, DAS has a stray hold

period policy that defines different hold times across age and available identification. Puppies under 4 months have no hold period; those 4–6 months have a 1-day hold; older dogs without any form of identification (such as a microchip or a collar) are held for 3 days, and adult dogs for whom identification is present have a 5-day hold period. Dogs taken in for custody or quarantine face longer hold periods but were not included under the scope of this study. Second, adult dogs (over 6 months) must go through desexing and microchipping under the shelter's ordinance, unless deemed unfit for surgery. Field RTOs are exempt from both requirements. Finally, DAS's policy requires owners to pay reclaim fees for Shelter RTOs, associated with the stay, microchipping, and desexing procedures. In practice, however, the fees are commonly waived, based on the owner's needs and at the shelter's discretion.

Data Preparation

All cleaning and analysis were performed in R (29). DAS provided the dataset for this case study, which consisted of all dogs that have gone through the shelter in the 2019 Dallas fiscal year, October 1st, 2018 to September 30th, 2019, as pulled out of its information system in the beginning of this research. For each dog, the following features were used: intake and outcome dates, LOS (the number of days between these dates plus one), intake type (e.g., stray, owner surrenders), intake subtype (whether there was any indication of an owner, e.g., a collar), intake condition (e.g., healthy, injured, sick), breed, age, microchip scan result (yes, no, or unknown, regardless of registration or correctness of details), intake address and ZIP code, outcome type (e.g., adoption, RTO), and outcome address and ZIP code. The intake address and ZIP code for stray dogs were their found location (also known as Crossing), whether they have been brought in over the counter or RTOed by a field officer. Outcome address for RTOs was the owner's address, existing (RTO) or new (adoption). Breed was only used when examining microchip prevalence, as discussed later; since it is a notorious field due to people's inability to accurately identify dog breeds, only pure vs. mixed breed status was considered (30). The final data file contained a single record for each instance of a dog entering the shelter, which means that some dogs appeared multiple times if they re-entered the shelter.

This analysis used ZIP codes as the main geographical hierarchy that organizes results for several reasons. First, it was available for all data points. Second, the high-level overview of the geographical patterns around strays and RTOs that is obtainable via ZIP codes was sufficiently relevant for the shelter. Finally, the shelter staff are used to working with ZIP codes in their daily work and when compiling different metrics. Nevertheless, ZIP codes have clear limitations—as suggested by Reading et al., they are too wide to support targeted interventions and cannot be correlated with demographic data. Future research to meet these limitations is discussed later.

Due to the geographical focus, 50 dogs that were missing an intake ZIP code were removed, leaving a total of 30,609 dogs in the final dataset. Stray dogs whose intake address was listed as the shelter's address ($n = 205$) were excluded from the stray count to avoid skewing the results, as they are essentially missing their true found location. After this filtering, it was still clear that most of the shelter's intake comes from strays ($n = 20{,}763$), which motivated the shelter's interest in its RTO patterns. RTO rate was defined as the number of RTOs out of the number of strays, which for the shelter stands at 48% (10,035/20,763). Scarlett (6) suggested that this is a conservative definition because stray puppies are less likely to have owners and could be excluded from the calculation, as RTO should only be about strays that have owners. Yet in DAS's case, the RTO rate for puppies was 18% (381/2,091), which was found high enough to include.

The second research question, investigating the distance RTOs travel away from home, required manual inspection to ensure data integrity. The distances were derived as follows: first, data were filtered to remove dogs ($n = 4{,}778$) that had identical intake and outcome addresses. According to the shelter staff, this happened often when field officers used the shelter's or the owner's address instead of the location in which the dog was found. Then, the distance traveled by each dog was calculated in two ways: first, using the intake and outcome addresses as is to calculate a walking distance *via* Google Maps API and second, by geocoding the address and then calculating the distance between them *via* the *Imap* package, which finds the geodesic distance between two points specified by latitude–longitude pairs. A manual examination of the two types of distance searches by the author found that the first method, using the explicit addresses, was more error prone, including erroneous distances and NA responses, so the *Imap* approach was chosen. Since the *Imap* address also indirectly used the addresses for geocoding, the results were further examined to identify wrong identifications resulting from faulty data. This way, for example, data with missing letters were corrected, and addresses that exist in multiple states were modified to similar ones in Dallas. In the cleaning process, distances for 8 dogs were tuned, and 80 were removed, 2 of which due to unclear addresses and 78 due to owner addresses outside Texas that resulted in over 25 miles traveled (cut-off chosen arbitrarily). The shelter's geolocation was also found to center the maps, and a spatial file containing the boundaries of all ZIP codes was prepared for the spatial visualizations.

Data Analysis

Starting with question #1, examining the relationship between the number of strays and RTO rate, these two quantities were calculated by aggregating intake and outcome data for each intake ZIP code. To visualize the results as a choropleth, in which each ZIP code is colored by the quantity of interest, a spatial file containing the ZIP code boundaries for Dallas was obtained. This spatial file was presented on top of a base map centered around the Dallas City Hall obtained *via* the Google Maps API. ZIP codes with <10 strays were excluded.

For question #2, looking at the distances traveled, after the data were prepared as described above, the distribution of distances traveled by the dogs with different intake and outcome addresses ($n = 5{,}228$) was plotted on a histogram, and summary statistics were obtained. The distances were also aggregated by the found ZIP codes and plotted as before, to identify the trends in different parts of the city.

Question #3 regarding LOS relied on the LOS feature available in the data, but 5 days was deducted from it to account for the stray hold period for adult dogs at DAS. To create a less noisy comparison with other outcome groups, only stray adults that were found "at-large," i.e., without any indication of an owner (as opposed to others labeled as "possibly owned" or "confined" under the intake subtype field) and had no health condition, were examined. For RTOs, only Shelter RTOs were counted. It is possible to create a more sophisticated comparison between dogs that are similar on more characteristics (i.e., not only age, subtype, and condition) or more closely similar (e.g., account for exact age). However, since this comparison is not meant to provide a comprehensive model for LOS but a rough estimate of its difference across outcome groups, this one suffices. The distributions, median, and 90th percentile of post-hold LOS were thus compared between Shelter RTO (n = 2,400), adoption (n = 3,916), and transfer (n = 1,210). Spatial plotting was done similarly to previous sections, but this time aggregated by outcome rather than intake ZIP code to examine the LOS for RTOs across the city.

Finally, to investigate the microchip layer of the data for question #4, stray and RTO counts were found for dogs with and without microchips, excluding those with unknown status. Similar to LOS, a simple comparison between "microchip" and "no microchip" could be misleading, because there could be other differences between the groups that might affect the different RTO rates. The "no microchip" group was identified to have more puppies than the microchip group, and they are much harder to RTO. The microchip group also had more strays that were marked with an intake subtype of "possibly owned," meaning that there was a potential indication of an owner, e.g., a tag or word of mouth. They are easier to RTO, regardless of a microchip. Thus, only healthy adults that were found "at-large" (n = 13,794) were divided by microchip status, and RTO rates were compared through a chi-square analysis of a 2 × 2 contingency table.

As a final consideration, it could be that the non-chipped dogs lived in ZIP codes that had lower RTO rates for other reasons, such as shelter accessibility. To account for intake location, RTO rates between "microchip" and "no microchip" groups were compared seven times using a chi-square analysis when only selecting the healthy at-large adults from each of the highest-intake strays identified under question #1, the smallest of which recorded 1,015 strays.

Other available variables, such as color, breed, and date of intake, were similarly distributed among dogs with and without microchips, suggesting that they do not account for the difference. Again, it is possible to create a more sophisticated comparison between dogs of all subtypes that are similar on more characteristics than those used above, but since achieving an RTO is most relevant for dogs with this profile (i.e., adults with no owner indications) and most strays in the data fell under the "healthy, at-large, adult" description, a direct comparison was performed between these groups.

Then, for each ZIP code, a "microchip rate" was defined as the number of microchipped strays found in that ZIP code out of all strays found in it. This rate was plotted against the ZIP code's size, to examine whether larger-intake areas also had more microchip awareness. Finally, the microchip rate was plotted on a map as in previous sections.

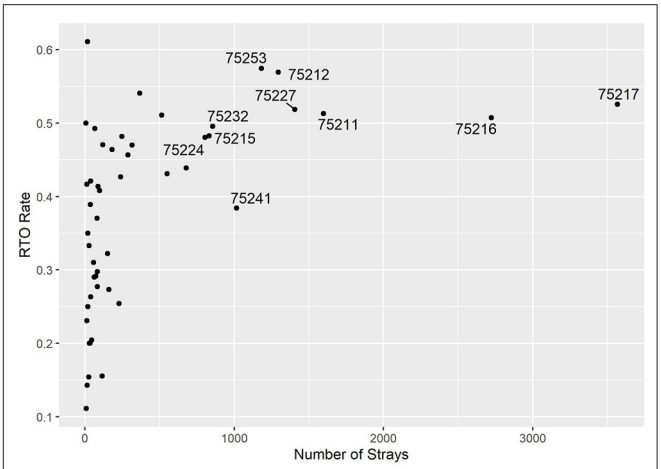

FIGURE 1 | RTO rate and the number of strays per ZIP code. Labels indicate high-intake areas.

The web-based Shelter Databoard visualizes the result of the analysis, built using the *Shiny* R package. The tool takes in the preprocessed CSV file with shelter data as described above. Some additional settings are manually tuned to enhance readability (for example, legend values). The user can control the date range of data fed into the figures to compare different periods, switch between types of data on an interactive map, break down the data by different dimensions (for example, examine only over the Shelter or Field RTOs), and find key summary statistics of their data. As of writing this paper, new sections were added to the tool, including demographic data and a visualization of euthanasia requests, as discussed in the Future Research section.

RESULTS

The Relationship Between the Number of Strays and RTO Rate per ZIP Code

Most ZIP codes contribute a small share of the shelter's stray intakes, whereas a few ZIP codes have high intakes, as shown in the horizontal axis of **Figure 1**. While the ZIP codes with smaller intakes display high variability of RTO rate (vertical axis), the few large areas have roughly similar ones around the 50% mark. ZIP code 75241 stood out with a high-intake count but lower than usual RTO rate at 38%. When looking at Field RTOs only (who never arrived at the shelter; not plotted), the trend looked similar.

It is also helpful to see the dimensions of this figure on a map of Dallas. **Figure 2** visualizes the horizontal axis of the previous figure—the number of strays across different ZIP codes. Moreover, 63% of all strays come from the seven labeled ZIP codes. The map clearly shows that most strays are found in the southern area of the city. Similarly, **Figure 3** shows the vertical axis of **Figure 1**—the RTO rate for each ZIP code. Generally, the southern areas with higher stray numbers also have high RTO rates compared with the northern regions, but the variability is not as strong as in the number of strays.

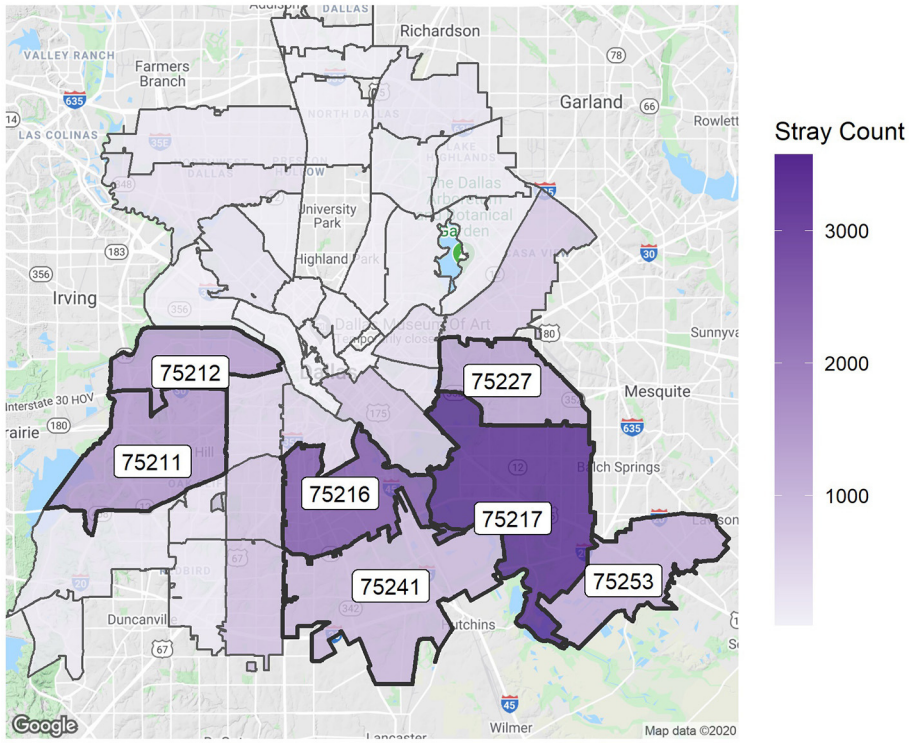

FIGURE 2 | Strays per ZIP code. The map is centered on Dallas City Hall. The seven largest areas are labeled.

How Far Do RTO Strays Travel Away From Home?

As mentioned before, out of 10,000 RTO strays with known owner addresses, 4,775 had the exact same owner address and found location. Out of the other 5,228, 70% of dogs are not found beyond 1 mile away from their owner address. **Figure 4** zooms into the 70% of dogs that walk under 1 mile. Of these 70, 60, or 42% of all dogs, go <400 ft away from their owner address (an estimate of an average city block).

The results so far were aggregated for the whole shelter, but a further question was whether there was some variation in these distances for dogs found in different locations. In other words, are dogs found in some parts of the city likely to have gone farther from home than others? **Figure 5** tries to answer this question by showing the median distance traveled (in miles) by all dogs found in a certain ZIP code. Dogs found in the northern part of the city tend to travel farther away from home (1.5–2.5 miles) than those in the southern ZIP codes (around 0–0.5).

How Long Do Strays Stay Before They Are RTOed? Does That Vary Based on the Owner's Location?

Figure 6 shows that post-hold period LOS for RTOs is much lower than adoptions and transfers. All outcome categories exclude the upper 4–5% outliers of their outcome types with a cut-off of 60 days to allow an easier view. Moreover, 91% of dogs were reclaimed during the 5-day hold stray period; hence, the median and 90th percentile values of 0 were post-hold LOS. For adoptions, while the median post-hold LOS was 2 days, there was a longer "tail" into the longer stays area, with 24% of dogs staying at least 7 days, after which the number of days decays until hitting the 90% mark at 16 days. Transfers were similar to adoptions, with a lower median of 1 day, a similar 23% of dogs that stayed a week or more, and a slightly higher 90th percentile at 17 days. **Table 2** summarizes these summary statistics for each outcome category for comparison. The low RTO statistics compared with other live release outcome types help to demonstrate the additional days a stray dog is expected to spend in the shelter if not RTOed.

Focusing back on RTOs across Dallas, few differences (of <1 day) were observed in the mean, median, and 90th percentile of LOS when grouped by Owner ZIP codes. In other words, LOS for Shelter RTOs was relatively unaffected by the area in Dallas in which the owner lives.

What Is the Difference in RTO Rate Between Strays Found With or Without a Microchip? Were Microchips Uniformly Present Across the City?

In a naïve comparison, excluding 2,013 strays whose scan status was unavailable, those found with a microchip were RTOed 70% of the time, compared with 33% when no microchip was present.

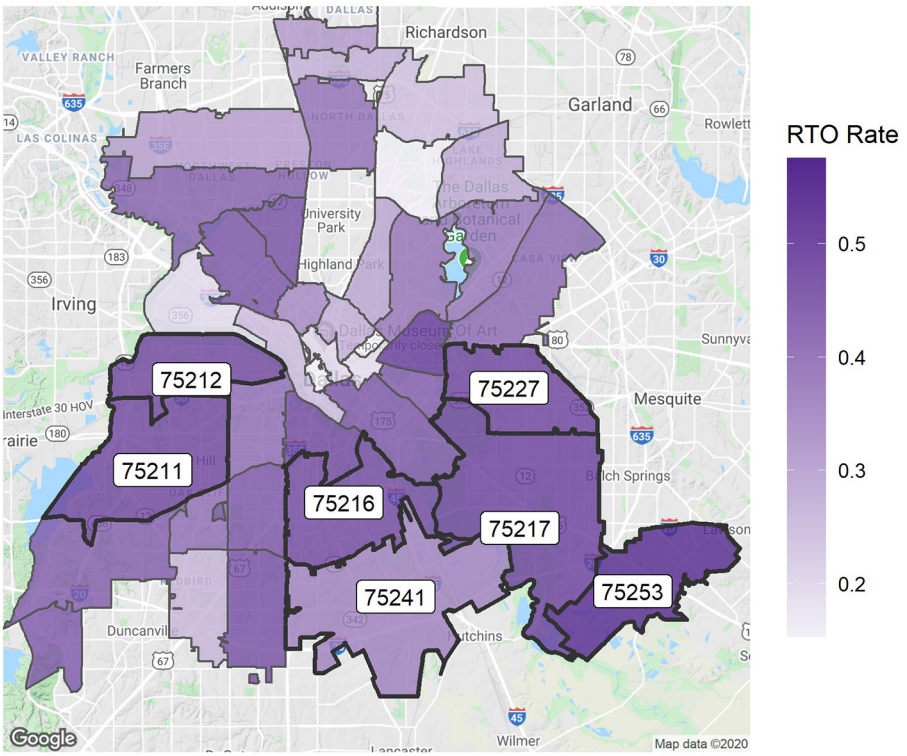

FIGURE 3 | RTO rate per ZIP code. The seven highest-intake ZIP codes are labeled.

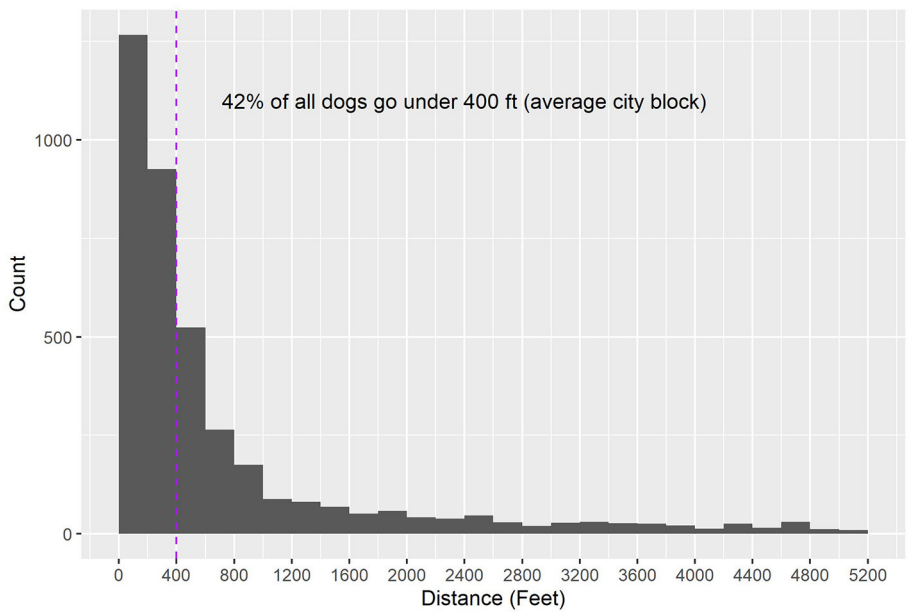

FIGURE 4 | Distance traveled by RTO strays, excluding those with identical intake and outcome addresses, zoomed in on dogs who traveled up to 1 mile. The 400 ft mark is indicated with a purple line.

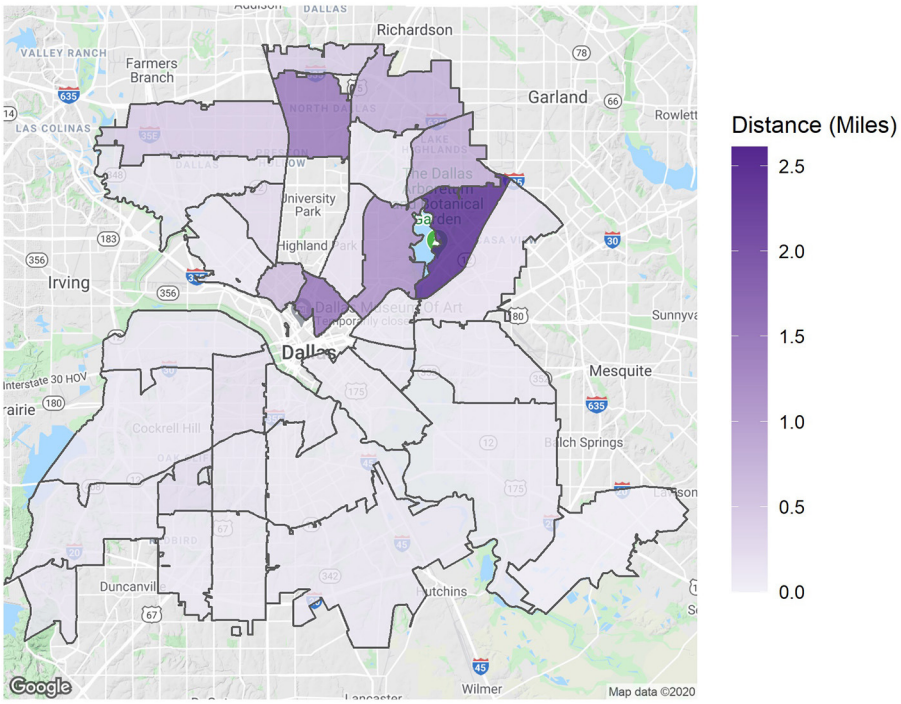

FIGURE 5 | Median distance traveled by RTO strays per intake ZIP code.

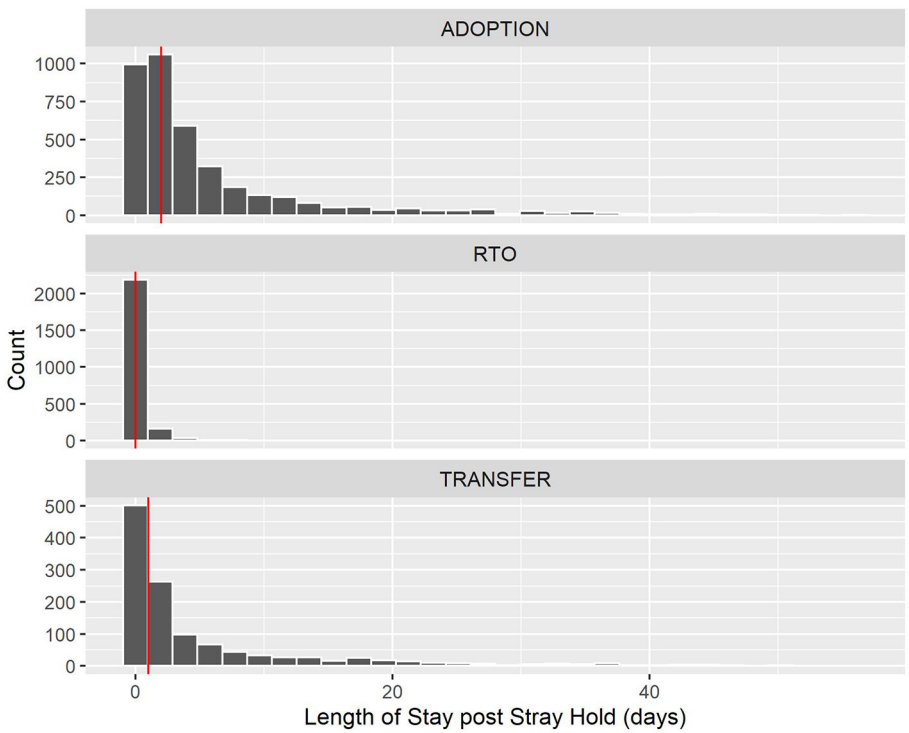

FIGURE 6 | Length of stay after hold period for healthy, adult stray dogs who were adopted, RTOed, or transferred. The red vertical line indicates the median for that outcome type, also summarized in a table below.

TABLE 2 | Summary statistics of LOS post a 5-day hold period (in days) for different outcome types and the percentage of dogs who stayed at least a week per group.

Outcome type	Count	Median LOS	90th percentile LOS	LOS ≥7 (%)
RTO	2,400	0	0	0
Adoption	3,916	2	16	24%
Transfer	1,210	1	17	23%

TABLE 3 | RTO rates for all strays and healthy, at-large, adult strays with and without microchips.

Which strays	Microchip	Strays	RTOs	RTO rate
All	No	13,032	4,265	33%
All	Yes	5,691	3,971	70%
Healthy at-large adults	No	8,311	3,213	39%
Healthy at-large adults	Yes	3,867	2,744	71%

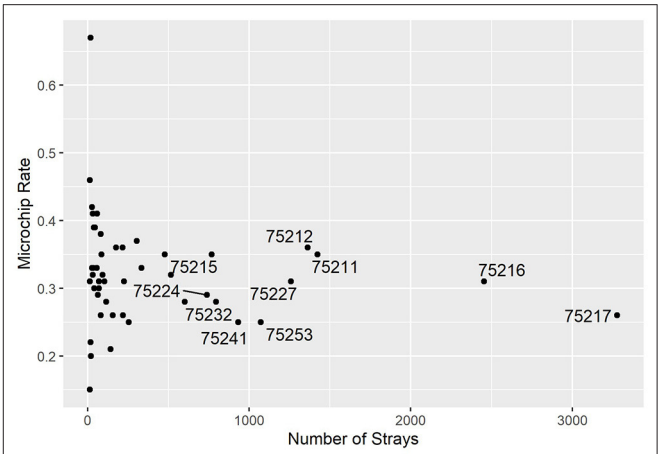

FIGURE 7 | Microchip rate vs. number of strays by ZIP code. Highest-intake areas are labeled.

When comparing only healthy, at-large, adult strays with and without a microchip, the gap has narrowed slightly but was still meaningful and statistically significant: 71% RTO rate for strays with a microchip compared with 39% for non-microchip (**Table 3**; $\chi^2 = 1,101$, $df = 1$, $p < 0.001$). The increase in the non-microchip rate was likely due to the exclusion of puppies and "possibly owned" strays.

When performing the test again but only selecting the healthy at-large adults from each of the highest-intake ZIP codes, the RTO rates remained almost the same, varying between 39 and 45% for "no microchip" and 71 and 75% for "microchip," and the difference was similarly statistically significant ($p < 0.001$) in all cases.

The distribution of microchip presence across town was also examined. For each ZIP code, the "microchip rate" was defined as the fraction of all stray intakes that were found with a microchip. Across the entire city, 30% of strays were found with microchips. The highest-intake ZIP code, 75217, was on the lower end of the microchip rate compared with other areas across Dallas, as shown in **Figure 7**. Since it is the largest intake ZIP code by a margin (alongside 75216, which was close to the average rate), it could be a good target to focus programs to promote microchip use. Other large ZIP codes are labeled.

DISCUSSION

While the results and figures are specific to DAS, they demonstrated the sort of insights that could arise from the tool. Starting with the big picture, the RTO rate was relatively high across the high-intake ZIP codes. From several conversations I had with other shelters and industry professionals, this is an anomaly. In another shelter that tried the tool, for example, there was a pronounced negative correlation between strays and RTO rate. The few large intake ZIP codes also accounted for a substantial amount of the shelter's overall intake, which suggested that even though the rates were at a strong starting point, these are the areas worth targeting for improving RTO rates even further. One area to investigate might be 75241, which had a lower overall and field-only RTO rate relative to other ZIP code with a similar stray intake size.

The most striking finding was that across Dallas, and particularly in the southern, high-intake ZIP codes, dogs rarely went far from home. Of all strays, 70% were found up to 1 mile away from home, and 42% were found within a block's range. The shelter expected something along these lines, but to see how close to home most dogs go, and have the data to back it up, was helpful. Plotting the median and 90th quantiles of distances also showed that the typical distances are similar across the city, but when it came to outliers, dogs found in northern ZIP codes tended to have gone farther from home—but usually still within the same ZIP code. This also aligned with the higher density of houses in southern neighborhoods. Since a successful RTO in the field saves a variety of resources that are given to every dog that gets brought into the shelter, these findings motivated investing in different programs that attempt to achieve RTOs within the neighborhood range. As a basic step, the shelter encourages community members, local lost and found groups, and field officers to further look for lost dogs within the neighborhood—perhaps an obvious suggestion, but the shelter now had data to effectively advocate for it. In addition, the shelter uses NextDoor, an information-exchange platform within a ZIP code, for posting lost pets within the area in which they were found. Another potential step is to equip field officers with posters to be hung around the block in which an animal is found.

The microchip enquiry raised another set of interesting findings. First, the results were in line with previous studies of RTO rates among microchipped and non-microchipped stray dogs, while also verifying the difference remains across physical characteristics, such as health condition. Although factors other than presence of a microchip could have contributed to these differences (for example, microchipping could be considered an indicator of responsible pet ownership), these results highlight

the importance of microchips in reuniting owners and pets in Dallas and motivated more microchip-related programs. This was an encouraging result since there could be multiple challenges even if a microchip is present, including the chip not being registered or showing incorrect information. Further research and data collection are needed to characterize the reasons for RTO failure in cases of microchip presence. Finding that 75217, the highest-intake ZIP code, has among the lowest microchip rates helps to focus the efforts of microchip programs. One example that is being introduced is equipping field officers with microchips so that dogs found without one and are RTOed can undergo the process. The shelter is also looking into ways to reduce their microchip procedure fees, to lower the financial burden involved, and to encourage more owners who arrive at the shelter to use them.

The LOS results allow quantifying the time differences gained by RTOs compared with other outcome types. Of non-Field RTOs, 91% were reclaimed within the 5-day hold period, and 99% were reclaimed within 5 days after that period. Conversely, while 50% of dogs who ended up transferred or adopted stayed in the shelter an extra 1 or 2 days, respectively, 23 and 24% of dogs have stayed at least a week past the stray hold, and 10% stayed over 16 days in both non-RTO groups.

Moreover, plotting the results by Owner ZIP code shows that these rates are largely similar across the city—in other words, people who live across town take the same time to get their pets back from the shelter, which is good news. Had it not been the case, this sort of figure could motivate looking into ways to make the collection process easier for people who live farther from the shelter. Seeing that 91% of owners complete an RTO by 5 days affirms the shelter's choice to reduce the hold time to 5 days. For shelters with differing LOS averages by ZIP code, a potential experiment for improving RTO rates would be to vary these hold times and examine its effect on RTO rates in that area.

This analysis also has several limitations. First, it is just a starting point for spatially driven research to guide resource allocation. Using ZIP codes poses difficulties in focusing down on a specific area. Using higher-resolution data, such as Census tracts, would also enable integrating this with socioeconomic data, and one such direction is described in the next section. Another key layer of information that was not present here is the method of RTO and the RTO efforts attempted—was an RTO achieved due to a microchip, license record identification, or a Facebook group? Which attempts to identify an owner were made for successful and unsuccessful RTOs? Collecting this data, even for a short time, and integrating it with the existing analysis presented above would provide some further ideas for improving RTO rates. Relatedly, because there were no available data on microchip registration or correctness of detail, only a "microchip" vs. "no microchip" comparison could be made, rather than a more nuanced comparison, such as "microchip with correct data," "microchip with incorrect data," and "no microchip," which would provide further insight into how RTO rates vary based on the microchip's data integrity. In addition, several statistical methods could be used to perform more nuanced analyses into some of the aspects of this study, such as LOS comparisons. Finally, as mentioned above, DAS's data were remarkably rich and complete, which enabled all sections of this analysis, but this may not be present for all shelters. Yet, while exact intake and outcome addresses may be harder to maintain, and microchip status is not always collected, all other types of data used are basic, which would allow many shelters to enjoy most of this tool. Hopefully, this paper also highlights the benefits of solid data integrity and encourages shelters to improve their data collection practice.

FUTURE RESEARCH

As more shelters have been interacting with the tool, new suggestions for visualizations and perspectives were added to the drawing table. As of writing this paper, a new page focused on euthanasia cases, broken down by intake ZIP codes, age groups, and intake conditions, was already added. Another set of improvements might come from a more convenient way of examining the differences in the findings above between different years, a first step of which was a time series that breaks down monthly intake and outcome patterns.

Another central inclusion involves demographic data. The live version of the tool includes Census data directly, such that shelter-level metrics can be assessed alongside human demographic data, such as median household income and percentage of foreign-born. For this purpose, all intake and outcome addresses were mapped onto Census tracts, and all other metrics were shifted from visualizing data by ZIP code to Census tracts, so that both demographic and shelter data are along the same spatial units. One implication of this transition for DAS was in designing their communications in a campaign launched in March 2021 to improve RTO rates. The stray and RTO metrics were used to choose focus areas as before, with Census level allowing a finer resolution than ZIP codes, and data about foreign languages spoken per Census tract guided the development of pamphlets and posters. The next step in this direction would be incorporating spatial data such as locations of pet food and medicine that would help illuminate some of the intake trends (for example, whether these indicators correlate with under-nourished intakes). The tool is planned to allow users to switch between ZIP codes and Census tracts to allow the benefits of both hierarchies.

The iterative development process of the tool has reaffirmed the notion that sparked it—shelters have shared interests. The tool currently spans across multiple aspects of a shelter's data—an overview of intake and RTO rates across town, the distances traveled by strays, the LOS for different outcome types, microchip trends and effects, and trends in euthanasia cases. Surely, not all shelters will find everything insightful. However, any new suggestion or feedback could be the beginning of an exciting change for another shelter—the scatter plot showing RTO rate vs. stray intake and the microchip inquiry are examples of development in response to suggestions or requests made by other shelters.

On the procedural level, the data still require preprocessing before being uploaded into the tool, for the reasons explained earlier: standardizing field values, calculating the distance traveled, fixing errors, and tuning the legend manuals. This might be an issue in attempting to scale the tool into many more shelters, but the processing time can currently take about one workday, so on the short-term, it is not prohibitive. In a later version, the tool could have a native way to upload a raw CSV file that would allow shelters to initiate preprocessing and get access to the tool within a day or two after the data are ready and loaded by the author. Expanding the computational infrastructure to support more shelters and automate some of the process is also possible, only subject to shelter interest and available resources; currently, using the tool is free of charge, and the author funds the hosting costs. After the data are cleaned and loaded, using the tool is intuitive *via* a web browser. The current version also includes a demo environment that any user can interact with featuring the DAS data.[1]

To conclude, I invite shelter directors and staff interested in further exploring their data, both those who found the above analysis compelling and others who wished to see something different—please reach out and join the process. Ultimately, I hope that the Databoard can continue to grow into a meaningful tool that could guide shelters' resource allocation, decision-making, and program planning and support their missions to improve the well-being of the animals and humans of their communities.

[1]The current version of the tool with DAS's data can be found in the following URL: https://tomkremer.shinyapps.io/databoard/. Since this is a prototype, mind me for potential glitches.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The dataset is owned by Dallas Animal Services. Requests to access these datasets should be directed to tom.kremer@minerva.kgi.edu.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Workplace Relations and Opportunities for Career Development Impact the Retention of Veterinarians in Shelter Medicine

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Shelter medicine has grown considerably over recent years with many shelters hiring veterinarians for the first time or expanding their veterinary teams. As a result, there is a dearth of shelter veterinarians and retention has become a key concern for the field. The goal of this study was to describe veterinarians' perceptions of shelter medicine, and their feelings of job satisfaction, loneliness, and professional fulfillment. The sample included 52 shelter veterinarians, 39 previous shelter veterinarians and 130 non-shelter veterinarians ($n = 221$) who each completed an online survey. Current and previous shelter veterinarians had comparable perceptions regarding the appeal of most shelter medicine duties, although there were differences in the duties they performed within their job. More current shelter veterinarians participated in population management, policy development, administrative duties, and decision-making for individual patients (euthanasia, treatment, and adoptability). Considering other employment attributes, we found previous shelter veterinarians had lower mean rankings than current and non-shelter veterinarians regarding their interactions with administrative staff, ability to be part of a multiple veterinarian team and the availability of mentorship. Loneliness and professional fulfillment were mostly comparable between the groups, although previous shelter veterinarians were more likely to report they felt unhappy ($X^2 = 16.60$, $p = 0.02$) and left out at work ($X^2 = 12.43$, $p = 0.02$). Our findings suggest veterinarians who participate in decision-making for patients and shelter management procedures may be more willing to continue working in shelter medicine. Animal shelters should also employ strategies to improve workplace relationships and offer career development opportunities to improve job satisfaction and retention of veterinarians within the field.

Keywords: shelter medicine, retention, veterinarian, job satisfaction, professional fulfillment

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INTRODUCTION

Shelter medicine was formally recognized as a specialty of veterinary medicine by the American Board of Veterinary Practitioners (ABVP) in 2014 (1). Shelter practice differs from traditional companion animal medicine as shelter veterinarians support the health and welfare of individual shelter animals, the population of shelter animals, animals within the community, and public health (2). The responsibilities of shelter veterinarians are wide ranging, including individual

patient care, behavior evaluation, population management, disaster response, policy development for preventative health care, cruelty investigations, and community education (2, 3).

The field of shelter medicine has grown steadily over recent years as shelters increasingly recognize the need for veterinarians to maintain wellness and prevent disease in the shelter environment (2). Many shelters are hiring veterinarians for the first time or expanding their veterinary team (3, 4). Demand is also growing for veterinarians in low-cost spay/neuter clinics and access-to-care community clinics (4). As a result, there is currently a shortage of veterinarians in shelter medicine and retention of shelter veterinarians has become a crucial concern for the field (3, 4).

Animal shelters have implemented a number of strategies to increase recruitment and retention in shelter medicine (4). The average salary of shelter veterinarians has increased considerably over recent years (3) and is now equivalent to the median salary of private practice veterinarians (5). The field has also seen an increase in the provision of benefits, such as health insurance and paid continuing education leave (3). However, preliminary evidence shows shelter veterinarians continue to leave the field due to poor relationships with management, poor work/life balance, internal criticism, inadequate staffing/budget, and inadequate input in operations (4). Occupational stress, burnout, and compassion fatigue (a unique form of stress and burnout in which individuals have a reduced capacity to show empathy) are also key concerns for the field of veterinary medicine (6). Shelter veterinarians may be particularly susceptible to feelings of stress and burnout due to euthanasia-related duties within their role and the caring-killing paradox, i.e., the notion that shelter staff must kill the animals for whom they have been providing care (7). On the other hand, high levels of job satisfaction and professional fulfillment, which includes feelings of happiness, engagement, and meaningfulness at work (8), can reduce feelings of burnout in the veterinary profession (9).

There is negligible existing research that has investigated characteristics of employment in shelter medicine relative to turnover or retention of shelter veterinarians. Understanding these characteristics is crucial to the continued growth of the field, so the aim of this study was to investigate veterinarians' perceptions of common duties and attributes of employment in shelter medicine, and veterinarians' feelings of job satisfaction, loneliness, and professional fulfillment.

METHODS

Protocol

Veterinarians were recruited to participate in this study between September 1st 2020 and March 1st 2021 through social media postings, relevant industry groups, and email listservs, such as the Association of Shelter Veterinarians' listserv and the American Association of Veterinary Medical College's (AAVMC) Primary Care Veterinary Educators listserv. The study was also shared in the University of Pennsylvania School of Veterinary Medicine alumni newsletter and the ABVP newsletter. Veterinarians from all fields of veterinary medicine were eligible to participate in the study and were categorized into 3 groups based on their employment history: (1) current shelter veterinarians who were employed in shelter medicine at the time of completing the survey; (2) previous shelter veterinarians who worked in shelter medicine previously but were not working in the field at the time of completing the survey; and (3) non-shelter veterinarians who were qualified veterinarians who had never worked in shelter medicine. We included current and previous shelter veterinarians to identify characteristics of shelter medicine that may be related to retention in the field. The non-shelter veterinarians served as a control group. The study was exempt from review by the University of Pennsylvania Institutional Review Board (Protocol No. 843889). All study participants provided informed written consent prior to completing the survey.

Questionnaire

Qualtrics was used to administer the questionnaire, and all responses were recorded anonymously. The full questionnaire is provided in the **Supplementary Material** and included questions under 3 main sections: (1) demographics and employment characteristics; (2) perceptions of shelter medicine duties and attributes of employment in shelter medicine; and (3) job satisfaction, loneliness and professional fulfillment. The demographic questions included the participant's age, gender, race, ethnicity, education, and student loan debt. Participants were then asked questions about their current employment including the field of veterinary medicine, employment type (full time, part-time, etc.), length of employment, and salary.

The second part of the questionnaire required participants to rate the appeal of 25 common duties of shelter medicine on a 5-point scale from very unappealing (1) to very appealing (5). We then asked participants to rate the influence of 23 characteristics of shelter medicine on their willingness to work in the field, ranging from strongly discourage (1) to strongly encourage (5). These questions were developed based on the core duties and tasks of shelter veterinarians identified through the 2007 DACUM (Developing A Curriculum) analysis and described in the ABVP applicant handbook (2), as well as previous research from Kreisler, Spindel et al. (3), and the experiences of the authors and other experts within the field. Each of the duties and characteristics of shelter medicine were presented in a randomized order in Qualtrics to avoid possible order effects.

The final section of the questionnaire asked participants to rate their overall job satisfaction on a 5-point scale from very dissatisfied (1) to very satisfied (5). Participants were also asked if they would change the number of hours they worked per week. Possible answers included 'work fewer hours for less compensation', 'work more hours for more compensation' or 'work the same number of hours for the same compensation'(10). We also included 3 questions about feelings of loneliness at work from the UCLA-3 loneliness scale (a valid and reliable tool to assess loneliness (11)), whereby respondents had to indicate how often they felt each statement was applicable to them. Answers ranged from hardly ever (1), to some of the time (2), and often (3). A UCLA-3 score was calculated as the sum of all items (11). Finally, we included 6 statements from the professional fulfillment scale of the Professional Fulfillment Index (PFI), such

as "I feel in control when dealing with difficult problems at work" (8). Participants could respond to each statement on a 5-point scale from not at all true (0) to completely true (4). A professional fulfillment scale score was then calculated as the average of the 6 items. Previous shelter veterinarians were instructed to answer these questions regarding job satisfaction, loneliness, and professional fulfillment in reference to their previous role.

Statistical Analysis

Statistical analyses were conducted in SPSS (IBM SPSS Statistics version 27). Pearson Chi-Square tests, or Fisher Exact tests where more than 20% of cells had expected values <5, were used to examine differences in demographic characteristics between the groups. Kruskal-Wallis tests with *post hoc* analyses including Bonferroni correction were used to compare the median responses of shelter veterinarians, previous shelter veterinarians, and non-shelter veterinarians regarding the appeal of common shelter medicine duties and the importance of employment attributes. Kruskal-Wallis tests were also used to investigate job satisfaction and UCLA-3 loneliness scores between the groups of veterinarians. A one-way ANOVA was used to compare the professional fulfillment scale score between current, previous, and non-shelter veterinarians. Responses to individual items within the UCLA-3 loneliness scale and the professional fulfillment scale were assessed using Pearson's Chi Square. Pearson's Chi Square/Fisher Exact tests were also used to examine the relationship between veterinarians' student loan debt and the importance of salary, employee benefits and loan forgiveness programs in shelter medicine, as well as the relationship between desired work hours and the importance of the regularity of work hours, number of work hours, the appeal of being on-call and the appeal of working on weekends. $P < 0.05$ was considered statistically significant.

RESULTS

Demographic Characteristics

Fifty-two shelter veterinarians, 39 previous shelter veterinarians and 130 non-shelter veterinarians completed the survey, including graduates from 46 veterinary medical university programs across Australia, Canada, United States, Scotland, England, West Indies, New Zealand, Italy, the Netherlands, and the Philippines. The University of Pennsylvania (36%) and Cornell University (9%) were the most represented universities. The non-shelter veterinarians in this study primarily worked in small animal practice ($n = 74$, 57%) and academia ($n = 36$, 28%), although there were a few veterinarians from mixed practice ($n = 3$), equine ($n = 4$), exotics ($n = 2$), laboratory animal ($n = 4$), research ($n = 3$), and regulatory/policy ($n = 2$). One large animal veterinarian and 1 government veterinarian also completed the survey. Of the 39 previous shelter veterinarians, 25 had moved to small animal practice, 12 had moved to academia, 1 worked in government and 1 worked in regulatory/policy. Most previous shelter veterinarians had left the field 3–5 years ago ($n = 13$, 33%) or <1 year ago ($n = 10$, 26%), although some veterinarians had left shelter medicine more than 20 years prior.

The descriptive characteristics of the sample are provided in **Table 1**. There were no significant differences in gender ($X^2 = 5.76$, $p = 0.16$), age ($X^2 = 11.60$, $p = 0.07$), or race ($X^2 = 13.77$, $p = 0.17$), although salary differed between current, previous, and non-shelter veterinarians ($X^2 = 27.61$, $p = 0.001$). *Post hoc* analysis with standardized residuals showed current shelter veterinarians were more likely to earn $50,000–$99,999, while non-shelter veterinarians were more likely to earn <$50,000 or $100,000–$149,999. There were no significant differences in outstanding student loan debt ($X^2 = 6.53$, $p = 0.32$) or student loan debt at the time of graduation between the groups ($X^2 = 2.13$, $p = 0.94$).

For both current and previous shelter veterinarians, the length of employment in shelter medicine ranged from <1 year to more than 20 years. For current shelter veterinarians, 27% had been employed for 3–5 years, 23% had been employed for 5–10 years and 25% had been employed for 11–20 years. Among previous shelter veterinarians, 31% were employed for 1–2 years, 28% were employed for 3–5 years and 21% were employed for 11–20 years prior to leaving the field. There were no significant differences in the length of employment between previous and current shelter veterinarians ($X^2 = 6.66$, $p = 0.25$).

There were no significant differences between current, previous, and non-shelter veterinarians ($X^2 = 6.75$, $p = 0.16$) when asked if they would change the number of hours they worked per week. Most veterinarians would choose to continue working the same number of hours with no change to their compensation (59%), although 25 % would prefer to work fewer hours for a lower level of compensation and 16% would prefer to work more hours for a higher level of compensation.

Likelihood of Future Employment in Shelter Medicine

Most non-shelter veterinarians were extremely unlikely (41%) or somewhat unlikely (22%) to consider working in shelter medicine in the future, while 14% were somewhat likely and 11% were extremely likely to consider future employment in the field. Comparatively, 21% of previous shelter veterinarians were extremely unlikely and 18% were somewhat unlikely to work in shelter medicine in the future. A larger portion of previous shelter veterinarians were somewhat likely (23%) or extremely likely (28%) to consider working in shelter medicine.

Duties of Shelter Medicine

Table 2 displays the median appeal of common shelter medicine duties for current, previous, and non-shelter veterinarians. There were no significant differences between current and previous shelter veterinarians in the appeal of most duties, with one exception: population management. Previous shelter veterinarians reported a significantly lower mean rank regarding the appeal of population management compared with current shelter veterinarians. Non-shelter veterinarians reported significantly lower mean ranks than current and previous shelter veterinarians across a number of duties, including spay/neuter, pediatric spay/neuter, other surgery, and the development of

TABLE 1 | Descriptive characteristics of study sample.

	Shelter veterinarians (*n*=52)		Previous shelter veterinarians (*n* = 39)		Non-shelter veterinarians (*n* = 130)	
Characteristics	**%**	***N***	**%**	***N***	**%**	***N***
Gender						
Female	90.4	47	74.4	29	86.2	112
Male	9.6	5	25.6	10	13.1	17
Other	0	0	0	0	0.8	1
Age						
20–29 years	19.2	10	5.1	2	21.5	28
30–39 years	36.5	19	28.2	11	32.3	42
40–49 years	26.9	14	23.1	9	20.0	26
>49 years	17.3	9	43.6	17	26.2	34
Race						
American Indian/Alaskan Native	0	0	0	0	1.5	2
Asian	1.9	1	5.1	2	0	0
Black/African American	0	0	0	0	0.8	1
Hispanic/Latino	1.9	1	2.6	1	4.6	6
White	94.2	49	82.1	32	90.0	117
Mixed race	1.9	1	2.6	1	1.5	2
Prefer not to answer	0	0	7.7	3	1.5	2
Current student loan debt						
<$50,000	46.2	24	66.7	26	57.7	75
$50,000–$149,999	21.2	11	12.8	5	20.0	26
≥$150,000	32.7	17	17.9	7	20.8	27
Prefer not to answer	0.0	0	2.6	1	1.5	2
Student loan debt at graduation						
<$50,000	30.8	16	33.3	13	36.9	48
$50,000–$149,999	28.8	15	33.3	13	26.9	35
≥$150,000	40.4	21	33.3	13	34.6	45
Prefer not to answer	0.0	0	0.0	0	1.5	2
Salary						
<$50,000	3.8	2	10.3	4	**15.4**	**20**
$50,000–$99,999	**55.8**	**29**	35.9	14	20.8	27
$100,000–$149,999	36.5	19	38.5	15	**39.2**	**51**
≥150,000	1.9	1	10.3	4	16.2	21
Prefer not to answer	1.9	1	5.1	2	8.5	11

Bold text indicates there was a statistically significant difference based on Pearson Chi-Square ($p < 0.05$).

health care policies or standard operating procedures (SOP). Non-shelter veterinarians also rated population management, humane euthanasia, euthanasia decision-making, administrative responsibilities, being on-call for emergencies, forensics/cruelty investigations, and testifying in court as significantly less appealing compared with current shelter veterinarians.

Current and previous shelter veterinarians differed in the duties they performed as part of their job in shelter medicine. A significantly higher percentage of current shelter veterinarians undertook population management, euthanasia decision-making, administrative responsibilities, treatment decisions, adopt-ability decisions, health care and SOP development and forensics/cruelty investigations (**Table 3**).

We also categorized veterinarians based on their desired work hours (fewer, the same, more) to examine the relationship between desired work hours and the appeal of being on-call or working weekend hours. In both cases, the relationship was not statistically significant (≥0.63).

Characteristics of Shelter Medicine

Table 4 shows how characteristics of shelter medicine encouraged or discouraged current, previous, and non-shelter veterinarians' from working in the field. Previous shelter veterinarians had significantly lower mean rankings regarding the impact of promoting animal welfare, the ability to access employee benefits, opportunities for career development, and the availability of mentorship. They also had lower rankings for their interactions with administrative staff, their interactions with shelter veterinarians/staff, and

TABLE 2 | Kruskal-Wallis tests describing differences in appeal of duties of shelter medicine between current, previous and non-shelter veterinarians.

	Current shelter veterinarians		Previous shelter veterinarians		Non-shelter veterinarians		X^2	*P* value
	Median (IQR)	Mean rank	Median (IQR)	Mean rank	Median (IQR)	Mean rank		
Spay/neuter	5 (4–5)	142.29	5 (4–5)	134.64	**4 (2–5)**	**91.39**	**32.93**	**<0.001**
Pediatric spay/neuter	5 (4–5)	150.13	4 (3–5)	131.50	**3 (2–4)**	**89.20**	**40.89**	**<0.001**
Other surgery	5 (4–5)	134.67	4 (3–5)	125.99	**4 (2–4)**	**97.03**	**16.65**	**<0.001**
Population management	4 (3–5)	144.37	**4 (3–5)**	**112.32**	**3 (2–4)**	**97.26**	**21.36**	**<0.001**
Humane euthanasia	3 (3–3)	131.11	3 (2–3)	108.63	**2 (1–3)**	**103.27**	**8.57**	**0.01**
Euthanasia decisions	3 (3–3)	130.24	3 (2–3)	110.81	**2 (1–3)**	**103.36**	**7.24**	**0.03**
Administrative responsibilities	3 (2–4)	130.24	3 (1–4)	113.32	**2 (1.75–3)**	**102.61**	**7.46**	**0.02**
Physical exams	4 (4–5)	119.03	4 (3–5)	118.27	4 (3–4.25)	105.61	2.54	0.28
Treatment decisions	4.5 (4–5)	124.42	4 (4–5)	121.41	4 (4–5)	102.51	**6.56**	**0.04**
Adopt–ability decisions	4 (3–4)	124.63	3 (3–4)	117.05	3 (2–4)	103.73	4.71	0.10
Behavior evaluations	4 (3–4)	126.97	3 (3–4)	110.99	3 (2–4)	104.62	4.87	0.09
Developing health care policies and/or SOPs	4 (3.25–5)	134.89	4 (3–5)	127.15	**3.5 (2–4)**	**96.60**	**17.52**	**<0.001**
On call for emergencies	2 (1–3)	124.88	2 (1–3)	122.82	**1 (1–2)**	**101.91**	**8.04**	**0.02**
Working on weekends	1 (1–2)	112.63	1 (1–2)	112.05	1 (1–2)	110.03	0.09	0.96
Forensics/cruelty investigations	3.5 (2.25–4)	135.91	3 (2–4)	116.94	**2 (1–4)**	**99.25**	**13.34**	**0.001**
Testifying in court	3 (2–4)	127.52	3 (1–4)	116.24	**2 (1–4)**	**102.82**	**6.30**	**0.04**
In house laboratory procedures	4 (3–4)	106.85	3 (3–4)	109.92	4 (3–4)	112.98	0.39	0.82
Development/fund raising	3 (2–3)	107.68	3 (2–4)	118.58	3 (1–4)	110.05	0.76	0.68
Humane education	4 (3–4)	99.88	4 (3–4)	104.41	4 (3–5)	117.42	3.64	0.16
Community education	4 (3–4)	97.59	4 (3–5)	107.77	4 (4–5)	117.33	4.18	0.12
Outreach clinics	4 (3.25–5)	107.64	5 (3–5)	125.24	4 (4–5)	108.07	2.67	0.26
Access-to-care clinics	4 (3–5)	109.09	4 (3–5)	121.67	4 (3–5)	108.57	1.46	0.48
Developing emergency preparedness plans	3.5 (3–4)	110.44	3 (3–4)	115.69	3.5 (2.75–4)	109.82	0.28	0.87
Staff training	4 (3–4)	124.53	4 (3–4)	117.41	4 (3–4)	103.67	4.89	0.09
Staff supervision	3 (2–4)	113.91	3 (2–4)	117.03	3 (2–4)	108.03	0.78	0.68

Possible range from 1 (very unappealing) to 5 (very appealing).
Bold text indicates there was a statistically significant difference based on Kruskal-Wallis H test and post-hoc pairwise comparisons with Bonferroni correction.

the ability to be part of a multiple veterinarian team. Non-shelter veterinarians had lower mean ranks regarding the importance of their ability to promote animal welfare in shelter medicine, their interactions with shelter veterinarians/staff, their confidence in performing common shelter medicine procedures and the ability to perform duties without interacting with pet owners. In other words, current shelter veterinarians were encouraged to seek employment in shelter medicine based on these attributes at a higher rate than previous and non-shelter veterinarians.

We then grouped veterinarians based on their current outstanding loan debt and their loan debt at graduation (<$50,000, $50,000–$149,999 and ≥150,000). With increasing student loan debt (both current and at the time of graduation), we found the importance of employee benefits ($p \leq 0.03$) and loan forgiveness increased ($p < 0.001$). There was no significant relationship between current or graduation loan debt and the importance of salary ($p \geq 0.11$). Veterinarians' desired work hours (fewer, the same, more) were also not associated with the importance of the number and regularity of work hours when considering employment in shelter medicine (≥0.21).

Job Satisfaction, Loneliness, and Professional Fulfillment

There was a significant difference in job satisfaction between the 3 groups of veterinarians ($X^2 = 9.14$, $p = 0.01$), with *post hoc* analyses indicating there was a significant difference between current and previous shelter veterinarians (**Figure 1**). Current shelter veterinarians had a median response of 5 ("very satisfied," IQR 4-5) and mean rank of 125.74. Previous shelter veterinarians had a median response of 4 ("somewhat satisfied," IQR 3-5) and a mean rank of 88.13. There was no significant difference between non-shelter veterinarians and either of the two groups of shelter veterinarians.

Current, previous, and non-shelter veterinarians reported relatively low levels of loneliness at work with a median score of 4 (possible range 3–9) and there was no statistically significant difference between the groups ($X^2 = 4.82$, $p = 0.09$). Considering the loneliness questions individually, we found current, previous, and non-shelter veterinarians did not differ in their feelings of companionship ($X^2 = 3.20$, $p = 0.53$) or isolation at work ($X^2 = 5.10$, $p = 0.28$). Most veterinarians said they hardly ever lacked companionship at work (53%), although 37% said they lacked

TABLE 3 | Frequency of common duties of shelter medicine among current and previous shelter veterinarians.

	Shelter veterinarian (%)	Previous shelter veterinarian (%)	X^2	*P* value
Spay neuter	84.6	87.2	0.12	0.77
Pediatric spay/neuter	84.6	74.4	1.48	0.29
Other surgery	84.6	71.8	2.22	0.19
Population management	**69.2**	**46.2**	**4.92**	**0.03**
Euthanasia	78.8	64.1	2.43	0.16
Euthanasia decisions	**88.5**	**66.7**	**6.41**	**0.02**
Administrative responsibilities	**59.6**	**30.8**	**7.44**	**0.01**
Physical exams	90.4	87.2	0.23	0.74
Treatment decisions	**96.2**	**82.1**	**4.97**	**0.04**
Adopt-ability decisions	**71.2**	**46.2**	**5.83**	**0.02**
Behavior evaluation	40.4	30.8	0.89	0.39
Developing health care policies and SOPs	**78.8**	**56.4**	**5.27**	**0.04**
On-call for emergencies	50.0	35.9	1.80	0.21
Weekend hours	48.1	38.5	0.84	0.40
Forensics/cruelty investigations	**53.8**	**30.8**	**4.82**	**0.03**
Testifying in court	38.5	28.2	1.04	0.37
Laboratory procedures	38.5	25.6	0.53	0.61
Fund raising	19.2	25.6	0.53	0.61
Humane education	32.7	28.2	0.21	0.65
Community education	46.2	35.9	0.96	0.39
Outreach clinics	65.4	53.8	1.24	0.29
Access-to-care clinics	40.4	28.2	1.45	0.27
Emergency preparedness	32.7	20.5	1.66	0.24
Staff training	71.2	48.7	4.74	**0.05**
Staff supervision	67.3	51.3	2.39	0.14

Bold text indicates there was a statistically significant difference based on Pearson Chi-Square ($p < 0.05$).

companionship some of the time and 10% lacked companionship often. Similarly, 60% of veterinarians hardly ever felt isolated from others, 30% felt isolated some of the time and 10% often felt isolated. However, there was a significant difference between the groups in terms of feeling left out at work ($X^2 = 12.43$, $p = 0.02$), with a greater proportion of previous shelter veterinarians (21%) reporting they often felt left out compared with 15% of current shelter veterinarians and 5% of non-shelter veterinarians.

Veterinarians' feelings of professional fulfillment are shown in **Figure 2**. Current, previous, and non-shelter veterinarians differed in terms of how often they felt happy at work ($X^2 = 16.60$, $p = 0.02$), with significantly more previous shelter veterinarians reporting they did not feel happy at work at all. There were no differences between the groups in the total professional fulfillment score [$F_{(2, 217)} = 0.83$, $p = 0.44$] with a mean response of 2.66 (possible range 0–4).

DISCUSSION

The goal of this study was to investigate the attributes of employment in shelter medicine that contribute to retention of veterinarians in the field. For the most part, there were no significant differences in the appeal of common shelter medicine duties between current and previous shelter veterinarians which suggests respondents were not motivated to leave shelter medicine due to a dislike of the job *per se*. The one exception was population management which was rated as significantly more appealing among current veterinarians compared with previous shelter veterinarians. A higher proportion of current shelter veterinarians in this study performed population management compared with previous shelter veterinarians, so it is possible that previous shelter veterinarians provided lower rankings due to their potentially limited understanding of what population management entails. It is also possible that previous shelter veterinarians were not exposed to population management if they left the field years ago, or that some veterinarians were required to undertake population management that would not be considered best practice by today's standards. The differing perceptions of population management between current and previous shelter veterinarians provides an interesting question for future research.

Non-shelter veterinarians found many of the common shelter medicine duties significantly less appealing than the other two groups, although 25% of non-shelter veterinarians indicated they were likely or extremely likely to seek employment in shelter medicine. More than half the previous shelter veterinarians

TABLE 4 | Kruskal-Wallis tests describing differences in the impact of characteristics of shelter medicine between current, previous, and non-shelter veterinarians.

	Current shelter veterinarians		Previous shelter veterinarians		Non-shelter veterinarians		X^2	*P*
	Median	Mean rank	Median	Mean rank	Median	Mean rank		
Salary expectations	2 (2–4)	107.02	3 (2–3)	112.10	3 (2–4)	112.26	0.28	0.87
Employee benefits	4 (3–5)	125.24	**3 (3–4)**	**71.97**	4 (3–5)	117.01	**19.96**	**<0.001**
Access to loan forgiveness	3 (3–5)	114.87	3 (3–4)	96.19	3 (3–5)	113.90	3.14	0.21
Regularity of work hours	4 (4–5)	122.43	4 (3–4)	92.19	4 (3–5)	112.07	0.57	0.06
Number of work hours	4 (3–4)	118.80	3 (3–4)	100.79	3 (3–4)	110.94	1.94	0.38
Workload	3 (2–4)	108.31	3 (2–4)	114.47	3 (2–4)	111.03	0.22	0.89
Promote animal welfare	5 (5–5)	142.05	**4 (4–5)**	**110.15**	**4 (4–5)**	**98.83**	**20.44**	**<0.001**
Provide community service	4 (4–5)	123.47	4 (4–5)	108.86	4 (4–5)	106.65	3.06	0.22
Opportunities for career development	4 (3–4.75)	127.27	**3 (2–4)**	**77.67**	4 (3–4)	114.49	**15.66**	**<0.001**
Perception of shelter medicine	3 (3–4)	116.35	3 (2–3)	101.92	3 (3–3)	111.58	1.44	0.49
Ability to find internship/ residency	3 (3–3.75)	119.87	3 (3–3)	102.85	3 (3–3)	109.90	2.59	0.27
Ability to find suitable jobs	4 (2–4)	118.59	3 (2–4)	110.85	3 (3–4)	108.01	1.11	0.58
Location of shelters	3 (3–4)	114.36	3 (3–4)	103.58	3 (3–4)	111.88	0.77	0.68
Opportunity to educate/ interact with owners	4 (3–4)	107.63	3 (3–4)	95.27	4 (3–4)	117.07	4.10	0.13
Opportunity to perform duties without interacting with pet owners	4 (4–5)	134.20	4 (3–5)	110.71	**4 (3–5)**	**101.81**	**10.46**	**0.01**
Strong emphasis on shelter live release rates	4 (3–4)	114.91	4 (3–4)	114.90	4 (3–4)	108.27	0.63	0.73
Risk of compassion fatigue, burnout or stress	2 (2–3)	114.02	2 (2–3)	125.62	2 (2–3)	105.41	3.66	0.16
Confidence in performing procedures	5 (4–5)	148.82	4 (4–5)	130.55	**4 (3–4)**	**90.01**	**39.73**	**<0.001**
Organizational policies/procedures	3 (2–4)	121.03	3 (2–3)	99.37	3 (2–4)	110.48	2.77	0.25
Interactions with administrative staff	3 (2–4)	116.53	**3 (2–3)**	**84.71**	3 (3–4)	116.68	**8.92**	**0.01**
Availability of mentorship	3 (3–4)	110.04	**3 (3–4)**	**87.91**	4 (3–4)	118.31	**7.55**	**0.02**
Ability to be part of a multiple veterinarian team	4 (4–5)	126.24	**3 (3–5)**	**89.10**	4 (3.75–5)	111.47	**8.48**	**0.01**
Interactions with shelter veterinarians/staff	4 (4–5)	137.33	**4 (3–5)**	**105.15**	**4 (3–4)**	**102.22**	**13.08**	**0.001**

Possible range from 1 (strongly discourage) to 5 (strongly encourage). Bold text indicates there was a statistically significant difference based on Kruskal-Wallis H test and post-hoc pairwise comparisons with Bonferroni correction.

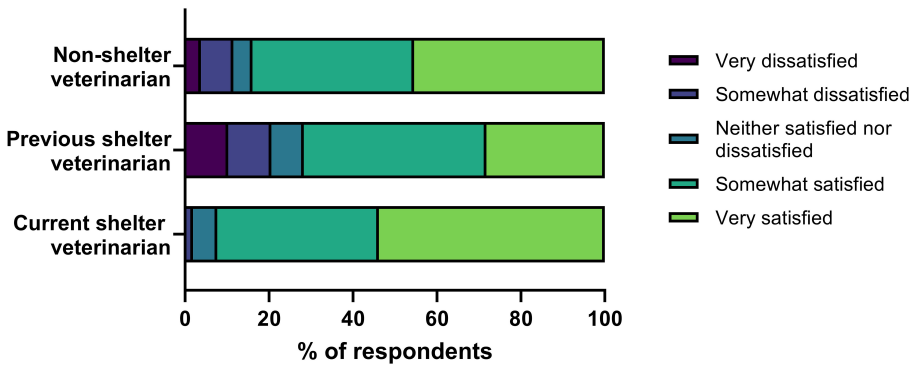

FIGURE 1 | Job satisfaction in veterinary medicine.

also reported interest in shelter medicine which emphasizes the potential for animal shelters to attract these veterinarians to open shelter positions in the right conditions.

Despite the comparable ratings of shelter medicine duties between current and previous shelter veterinarians, we found significant differences in the duties they performed as part of their jobs. More current shelter veterinarians made euthanasia decisions, treatment decisions and adopt-ability decisions, performed administrative responsibilities, population management, forensics investigations, and staff training, and developed health care policies and/or SOPs, suggesting these duties may be important for job satisfaction and retention. In particular, it seems veterinarians who can participate in decision-making regarding individual patients' treatments and outcomes and shelter management policies may be more inclined to continue working in shelter medicine. Previous research in

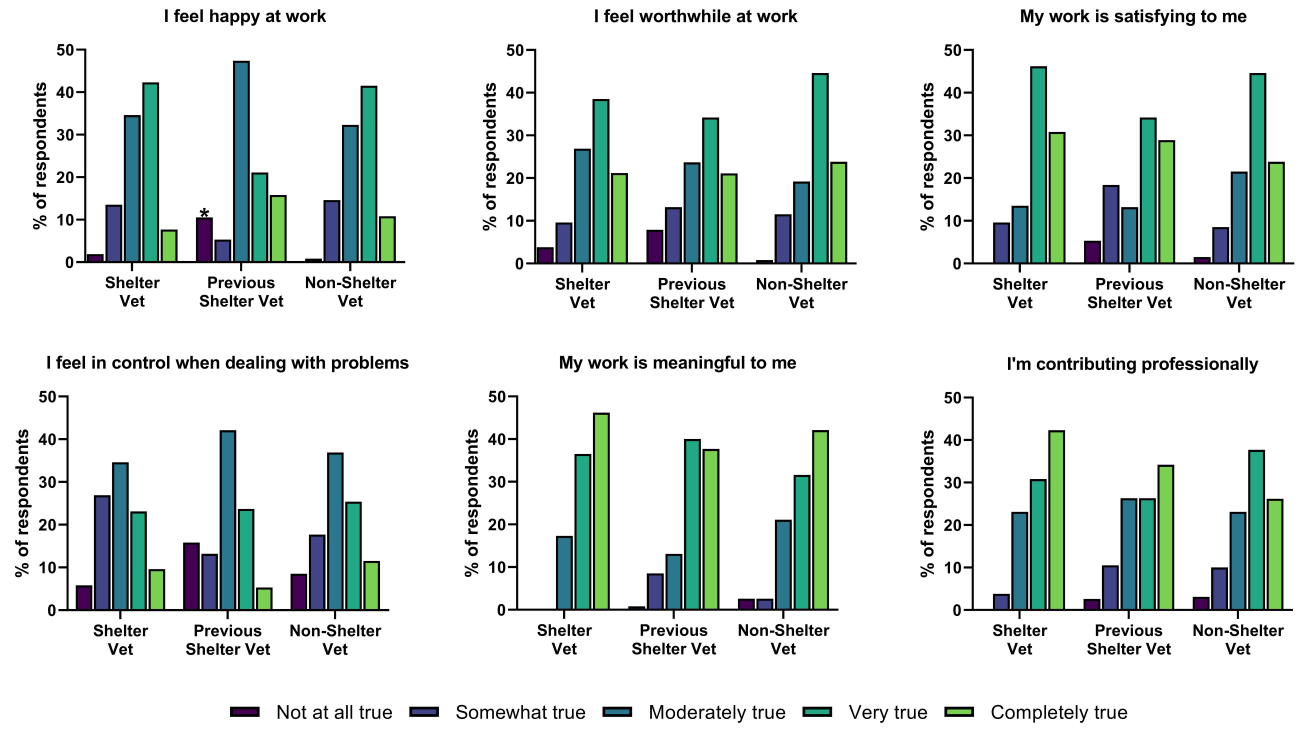

FIGURE 2 | Professional fulfillment in veterinary medicine.

animal shelters has found staff involvement in euthanasia-decision making could help to reduce occupational stress related to euthanasia (12). Employee participation in decision-making has also been associated with job satisfaction, commitment, and effort across other industries (13, 14). The differing duties of current and previous shelter veterinarians could also be explained, at least in part, by the evolving nature of the field. Between 2011 and 2018, the frequency of veterinarians who made adopt-ability decisions, developed health care policies, and/or SOPs, testified in court, and participated in forensics/cruelty investigations increased significantly (3). It is therefore possible that veterinarians who left the field years ago did not have the opportunity to perform these duties.

Current shelter veterinarians, like previous and non-shelter veterinarians, reported being on call for emergencies and working on weekends were highly discouraging when they considered their employment in shelter medicine. These responsibilities appear to be universally unappealing, so minimizing these tasks could help to boost recruitment and retention of shelter veterinarians.

Our findings suggest that veterinary retention in shelter medicine is also impacted by employment characteristics, particularly those related to career development and workplace relations. Previous shelter veterinarians indicated their opportunities for career development and the availability of mentorship in shelter medicine deterred them from seeking employment in the field more so than current and non-shelter veterinarians. Employees' perceived career opportunities and the availability of career mentoring has been shown to predict employee turnover in non-animal related services (15, 16). Students and veterinarians have also recognized the importance of mentorship in the veterinary profession (17, 18). However, in a New Zealand study of recent veterinary graduates, almost half of the respondents reported they did not regularly meet with their supervisor to discuss their work or have a clear plan to develop their skills or experience. Not surprisingly, inadequate support was one of the key reasons that new graduates in the study had left their employment position (19). Many U.K. veterinary graduates have also described inadequate support from mentoring veterinarians (20). However, mentorship requires veterinarians to provide additional time and support and many veterinarians do not have sufficient training or resources to support new graduates (21). Taken together, these findings illustrate the importance of mentorship in veterinary practice and suggest animal shelters should endeavor to provide robust mentorship programs to increase recruitment and retention.

Previous shelter veterinarians also had lower ratings regarding their interactions with administrative staff and shelter veterinarians/veterinary staff, and their ability to be part of a multiple veterinarian team. A lack of peer support is a common workplace stressor for veterinarians, particularly female veterinarians (22). Interpersonal conflict in veterinary teams has been associated with the occurrence of workplace bullying, poor mental health, poor physical health and increased turnover intention (23). Toxic work environments have also been associated with decreased job satisfaction, increased

cynicism, and burnout in veterinary medicine (9). Evidence also suggests workplace social support networks are crucial for veterinarians in the management of occupational stress and burnout (6, 9). Scotney, McLaughlin et al. (6) suggested the positive impact of a strong social support system at work may counteract the negative feelings of stress and burnout. Therefore, previous shelter veterinarians in the current study that felt ill-supported by administrative staff and their veterinary colleagues may have been more susceptible to burnout, stress, and compassion fatigue; phenomena that are all prevalent in the field of shelter medicine (6, 7, 24). Future research is needed to determine the prevalence and impact of workplace conflict in animal shelters and to develop interventions targeting improved workplace relations.

The importance of accessing employee benefits was also ranked significantly lower among previous shelter veterinarians compared with other veterinarians. It is not clear whether the ability to access employee benefits was simply less important for previous shelter veterinarians when considering their willingness to work in the field or whether previous shelter veterinarians believed the field of shelter medicine did not provide adequate employee benefits. The provision of employee benefits has increased significantly over recent years (3), so shelter veterinarians that left the field years ago may not have had access to the range of benefits that are offered to veterinarians today.

Veterinarians' ratings regarding the importance of accessing employee benefits and loan forgiveness programs were also impacted by their outstanding student loan debt and level of debt at the time of graduation. In both cases, veterinarians with a higher level of debt were more likely to indicate the provision of employee benefits and loan forgiveness programs encouraged them to seek employment in shelter medicine. Interestingly, the role of salary was not impacted by loan debt which suggests veterinarians with high loan debt placed an increased importance on loan forgiveness and benefits, perhaps due to the volume and burden of debt, compared with smaller differences in salary. Our findings support the increasing provision of employee benefits in the field (3) and the continued application of public service loan forgiveness programs. Animal shelters could also highlight the ability to access loan forgiveness programs as a benefit of the job when recruiting shelter veterinarians.

While the vast majority of veterinarians in this study were satisfied with their job, mirroring previous research from Australia (25), job satisfaction was significantly lower among previous shelter veterinarians. A higher proportion of previous shelter veterinarians also reported they did not feel happy at work and often felt left out which may be attributable, at least in part, to exclusion from the decision-making process and leadership roles. Although the overall scores for the loneliness scale were similar between the groups, 47% of veterinarians indicated they lacked companionship at least some of the time. Loneliness at work has been associated with emotional withdrawal from the employer and decreased work performance (26, 27). In veterinary medicine, poor job performance could have dire consequences for patients, including disability or death, which further emphasizes the need for animal shelters to address workplace culture and team relations.

Levels of professional fulfillment were not significantly different between the groups of veterinarians, although we found there were no current shelter veterinarians who felt their work was not at all satisfying or meaningful or who felt they were not contributing professionally compared with previous and non-shelter veterinarians. It seems current shelter veterinarians in this study recognized the importance of their work in shelter medicine which could benefit their well-being and job satisfaction. Future research is needed to further explore workplace satisfaction among shelter veterinarians using additional established questionnaires, such as the Gallup Employee Engagement survey. Veterinarians' feelings of professional fulfillment in this study were also comparable to previous reports from veterinary technicians (28) and human healthcare physicians (8).

Our data suggests the number of work hours was not a key factor driving turnover in shelter medicine. When asked if respondents would change the number of work hours per week, we found comparable responses between current, previous, and non-shelter veterinarians. Although, one quarter of veterinarians wished to work fewer hours for less total compensation. Data from the American Veterinary Medical Association (AVMA) has shown the percentage of veterinarians who want to work fewer hours per week increased between 2014 and 2018. Our findings suggest this trend is continuing. The AVMA reported 20% of veterinarians wished to reduce their weekly work hours in 2019 (29), compared with 25% in the current study in 2020–21. Like the AVMA, we found there was negative underemployment in veterinary medicine meaning there were more veterinarians who wished to work fewer hours per week than there were veterinarians who wished to work more hours per week. Expanding the veterinarian workforce is crucial to allow veterinarians to work at their optimal level and reduce burnout or stress (22, 30).

This study is the first of its kind to investigate retention of veterinarians in shelter medicine relative to common duties and characteristics of shelter medicine, and feelings of professional fulfillment and loneliness. The questionnaire was relatively comprehensive, and the study sample included veterinarians from various countries, universities, and fields of veterinary medicine. However, the study is also subject to some shortcomings. The breadth of questions in the survey meant we could not perform an in-depth analysis of the relationship between individual factors and retention. For instance, burnout is likely to play a role in turnover intention in the veterinary field, although we did not implement a validated tool to assess burnout. Nonetheless, the data provided in this study opens the door for future research to expand upon our findings. Recall bias may also have impacted our findings, particularly for previous veterinarians that left the field many years prior to the survey. We used various avenues to advertise the study and recruit veterinarians, although the sample size was limited which hinders the generalizability of the results. The study sample also included an overrepresentation of veterinarians from the University of Pennsylvania, likely due to the use of Penn Vet social media and newsletter postings to recruit participants. We also found the vast majority of respondents were Caucasian which mirrors the current racial profile of the

veterinary workforce in the U.S. (31), but also reinforces the long-standing need for racial diversity in veterinary medicine (32). Cultural and language barriers in veterinary medicine deter individuals from accessing veterinary care, possibly due to a fear of being judged, exploited, or not being understood (33). Many shelters serve diverse populations, including minorities and underserved individuals, which further emphasizes the need for increased representation and recruitment of racially diverse veterinarians in shelter medicine.

CONCLUSION

We investigated the perceptions of shelter medicine and feelings of job satisfaction, professional fulfillment, and loneliness among current, previous and non-shelter veterinarians. Our findings suggest that the appeal of shelter medicine duties was not a primary factor driving veterinarians to leave the field, although the ability to partake in duties related to shelter management and decision-making for individual patients appeared to be associated with retention of veterinarians in shelter medicine. Characteristics of employment related to career development and team conflict also appeared to impact the turnover of shelter veterinarians. Loneliness and professional fulfillment were comparable across the different fields of veterinary medicine, although previous shelter veterinarians were more likely to report they felt unhappy and left out at work. Animal shelters should employ strategies to improve workplace relationships and offer career development opportunities to improve job satisfaction and retention of veterinarians within the field.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Pennsylvania Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LP, CR, JS, and BW designed the study and interpreted the data. LP collected the data and conducted the statistical analyses and drafted the manuscript. All authors contributed to manuscript revision, and read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2021.732105/full#supplementary-material

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Effect of COVID-19 on Pet Food Bank Servicing: Quantifying Numbers of Clients Serviced in the Vancouver Downtown Eastside, British Columbia, Canada

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Previous research has focused on the benefits and difficulties of pet ownership in people, who are experiencing homelessness. However, many pet services, such as pet food banks, serve a more varied population of people. Furthermore, the effect of the COVID-19 pandemic has not been documented within the context of pet food banks. Vancouver's Downtown Eastside (DTES) population comprises a notable proportion of the city's overall population and has a high density of people who are experiencing financial hardships, but some of whom do not always experience homelessness. The purpose of this study was to gain an understanding of the number of clients and pets that are being serviced by a pet food bank, whether that has changed over time, and if it was impacted by the COVID-19 pandemic. We analyzed available attendance and service records from The British Columbia Society for the Prevention of Cruelty to Animals pet food bank between 2013 and 2020. We found that a median of 100 clients attended the food bank each week and that most of the companion animals serviced were cats (72.5%), then followed by dogs (25.2%), and rats (1.2%). Servicing was not consistent over time, with a weekly pattern of decreased attendance every fourth week of the month, which coincided with income assistance payments. This suggests that either servicing needs are decreased with income assistance or that the week of the month may present an access to care challenge. We also observed a decrease in the clientele attending in 2020 compared to previous years, suggesting an effect of COVID-19. Specifically, this trend was present for cats, rats, rabbits, and "other" companion animals, but not for dogs; the number of dog owners receiving services did not change in 2020, suggesting a difference between needed services in dog vs. other pet owners. The yearly trends shed light on the impact of COVID-19 on vulnerable populations, highlighting the need for additional support through times of crisis. Overall, the data show a complex relationship between pet service provision and other community issues and highlight the need to consider pet food banks within the greater social services networks.

Keywords: homelessness, food bank, companion animal, pets, human-animal bond, COVID-19

INTRODUCTION

The current global pandemic (COVID-19) has had a disproportionate impact on underserved populations (1–3). The pandemic has for instance, increased the level of food insecurity experienced worldwide, which serves to widen the gap between different socio-demographic groups (4–7). Furthermore, in the pandemic context, social work has become increasingly harder to perform due to government restrictions reducing in-person services, coupled with a lack of funding (8). Food banks are included in the social services that have been impacted by the pandemic, and certain cities have made active efforts to enhance offerings to support their populations (9). A deeper look into how the current pandemic has impacted access to social services such as that of pet food banks is paramount to ensure appropriate support is still available to populations in need. At the same time, research showed an increase in the strength of human-animal bonds during the COVID-19 pandemic (10–12), which all points to the importance of providing social structural support so that pet ownership can remain an option to those who benefit.

Research has demonstrated that owning companion animals while experiencing homelessness can have a myriad of mental health benefits (13, 14), and can help prevent the performance of self-destructive behaviors such as drug and alcohol misuse (15, 16). Furthermore, pet ownership in times of difficulty has been specifically shown to increase resiliency in vulnerable populations (17). Most of the current available data on pet-owning populations, who are experiencing financial hardship, are either restricted to those experiencing homelessness (i.e., living on the streets or otherwise unhoused), or focus on public perception of those populations (13, 17–19). However, populations experiencing hardship not only include those that are experiencing homelessness, but also involve people living in low-income housing, experiencing general housing instability, or who are "couch surfing," for example (20–22).

According to previous census data, the Downtown population of Vancouver, British Columbia (B.C.), Canada, comprises over 10% of the city's general population and is heavily marked by special challenges. For instance, 30% of the indicated downtown Vancouver population reports experiencing limitations in their day-to-day activities, often due to disabilities, and that proportion increases to over 50% when specifically looking at Indigenous or elderly populations. The area's population is composed in its majority of male-identified individuals, with female-identified people composing 47% of the population, as opposed to 51% in Vancouver, in general (23). Further, the age profile of residents of the Downtown area does not contain a large number of school-aged children, with those in their 30's making up a large proportion of the population (23). In terms of housing, the Downtown area contains a significantly larger proportion of apartment buildings than does the general city of Vancouver, with about 97% occupancy in the area being in apartment units as opposed to 61% occupancy of apartments in the city, in general. Further, only 3% of homes are semi-detached houses or row houses or duplexes. Last, 94% of homes in the area are composed of two bedrooms or less (23). An unknown proportion of people are experiencing housing challenges in downtown Vancouver, and over 25% of that population currently lives below the poverty line (24, 25). The Downtown area also presents a higher proportion of people living alone than that of the general city, at 31% as opposed to 18% for Vancouver. Specifically, the proportion of seniors who live alone in the area is high, sitting at 37% as opposed to 29% for Vancouver in general (23). The area within downtown Vancouver that houses and serves ∼20,000 people with many experiencing financial hardships is generally regarded as the Downtown Eastside (DTES; **Figure 1**), which is ∼4 km^2 and comprises the neighborhoods of Gastown, Chinatown, and Strathcona. A study in the area which focused on drug usage found that 26% of the population examined had an overdose or "life threatening event," and that 3% passed away between October 2015 and January 2019 (26). Anecdotally, the prevalence of companion animals in the DTES of Vancouver is high, however metrics of that population are lacking.

Research has demonstrated that the COVID-19 pandemic has had a disproportionate effect on populations in which opioid usage is high, causing an increase in depression, anxiety, loneliness, and frustration (27). To help address these challenges, government and non-profit organizations make several social support services available in the area (28–30), such as food banks, harm reduction and education centers, and emergency shelters. However, many community services were greatly reduced due to physical distancing requirements. For example, a safe injection site decreased its capacity by 75% resulting in only 6 available stalls (31).

During the pandemic, most veterinary services continued to operate but through virtual appointments and/or with only the animal admitted into the facility. The B.C. Society for the Prevention of Cruelty to Animals (SPCA) was deemed an essential service and thus was allowed to remain open, providing sheltering and veterinary services to Vancouver's pet population. The same was true for "Charlie's," the pet food bank run by the BC SPCA in the DTES area. While at times the pet food bank had fewer available staff, the availability of pet food to the DTES residents throughout the pandemic was overall consistent (32).

We aimed to provide data on the effects of the COVID-19 pandemic on pet food servicing by analyzing past data records from a pet food bank offered by the BC SPCA, which operates in the DTES area (33). Our purpose was to examine services provided to the pet owning DTES population with the goal of characterizing it and to understand whether supportive servicing in the area has been consistent across time. We hypothesized that COVID-19 would affect the numbers of clients serviced. Furthermore, we suspected that the types of services needed (i.e., companion animal species needing services) may differ in a population that is disadvantaged, but not necessarily experiencing homelessness, compared to previously published literature on pet food banks.

METHODS

Data Collection

We collected records from BC SPCA pet food bank "Charlie's" which operates every Thursday from 10 a.m. to 12 p.m. at a

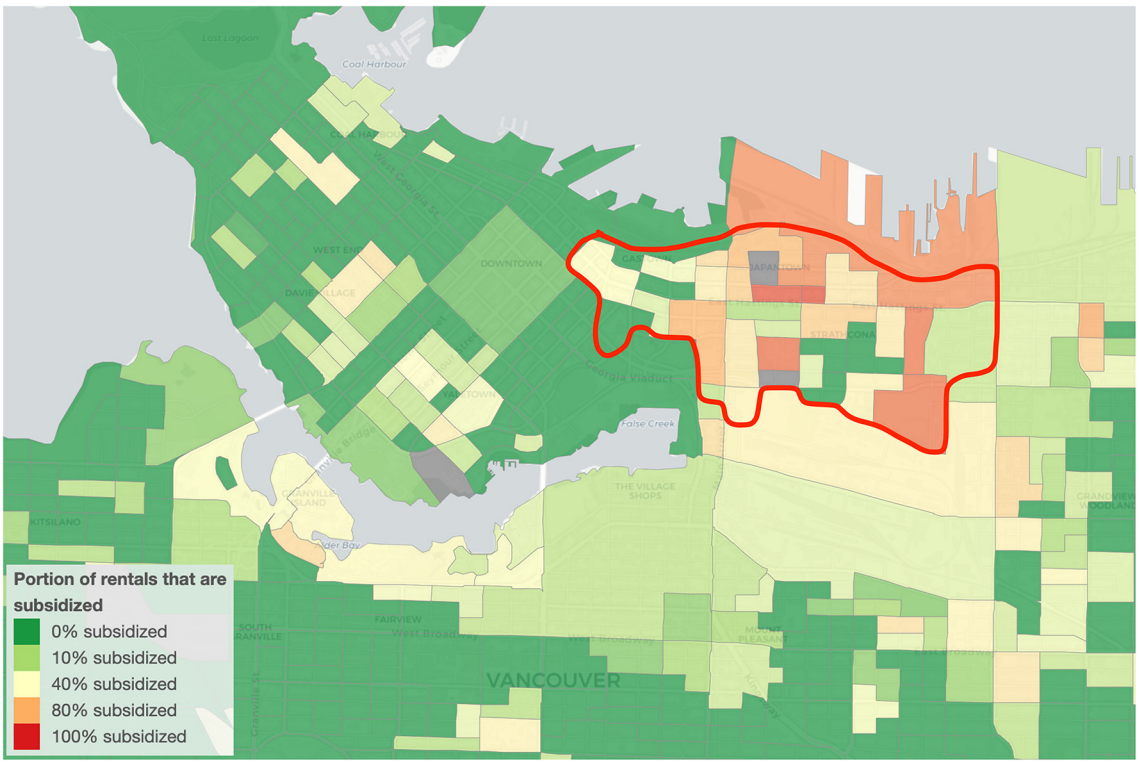

FIGURE 1 | Partial map of Vancouver, B.C., Canada, with the red line outlining the approximate area of the Vancouver Downtown Eastside (DTES). The portion of rentals that are subsidized, taken from 2016 census data, are color-coded as an example of financial challenges of the area. Source: OpenStreetMap; mountainmath.ca/census.

designated location in Vancouver's DTES. The data contained information regarding how many people and how many companion animals were serviced each week of the food bank. Services provided (e.g., nail trims) were also counted in addition to food and litter distribution but were not included in our analysis due to a lack of record-keeping consistency throughout the years. Thus, we refer to "servicing" in this paper, but are only describing pet food and cat litter provision. We aimed to collect records from 2013 to 2020, however 2015 and 2016 records were not found and thus were not included in our analysis. Paper records for 2013 and 2014 were digitized and combined with 2017, 2018, 2019 and 2020 records into a central database. The University of British Columbia Behavioral Research Ethics Board approved all research activities (H20-03807).

Data Analysis

Data curation and analysis were conducted using RStudio Team, 2020 (34). The descriptive data were first analyzed through the calculation of the number of each species of companion animals serviced as a proportion of the total number of animals. Further, the median number of animals and people in attendance each week, as well as interquartile ranges were calculated; this was done as a median for all years, for each year individually, as well as for the combined data for each week of the month. The data were analyzed by conducting a Shapiro-Wilk test for each of the different species to check for normality, which determined that most of the data were normally distributed (all $p < 0.05$, except the quantity of dogs by event was at $p = 0.058$). A total of 12 Kruskal-Wallis one-way analyses of variance were conducted, comparing each group (humans, cats, dogs, rats, rabbits, and "other" animals) in turn by both the year, as well as the week of the month during which the food bank took place. For the comparisons that were statistically significant ($p < 0.05$), Dunn Test *post-hoc* analyses were conducted.

RESULTS

Descriptive Data

The companion animal population serviced was comprised of mostly cats (72.5%), dogs (25.2%), rats (1.2%), rabbits (0.6%), and "other" animals (0.5%). The "other" category contained a vast array of animals such as birds, hamsters, guinea pigs, and chinchillas. Each week, a median of 100 people [interquartile range [IQR] = 44] were serviced by the pet food bank. Further, a median of 108 cats (IQR = 56), 37 dogs (IQR = 16), 1 rat (IQR = 2), 0 rabbits (IQR = 1), and 0 "other" animals (IQR = 1; **Figure 2**).

Yearly Trends

The number of clients and animals serviced was different across sampled years [humans: $H(5) = 72.9$, $p < 0.05$; cats: $H(5) = 63.9$, $p < 0.05$; dogs: $H(5) = 28.3$, $p < 0.05$; rats: $H(5) = 15.6$, $p < 0.05$;

rabbits: H(5) = 13.9, $p < 0.05$; "other": H(5) = 67.7, $p < 0.05$; **Figure 3**].

More people were serviced in 2013 (median = 121, IQR = 51, $p < 0.05$), 2014 (median = 115, IQR = 43, $p < 0.05$), 2017 (median = 95, IQR = 39, $p < 0.05$), 2018 (median = 91, IQR = 31.25, $p < 0.05$), and 2019 (median = 102, IQR = 28.5, $p < 0.05$) when compared to 2020 (median = 63, IQR = 30.5, $p < 0.05$).

The number of cats who received pet food provisions weekly was higher in 2013 (median = 128, IQR = 63, $p < 0.05$), 2014 (median = 122, IQR = 49, $p < 0.05$), 2017 (median = 104, IQR = 49, $p < 0.05$), 2018 (median = 103.5, IQR = 52.5, $p < 0.05$), and 2019 (median = 115, IQR = 34.5, $p < 0.05$) when compared to 2020 (median = 60, IQR = 34.5, $p < 0.05$).

The number of dogs, however, was only statistically significantly lower in 2020 (median = 27, IQR = 16, $p < 0.05$) than in 2019 (median = 43; IQR =9, $p < 0.05$). It was equivalent to that of 2013 (median = 31, IQR = 19, $p < 0.05$), 2014 (median = 36, IQR = 15, $p < 0.05$), 2017 (median = 36, IQR = 12, $p < 0.05$), and 2018 (median = 39, IQR = 9.25, $p < 0.05$; **Figure 3**).

The number of rats in 2020 (median = 0, IQR = 1, $p < 0.05$) was equivalent to that of 2013, 2014, 2017, and 2018 (medians = 1, IQRs = 2.5, 2, 3, 2, respectively, all $p < 0.05$). However, it was lower than that of 2019 (median = 2, IQR = 3.5, $p < 0.05$). No statistical difference was observed in rabbit numbers between 2020 (median = 0, IQR = 0, $p < 0.05$) and any other year (medians = 0, IQR's = 1, 1, 0, 1, 1, 0 for 2013, 2014, 2017, 2018, and 2019 respectively, all $p < 0.05$; **Figure 3**).

The population of "other" animals was equivalent in 2013 (median = 1, IQR = 2, $p < 0.05$) and 2014 (median = 1, IQR = 2, $p < 0.05$). These were both higher than the populations observed in 2017 (median = 0, IQR = 0, $p < 0.05$), 2018 (median = 0, IQR = 0, $p < 0.05$), 2019 (median = 0, IQR = 1, $p < 0.05$), and 2020 (median = 0, IQR = 0, $p < 0.05$), which were equivalent to each other (**Figure 3**).

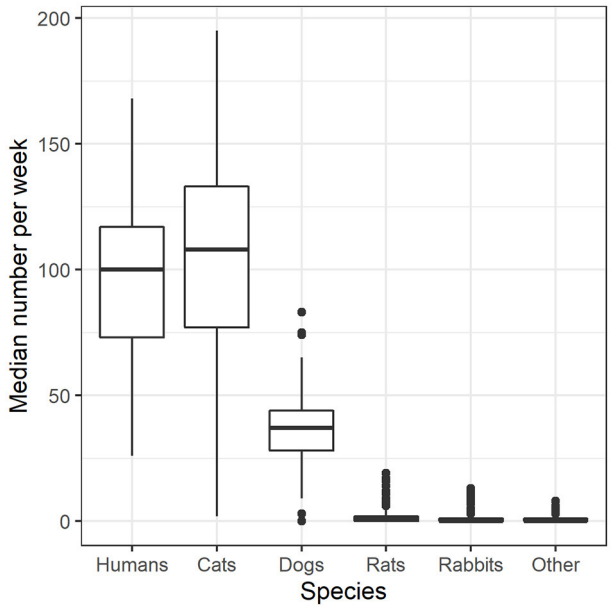

FIGURE 2 | Median number of clients per week for all years combined. Medians and IQRs are shown.

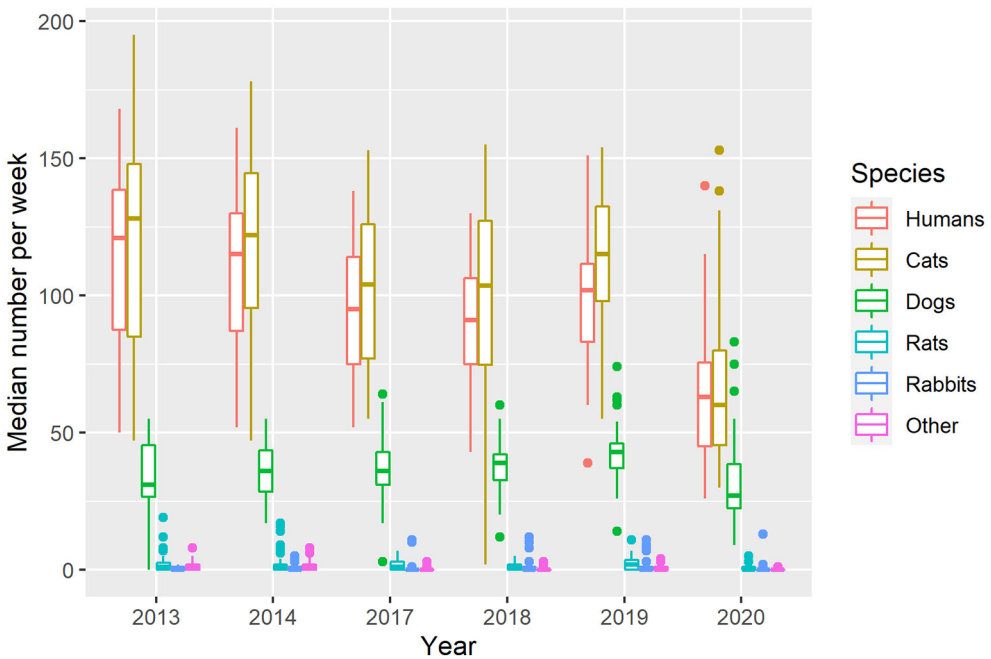

FIGURE 3 | Median (IQR) number of clients per week by year.

Weekly Trends

Human clients [$H(4) = 55.9$, $p < 0.05$], cats [$H(4) = 51.7$, $p < 0.05$], and dogs [$H(4) = 26.8$, $p < 0.05$] differed statistically significantly based on the week of the month. Rats [$H(4) = 3.6$, $p = 0.47$], rabbits [$H(4) = 8.1$, $p = 0.09$], and "other" animals [$H(4) = 0.69$, $p = 0.95$] did not differ based on the week (**Figure 4**).

The number of human clients serviced in Week 4 (median = 73, IQR = 20.75, $p < 0.05$) was lower than that of Weeks 1 (median = 104, IQR = 35.25, $p < 0.05$), 2 (median = 115, IQR = 25, $p < 0.05$), and 3 (median = 110, IQR = 50, $p < 0.05$), but equivalent to that of Week 5 (median = 89, IQR = 25, $p < 0.05$). The number of cats during Week 4 of each month (median = 78, IQR = 27, $p < 0.05$) was once again lower than that of Weeks 1 (median = 114.5, IQR = 35.25, $p < 0.05$), 2 (median = 131, IQR = 40, $p < 0.05$), and 3 (median = 112, IQR = 72.5, $p < 0.05$), but equivalent to that of Week 5 (median = 109, IQR = 36, $p < 0.05$; **Figure 4**).

Further, the same pattern was observed for dogs. The number of dogs during Week 4 of each month (median = 35, IQR = 16, $p < 0.05$) was lower than that of Weeks 1 (median = 36, IQR =12, $p < 0.05$), 2 (median = 42, IQR = 17, $p < 0.05$), and 3 (median = 40, IQR = 15, $p < 0.05$), but equivalent to that of Week 5 (median = 35, IQR = 16, $p < 0.05$; **Figure 4**).

The number of rats in Weeks 1 (median = 1, IQR = 2, $p < 0.05$), 2 (median = 1, IQR = 2, $p < 0.05$), 3 (median = 1, IQR = 3, $p < 0.05$), 4 (median = 1, IQR = 3, $p < 0.05$), and 5 (median = 1, IQR = 3, $p < 0.05$) were found to be equivalent. The same was also found for rabbits (medians = 0; IQR's = 1, 1, 1, 0, 0, for Weeks 1, 2, 3, 4, and 5 respectively, all $p < 0.05$), and "other" animals (medians = 0; IQR's = 1; $p < 0.05$ for all weeks; **Figure 4**).

DISCUSSION

General Population

As a very rough estimate, the data showed that ∼0.5% of the whole population of the DTES was serviced weekly through the pet food bank. As we suspected, the companion animal species served by the pet food bank in our target community, comprised of people who are experiencing hardship, but may be housed or partially housed, differed from the previous literature. We found that the companion animal composition in the DTES food bank service clientele was predominantly made up of cats. This is a surprising finding in this context, as previous research identified that the majority of companion animals owned by those experiencing homelessness tend to be dogs and not cats (13, 18, 35). The discrepancy may be explained by the ease of which dogs, as opposed to cats, can be maintained outdoors without a confined space (36, 37). The Charlie's food bank, however, not only services those who are experiencing homelessness, but also clients who live in low-income housing and have enclosed living quarters, which may explain this finding. The prevalence of small apartment units in the Downtown area (23) also helps explain the high proportion of cats owned, since it may be easier to keep cats in smaller spaces than dogs (36, 37). Our data highlight the need for researchers to evaluate programs serving a wider population to not make incorrect inferences about pet ownership.

Another result that warrants reflection is the size of the rat population represented, which is larger than that seen in the literature. The Animals Medicine Australia report (2019) (38) showed that 0.6% of companion animals owned were either mice or rats. In contrast, in our sample, we found that 1% of the companion animals were rats alone, and mice were a part of the "other" category. However, our data are consistent with that of the BC SPCA's shelter intake. A 5-year analysis of the BC SPCA animal population that services all of BC, revealed that rats make up a substantial proportion of admitted animals (39).

COVID-19 Effects

The decrease in the number of clients serviced in 2020 was not unexpected and we interpret it as being due to the impacts of the COVID-19 pandemic. What is surprising, however, is the fact that the number of dogs, but not other pet species, present at the food bank each week was not statistically significantly different from that of the prior year. This could be explained in different ways. First, housing differences could account for the maintenance in dog numbers. As previously mentioned, owning dogs while living outdoors may generally be an easier experience than owning a cat outdoors (13, 18, 35–37). It could be the case that dog owners, who attend the food bank, are living outdoors more often than cat owners. This would mean that they would not have the option to stay at home despite the "stay at home orders," and so would continue attending the food bank each week. Second, a possible explanation for this finding could be related to the price differences in owning a dog compared to a cat. Feeding prices for dogs generally tend to be higher than that for cats (40–42). This might then mean that dog owners are more dependent on the food bank and thus resistant to the public health recommendations to stay at home.

Weekly Trends

We observed a decrease in the number of people as well as companion animals serviced at the food bank every fourth week of the month. That week (usually the last of the month) coincides with the time during which income assistance is distributed to many residents of the area (43, 44). This results in an increase in personal resource availability for clients, which in turn can decrease their need for assistance in pet food acquisition. This effect has been documented, for instance, in food purchasing practices, with people utilizing food stamps and increasing their caloric intake right after income supplementation checks are received (45–47).

The decrease in attendance at the pet food bank every fourth week of the month may also bring to light issues regarding access to care. It is possible that clients are prioritizing other needed purchases during that week and are unable to come for pet food assistance. Previous research identified that income assistance payments in the DTES population that struggles with drug addiction coincides with drug-related harms, albeit the phenomenon is highly complex and nuanced (26, 26, 48). With that in mind, one possible way to mobilize this data to action could be to consider increasing the services offered during the third week of each month, for instance by distributing extra food to clients, to overcome this potential barrier to care. This

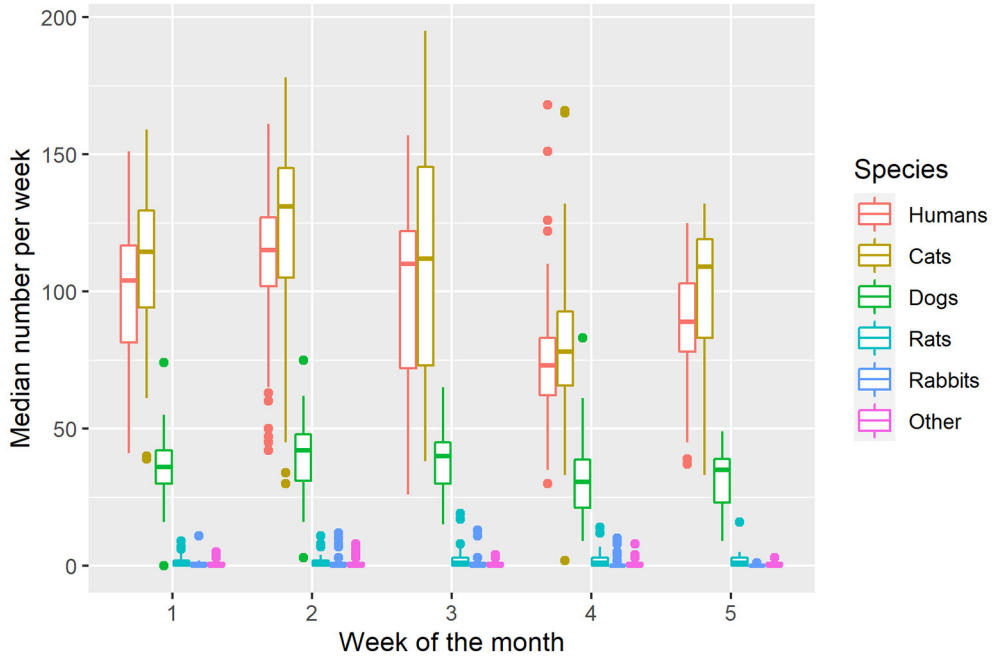

FIGURE 4 | Median (IQR) number of clients per week by week of the month.

would ensure that the population is still supported throughout the month with no interruptions. The data also reveal that pet servicing is tightly related to community issues and cannot be adequately understood in isolation.

Limitations

Our study focused on a limited population present in the Vancouver DTES area and uses data from a single pet food bank run by the BC SPCA. This decreases our ability to generalize our findings to other pet-owning populations experiencing financial strain in other areas of the world. However, unlike in previous studies, our data involves not only a population of people experiencing homelessness but also anyone who is experiencing financial hardship, providing a more comprehensive picture.

Further, we also missed 2 years of data (2015 and 2016), which could have provided us with a more complete understanding of the service patterns over time.

CONCLUSION

We found that most companion animals serviced in the Downtown Eastside of Vancouver, B.C., Canada, each week were cats, followed by dogs. This surprising finding is likely due to the nature of our target population, which comprised of people experiencing homelessness as well as those that are housed or partially-housed. We also found that a large proportion of companion animals serviced were pet rats, which indicates a need for greater focus on supportive services for pet rats in pet food banks. Both of these findings highlight the need for researchers to increase their focus on more diverse populations when studying the human-animal bond and community services. Furthermore, we found that in 2020, the number of human clients, and cats, rats, rabbits, and "other" animals statistically significantly decreased from the previous year, likely due to COVID-19. However, the number of dogs serviced remained stable across time, suggesting that servicing needs may be different by pet species. Our data showed that attendance at the food bank was lower during the fourth week of each month, which coincided with income assistance schedules. This finding may bring to light access to care issues and highlight the need to consider pet food banks within the greater social services networks. Taking a "One Health" approach to servicing, that is, integrating provision of health and community support for humans and their pets (49), is likely to be a useful strategy. Future research is needed on efficacy and feasibility of merging human and companion animal servicing to the benefit of both.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The University of British Columbia Behavioral Research Ethics Board (H20-03807). Written informed consent

for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MS and AP contributed to the conception of the study, subsequent study design, and performed statistical analyses. MS acquired and organized the data and wrote the first draft of the manuscript. Both authors contributed to the manuscript, further revisions, and approved the final version of the manuscript for submission.

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Free-Roaming Dog Surveys in Quito, Ecuador: Experiences, Lessons Learned, and Future Work

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The selection of a survey method of free-roaming dog populations should be based on analyses of local capacities and management priorities. Here, we compare the results of surveys of the stray dog population in Quito, Ecuador, using two different methodologies and propose an alternative method for future surveys in the city. We carried out all surveys in ∼5 km-transects in a sample of eight urban and eight rural parishes (16 transects total). In 2018, we used the capture-recapture method to estimate absolute population size and 95% CI. We began transect surveys at 04 h 00 (local time) and identified individuals with photographs. The main limitations of this method were errors in identifying individuals, since photographs were not always clear, partly due to low light conditions during the surveys. This method also required more time and more complex logistics. In 2019, we used distance sampling to estimate population density and began the surveys at 08 h 00 (local time). Errors in the estimation of animal-observer distances and angles were our main concern when using this method. For future surveys, we propose to carry out direct observations of dog abundance (number of free-roaming dogs/km) during street counts, complemented with capture-recapture surveys every 5 years. This alternative method albeit simple, is sensitive enough to (1) provide local authorities with objective assessments of management interventions, (2) better understanding the dynamics of free-roaming dog populations and (3) increasing public awareness about the problem of pet abandonment through citizen participation in the surveys.

Keywords: capture-recapture method, distance sampling, human:dog ratio, population density, abundance index

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INTRODUCTION

The abandonment of dogs is a complex problem affecting animal welfare, native wildlife and public health (1). Although the magnitude of the problem and its causes may vary among regions and countries, obtaining accurate estimates of the population size and structure of free-roaming dogs is always essential to design and implement public and private interventions, and to assess their effectiveness in population control (2). Considering the complexities of surveying free-roaming animals in urban landscapes, selecting an accurate method that takes into account the socio-environmental characteristics of the urban matrix and the dog's population dynamics is of outmost importance (3). In this paper we present our experiences and learned lessons in the process of defining an adequate method for surveying and monitoring free-roaming dog populations in the Metropolitan District of Quito, the capital city of Ecuador, to (1) provide local authorities with

objective assessments of management interventions, (2) better understanding the dynamics of free-roaming dog populations and (3) promote citizen participation in the surveys as means of increasing public awareness about the abandonment problem.

The need for reliable and updated information of the population status of free-roaming dogs in Quito is evidenced by the limited number of studies that have been carried out about this topic. The first estimations of the population size of dogs in the city did not provide sufficient information about the survey methods or were short term projects carried out by undergraduate students in specific sites of the urban area [e.g., (4)]. It was not until 2013 that Grijalva et al. carried out a base line estimation of free-roaming dogs in urban and rural parishes in the Quito metropolitan district using space-based random sampling procedures and the Capture—Recapture Chapman modified Lincoln-Petersen model (5). However, replicating that study was complicated because of logistic and financial constraints partly related to the limited investment in research in Ecuador (6). We believe that an effective strategy to overcome these constraints and to increase people's awareness about the problem of dog abandonment is to implement a citizen science project, with citizens actively participating in data gathering to monitor free-roaming dog populations in Quito. In 2018, we began such a project with interested citizens and personnel of public and private organizations, replicating the Capture-Recapture method used by Grijalva and collaborators in 2013 in a subsample of their surveyed areas.

The Capture-Recapture method (CR) has been used to estimate population size in several animal taxa (7). The Chapman modified Lincoln-Petersen CR model assumes a closed population and equal capture probability among animals. It requires a first survey in which animals are captured, marked and released in the population, and a second survey in which some of the captured animals are recaptures that were previously marked. The proportion of recaptured individuals is used to estimate population size (see equation in the Methods section) (8). This method has been used for estimating free-ranging dog populations in countries like Brazil (9); its limitations were analyzed by Belo et al. (1) and include the violation of the assumption of a closed population and difficulties in identifying/marking individuals.

Since we aimed to find a method that could be easily applied by volunteers to reduce errors in data collection, and that could provide adequate and sufficient information for management decisions, in 2019 we tested other method (Distance sampling). In the Distance sampling method (DS) distances to animals detected along a transect are recorded and used to estimate detection probabilities as a function of the perpendicular distances. Estimates of density are obtained based on these variables. The model assumes that all the animals on the transect are detected and that the detectability decreases with increasing distance (7). The main limitation of this method, that has not been widely applied for roaming dog populations, is the mismeasurement of distances (1).

Here, we describe the methods we used, present the survey results of each method and propose an alternative method that may be better suited for monitoring the population of free-roaming dogs in Quito.

MATERIALS AND METHODS

Study Area

The Metropolitan District of Quito has 65 parishes (32 urban and 33 rural). It is located in the Andes at 2,850 m above sea level and has an area of 4,183 km^2 divided in 32 urban parishes and 33 rural parishes (10). In the last national population census in 2010, there were 2,239,191 inhabitants in the district (11). In 2020, the estimated population was close to 2,800,000 inhabitants (12).

We carried out our surveys in the same 16 parishes that were surveyed by Grijalva in 2013. The parishes were selected with space-based random sampling following WSPA (13) guidelines. Eight urban parishes: Rumipamba, Mariscal Sucre, La Magdalena, La Ecuatoriana, Carcelén, San Isidro del Inca, Puengasí, Solanda, and 8 rural parishes: La Merced, Nanegalito, Chavezpamba, Yaruquí, Conocoto, Calderón, Calacalí, Nayón were selected (**Figure 1**). In each selected parish, 5 km transects were identified with a number in Google Earth®. A random number computer algorithm was used to select two sample transects per parish (5). Due to financial and logistic constraints, for the 2018 survey, in each parish we randomly selected one of the two transects used in 2013. We surveyed these same transects in the 2019 survey.

Data Collection

In the 2018 and 2019 surveys, teams of 2 to 4 previously trained volunteers slowly walked (2 km/h) along the selected transects and used the cell phone app Survey123 for ArcGIS to record all the dogs that were on the street without a leash. All dogs were photographed, and the date, time and geographic coordinates of each sighting were automatically recorded.

In May 11th and 12th 2018, we conducted simultaneous capture-recapture surveys in each of the 16 parish ∼5 km transects. We began the surveys at 04 h 00 (local time) in days with no rain. Each stray dog sighted was registered in a Survey123 form, that included a clear photograph for identification, the geographic location, and the sex of the animal. Additionally, survey teams were asked to write in a notebook a description of the color, size and notable characteristics of each animal. In the second survey, recaptured animals were identified based on similarities of photographs, written descriptions and geographic coordinates.

In November 2019, we conducted distance sampling surveys in the same ∼5 km transects of the 16 parishes. We began the surveys at 08 h 00 (local time) in days with no rain. In the Survey123 form, in addition to the photograph (used to avoid double counting of individual dogs), the geographic location and the sex of the animal, we recorded a consensus estimate of the animal-observer distance (see below), the animal-observer angle (obtained with a compass or a protractor), and if it was alone or in a group. The animal-observer distance was estimated by each survey team. No measurement tools were used, but each team was trained before the survey with exercises in which they validated their distance estimates with a measuring tape. When a group of

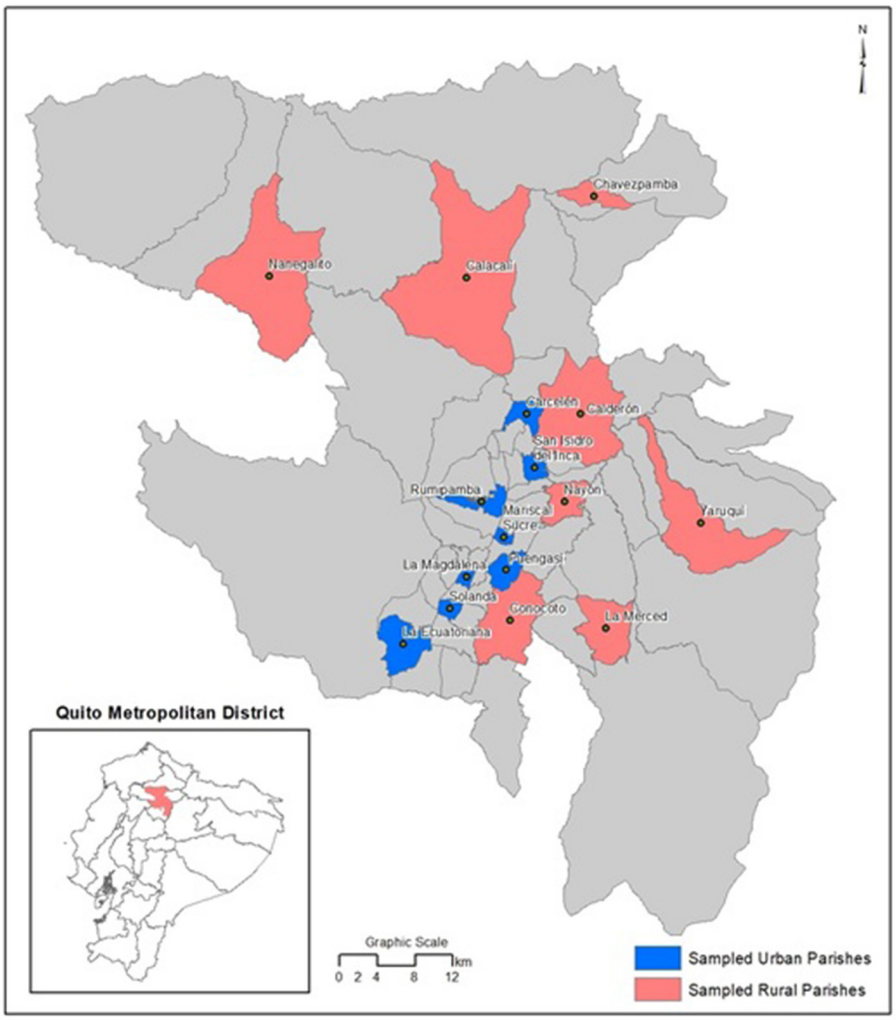

FIGURE 1 | Location of the surveyed urban (in blue) and rural (in red) parishes in the Metropolitan District of Quito.

dogs was observed, a single distance was recorded for the entire group, this distance was estimated between the observer and the first observed dog. When a group of dogs was recorded, a single angle was recorded for the whole group, this angle was estimated between the observer and the first observed dog.

Data Analysis

To estimate the free-roaming dog population in 2018, following Grijalva et al. (5), we used equation 1 (8). Where n1 is the number of animals observed on the first survey; n2 is the number of animals observed on the second survey; m2 the number of dogs observed both in the first and second surveys, and N is the total number of estimated animals.

$$N = \left[\frac{(n1+1)(n2+1)}{(m2+1)}\right] - 1 \quad (1)$$

We used the two-sample method (8) to calculate the 95% confidence interval (CI) for the total count (urban and rural). We divided the estimated dog population (N) per parish by the human population of each parish recorded in the last national census in 2010 (11) to calculate the human:free-roaming dog ratio (HD ratio) per parish. We then used the median of these ratios to estimate a ratio for urban and rural parishes and a total ratio for the district (5).

In the 2019 survey, we used the animal-observer distances and the animal-observer angles to calculate the perpendicular animal-transect distances. With this new variable and the number of individuals per sighting (status: solitary/group), we ran the "Distance 7.3" software (14) to estimate the population density for the rural and urban areas. We applied uniform key; half-normal key with cosine; half-normal key with Hermite polynomial and hazard-rate key with simple polynomial models. In addition, we ran six data filters: 5% truncation, 10% truncation, 80 m truncation and 90 m truncation. The fit of each model was defined based on the Akaike Information Criteria (AIC) (14).

In addition to these analyses, we used the raw data of dog counts of the 2018 and 2019 surveys to calculate indices of abundance (number of dogs/km) in urban and rural areas by dividing the number of observed dogs in a transect by the transect length. To extend the time range of the comparison, we also calculated the abundance indices of the 2013 survey (5). For the calculation of the abundance indices in 2013 and 2018, we used the data from the first (capture) survey only.

In 2018 and 2019, we carried out a post survey workshop with the survey participants to analyze the pros and cons of the method used, recording the difficulties that the participants experienced during the surveys and the problems that the research team encountered during the data analysis.

RESULTS

Capture—Recapture Method

In 2018, using the Capture—Recapture method, the estimated population of free-roaming dogs in the sample of urban parishes was 262 (95% CI 226–297), whereas in rural parishes it was 204 (95% CI 153–256). Combining urban and rural parishes, the total population was estimated in 460 (95% CI 402–517). The average HD ratio in all the surveyed parishes was 46:1 (1 dog for every 46 inhabitants). This ratio was greater in urban parishes (54:1) than in rural areas (38:1).

In the 2018 post survey workshop, the main concerns of survey participants were related to the time of the survey since low light conditions, especially from 04 h 00 through 05 h 00, made it difficult to find and photograph the dogs, affecting the reliability of the recapture events. Participants coincided in that most of the sightings occurred in the last hour of the survey, when there was more light and animals were more active.

Distance Sampling Method

In 2019, using Distance Sampling with Hazard rate—Simple polynomial models, we estimated a mean population density of 107 dogs/km^2 (95% CI 75–153) in the urban parishes, and of 211 dogs/km^2 (95% CI 147–302) in the rural parishes. The mean density of free-roaming dogs, combining urban and rural parishes, was estimated in 141 dogs/ km^2 (95% CI 109–183).

In the 2019 post survey workshop, participants commented that they were not sure about their distance estimates, especially of animals that were more than 50 m away. Some of them also mentioned they had difficulties in calculating the animal-observer angle.

Abundance Index

The abundance indices of free-roaming dogs in urban and rural parishes were greater in 2019 (6.15 dogs/km in urban parishes and 5.41 dogs/km in rural parishes) than in 2018 and 2013 (**Table 1**).

TABLE 1 | Index of abundance of free roaming dogs (number of dogs/km) in urban and rural parishes in Quito (indices calculated from raw data of the 2013, 2018, and 2019 surveys).

	2013	2018	2019
Urban parishes	2.89	4.12	8.33
Rural parishes	2.25	1.92	6.51

DISCUSSION

Finding an optimal method of surveying the free roaming dog population in Quito, an expanding city with an unresolved problem of pet abandonment (15, 16) is essential to provide local authorities with objective assessments of management interventions. The results of these surveys should also provide a better understanding the dynamics of stray dog populations and enhance public awareness about the problem of pet abandonment. In our citizen science study we applied the two most commonly used methods of estimating the abundance of animal populations (17) the capture-recapture method, in 2018, and line transect distance sampling, in 2019. In this section, we evaluate the feasibility of applying these methods considering the characteristics of the city environments and the conditions and resources available for research.

Given that in their baseline study of 2013, Grijalva et al. estimated the free-roaming dog population in Quito using the Capture-Recapture method (5), for our 2018 survey we decided to also use this method in a subset of their sampling areas. The comparison of the HD ratios calculated in 2013 [58:1, (5)] and 2018 (46:1), points to a 25% increase in population size in this five-years period. We are aware of the limitations of the surveys in terms of the relatively small sampling area (two and one ∼5 km-transect, in 2013 and 2018, respectively, out of ∼25 ∼ 5 km-transects in 16 of 65 parishes); however, the fact that in both surveys there was a higher HD ratio in rural parishes than in urban parishes and a similar pattern of HD ratio differences among urban parishes, suggests that the increase in the number of free-roaming dogs in Quito is real. The reasons for this population increase may be related to a weak enforcement of the city regulations for responsible pet ownership and to limited management actions to control the stray dog population (16).

Despite the obvious convenience of using similar methods for the long term monitoring of the population, some concerns about the application of this method were raised in the post-survey discussions. The low light conditions due to the time of the surveys, affected the quality of the photos and the accuracy of the individual identification. Survey participants coincided that dogs were more active and easy to detect in the last hour of the survey, with better light conditions. In addition, because of the time of the surveys, the presence of police officers in all the survey teams was a security requirement that made the logistics more complex.

When planning the 2019 survey, based on personal observations of dog abundance, we decided to begin the surveys later in the day, at 08 h 00. We also simplified the logistics by carrying out line transect distance sampling with one survey per transect; thus devoting 1 day per transect instead of the 2 days in the capture-recapture survey. These changes facilitated dog sighting and survey organization, however, in the post-survey discussions, concerns were

raised about the accuracy of the estimates of distances and angles.

To our knowledge, there is only one published study that estimated stray dog population density with distance sampling in rural villages in Philippines (18). The estimated density in that study (468 dogs/km^2 CI 359–611) is higher than our estimated mean population density of 141 dogs/km^2 (95% CI 109–183) in the Quito district. This could be related to differences in the socio-environmental characteristics of the study areas but we cannot exclude possible biases caused by errors in distance and angle estimations.

Evidently, given the different methods we used in the 2018 and 2019 surveys, the population estimates of both years are not comparable. However, since we used the same transects and a similar protocol to record the animals (except for the time of the surveys), we decided to calculate and compare the abundance indices of free-roaming dogs across years, including the 2013 surveys (5). Direct observations of dog abundance (number of free-roaming dogs/km) during street counts could be a good indicator of population changes to evaluate the impact of management interventions and require fewer resources than the other methods (13, 19).

The increase of the abundance indices across years agree with the trend we found when comparing the HD ratios of the 2013 and 2018 surveys, suggesting that the method, albeit simple, is sensitive enough to detect population trends. The two-fold increase from 2018 to 2019 in the abundance index of urban parishes could be partially explained by the time of the day when surveys were carried out (surveys began at 08 h 00 in 2019, whereas in 2013 and 2018 surveys began at 04 h 00), suggesting that delaying the start of the surveys to 08 h 00 enhances dog detection. The fact that the abundance index of rural parishes did not increase at the same rate, could be related to differences in the area available for the dogs to roam. This area is usually larger in rural parishes (pers. obs.) and may decrease the detectability of the animals since dogs are not restricted to the streets, as they are in most urban parishes. More surveys are needed, however, to better understand the dynamics of free-roaming dog populations in urban and rural areas.

Based on these analyses, we propose to carry out annual dog counts to calculate abundance indices in the same ∼5 km transects of the 16 parishes that we have sampled in previous years. Each transect will be surveyed once by a team of 2–4 trained volunteers, walking at a pace of 2 km/h. Surveys will begin at 08 h 00 and will be carried out in the same month every year in days with no rain. Dogs sightings will be recorded in a Survey 123 form, similar to the forms we have used. We propose to maintain the citizen science approach in these future surveys since we have seen that the active participation of local people in the research allows them to better understand the problem of pet abandonment, and may facilitate their involvement in the design and implementation of actions to solve it. Data gathering with this method is less complicated, so citizen participation in the surveys will be facilitated. In addition, since implementing this method requires less resources, it may be easier for us to increase the number of sampled urban and rural parishes if we are able to obtain new funding. We propose to complement these annual direct observations of dog abundance during street counts with a capture-recapture survey every 5 years for a more complete characterization of the population dynamics. We believe this combination will allow us to better assess the effectiveness of implemented interventions and to plan future actions. We were not able to carry out the survey in 2020 because of the pandemics lock down, but we are looking forward to carry out the 2021 survey in the second semester of this year. Meanwhile, we will keep working in our education campaign to increase citizens' awareness of the pet abandonment problem, promoting the principles of responsible ownership and the adoption of rescued animals through the website https://petfriendly.usfq.edu.ec, free webinars and free neutering campaigns in rural and peri-urban areas. We are also exploring strategies to facilitate the coordination of the management interventions of public and private organizations since we strongly believe that only through long term and systematic collaborations we will eventually achieve our aim of a city with no free-roaming animals.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the animal study because the study was non-invasive. Free-roaming dog surveys did not involve any type of manipulation of the animals.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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Pet-Friendly for Whom? An Analysis of Pet Fees in Texas Rental Housing

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Previous studies have underscored the difficulty low-income pet owners often face when attempting to secure affordable rental housing. Further exacerbating this housing disparity are fees charged on top of normal monthly rent to pet owners in "pet-friendly" rental housing. In this study, we aggregated rental housing listings from the twenty most populous cities in Texas, USA from a popular online rental database. We paired the rental listings with census tract information from the American Community Survey in order to investigate economic and racial/ethnic patterns in the spatial distribution of the properties. We find that less expensive pet-friendly listings were more likely to have pet fees charged on top of rent than rental units that were more expensive. Additionally, when pet fee burden was defined as a function of average income by census tract, low-income communities and communities of color were more likely than higher income and predominantly White communities to pay disproportionately higher fees to keep pets in their homes. We also find patterns of spatial inequalities related to pet fee burden by a metric of income inequality by city. The burden of pet rental fees may contribute to both housing insecurity and companion animal relinquishment. We discuss these findings as they relate to inequalities in housing, with particular attention to marginalized and disadvantaged people with pets. We conclude with recommendations for policy and practice.

Keywords: pet-friendly housing, housing inequality, pet ownership, companion animals, pets, housing, human-animal interaction, animal welfare

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INTRODUCTION

Pet ownership is very common in the United States: recent estimates suggest that ∼60% of households in the U.S. contain at least one pet (1) and it is likely this number has increased with the popularity of pets during the COVID-19 pandemic (2). While most pet owners consider their pets to be family members (3–9), pets are legally considered to be property and are therefore not afforded the same legal protections as human family members (10, 11). Notably, pet ownership is not a protected status under the Fair Housing Act and therefore tenants are not protected from housing discrimination on the basis of having a pet in their family (12). Moreover, there are no federal regulations limiting the amount of pet fees (i.e., upfront, one-time, non-refundable fee), pet deposits (i.e. upfront, refundable fee, provided there is no damage), or pet rents (i.e., monthly, recurring, non-refundable fee, regardless of damage) a landlord can charge, since rental laws vary by state (13). In Texas, the setting of this study, pet fees, pet rents, or pet deposits are all legal and there is no cap on their amount, although industry best practice is to make security deposits "reasonable" (14).

Despite the popularity of pets within U.S. households, their increased adoption during the pandemic, and the evidence that living with a pet may be beneficial for human health and wellbeing (15, 16), the capacity to realize such benefits varies markedly based on the resources to which one has access (17). A decade ago, Herzog pointed to possible differences in people's capacities to "choose" pet ownership, stating that people who have the time, energy, and economic resources needed to care for a pet may be better able to keep them for extended periods (18). Indeed, there is evidence that, despite the fact that companionship and social support from pets may be most beneficial in times of stress and adversity, there are many structural barriers and larger social inequalities that stand in the way for disadvantaged and marginalized people to keep pets in their families and households (17). For example, housing issues are a commonly reported reason for animal relinquishment, particularly among low-income individuals (19, 20). Studies investigating the demographic patterns of pet ownership have found that White people are more likely to own pets than those from other racialized backgrounds (particularly Black individuals), homeowners are more likely to own pets than people who do not own a home, and that wealthier people are more likely to own dogs than people with access to fewer economic resources (1, 21). More than ever, there exists a need to consider the potential inequalities in capacities to keep and care for pets, which could be improved through better understanding and addressing access to affordable rental housing for pet owners.

Pet ownership is identified as a mechanism for housing insecurity among renters (11, 22, 23). Families with pets report feeling powerless and discriminated against when they search for rental housing (11). Pet-friendly housing is often perceived to be of poorer quality and located in neighborhoods deemed less desirable (11, 22). Even so, families with pets report paying higher rents and fees (11, 22, 24). Families also report staying put, as they do not want to lose more money by having to pay another pet fee they will never get back, should they move into another rental (11). The low turnover rate of pet-friendly housing is therefore likely in part due to the practice of charging pet fees as opposed to any feelings of housing security or satisfaction. Meanwhile, the ability for landlords to fill a pet-friendly vacancy fast is likely due to the limited availability of units that accept pets (25).

Given these challenges, an estimated 20% of owners have been found to keep their pets in rental units illegally (24), yet by doing so they could be faced with eviction, a bad referral, or other ramifications (12, 22, 23, 26, 27). The relationship between pet ownership and eviction has not yet been explored directly in the literature; however, research has shown that renters who face evictions are more likely to relocate to poorer and higher-crime neighborhoods compared to those who move voluntarily (28). Furthermore, evictions that go through the court system result in a public record with little mechanism for expungement, which can damage a tenant's credit record and thus harm their ability to find future rental housing (29). Depending on the market, tenants who stay longer in their units may be at risk of "renovictions"–where landlords evict a long-term tenant and renovate the property, raising rents beyond what the last occupant could have afforded (30).

Housing Inequality and Insecurity

In the U.S., low-income residents are increasingly challenged to find available and affordable housing. Homelessness and housing insecurity are being described as their own "epidemic" in the last year, as millions of renters became behind on rent payments due to the COVID-19 pandemic (31). Since June 2020, the U.S. Census Bureau has conducted Housing Pulse Surveys at two-week intervals to assess household needs related to food and housing security, employment, and access to education, among other issues. In August 2021, 7.9 million households reported being behind on rental payments and 5.8 million households reported having no confidence in being able to pay rent in September. Over 3.5 million households reported that they were very likely or somewhat likely to leave their current home within the next 2 months due to eviction (32).

However, millions of families were experiencing housing insecurity long before the COVID-19 pandemic began in the U.S. Princeton University's Eviction Lab estimates that there are ∼3.7 million eviction filings in the U.S. each year and a 2020 report found that in 2019, 20.4 million renters were housing cost burdened (33). A family is defined as housing cost burdened if they spend >30% of their monthly income on housing expenses, including utilities and pet rent. A family is severely housing cost burdened if they spend >50% of their monthly income on housing related expenses (34).

Researchers estimate that just under one-quarter of all rental households in the U.S., or just under 11 million households, are extremely low-income, meaning that they are living at or below the national poverty level or make <30% Area Median Income (34). According to the National Low-Income Housing Coalition, in the U.S. there are only 37 affordable and available units for every 100 extremely low-income renter families (34). The lack of affordable housing options for extremely low-income families is not a localized event. As of August 2021, there is not a single state or metropolitan area in the country with enough housing that is affordable to extremely low-income families (34).

In Texas, the situation is even more dire, with only 29 affordable and available units for every 100 extremely low-income families (34). Over 838,000 families across Texas are considered extremely low-income renters and 74% of those renters experienced severe housing cost burden in 2020 (35). Nearly every major metropolitan area in Texas has a severe shortage of affordable housing, making it one of the lowest ranking states in the country for affordable housing. For example, in 2020, in the Houston metropolitan area there were only 19 affordable and available units for every 100 extremely low-income families. The San Antonio and Dallas-Fort Worth metropolitan areas had only 38 and 21 affordable and available units for every 100 extremely low-income families, respectively. Ranking last among Texas cities analyzed in 2020, the Austin-Round Rock region had a distressingly low 14 affordable and available units for every 100 extremely low-income families (35). None of these federal or Texas specific statistics account for pet-friendly affordable housing and it is likely that the housing stock that is both affordable to low- and extremely-low income families and accepting of pets is even smaller.

Beyond lack of available and affordable housing, landlord-tenant laws in Texas are landlord-friendly. Texas boasts one of the highest late fees in the country (36) and landlords can refuse to pay for repairs if tenants are behind on rent payment. Without stronger tenant protections in place, millions of renters are one emergency away from not being able to pay rent on time and, "the threat of eviction provides an omnipresent signifier that, for poor renters, their tenure is a contingent one" (p. 3) (37).

Housing insecurity is not race-neutral. Across the U.S., people of color are more likely to be housing insecure than White individuals, and these disparities were only exacerbated by the COVID-19 pandemic (38). This fact is linked to the racialized history of oppression in the U.S., and the legacy of redlining [the historic practice of systematic divestment in communities of color, notably with respect to mortgage lending (39)] is still evident in residential segregation today (40). For example, several researchers have outlined the pathways by which historical redlining of neighborhoods of color by the U.S. government and continued discriminatory practices led to systematic neighborhood disadvantages that trickle down to educational disparities, public health concerns related to environmental hazards, concentrated poverty, higher disease prevalence, and earlier mortality [see (41)]. Not only do people of color in the U.S. face wealth and income disparities that certainly determine the type of housing they can afford and the environments in which they live, they also often face continued race-related housing discrimination that can determine where they can secure leases, regardless of their ability to afford them (41).

The Current Study

In this study we analyze rental housing data in Texas, U.S., in order to understand the extent to which renting with pets may create an additional cost burden for renters. Further, considering the state of housing discrimination and segregation among communities of color (42), we investigate the extent to which these fees may be a barrier to housing security for low-income individuals and people of color whose families include pets. As discussed above, Texas is a salient case study for investigating these relationships due to the lack of affordable housing combined with policy that tends to favor landlords over tenants. We build here on findings from Rose and colleagues (43) in a county in North Carolina, who showed that pet-friendly rental housing was more likely to be available to renters in predominantly White neighborhoods, compared to communities of color. Our analysis focuses on the spatial distribution of rental housing, as related to economic and racial-ethnic aggregated information by census tract, that is advertised as "pet-friendly." Finally, we explore whether within-city income inequality is related to inequality in pet rent burden.

Hypotheses

Presence of Pet Fees

1. The presence of pet rental fees will be negatively associated with income such that lower income communities will have higher incidences of pet rental fees than higher income communities.
2. The presence of pet rental fees will more frequently occur in communities of color, compared to communities that are predominantly White.

Burden of Pet Fees

3. The burden of pet fees, defined as a percentage of median census tract income, will be greater for communities of color, compared to communities that are predominantly White.

Pet Fees and Within-City Inequality

4. Cities with greater income inequality, as measured by the Gini index, will be more likely to have greater spatial inequality in pet fee burden. Specifically, cities with high income inequality will have evidence of geographically close census tracts with notable fee burden differences.
5. Within cities with higher Gini indices, there will be observable relationships (as measured by linear regression modeling) between pet fee burden and the proportion of residents of color by census tract, and this effect size will be proportional to the Gini Index in each city.

METHODS

Data Sources

Data were collected on January 19, 2021 *via* apartments.com by examining the available apartments in each target city. The top 20 cities in Texas were identified via the 2019 census estimate of overall population. The base query, https://www.apartments.com/-tx/pet-friendly/ was used to identify housing which was pet friendly. Then, the needed information from each housing sample was extracted and joined with census tract data collated from http://www.justicemap.org/ which was primarily comprised of data from the 2014–2018 American Community Survey by the United States Census (**Tables 1**, **2**).

Note that for all analyses in this paper, the fees for dogs are evaluated. Although the data contains fees for both dogs and cats, 5811/5911 (∼98.3%) samples contained identical cost values.

These data contain 5,911 total samples with 3,875 of those having some form of pet fee (65.6%).

Outlier Removal

As the primary dataset in question is sourced from values reported on a website, significant outliers are present which can dramatically skew the results of an analysis which is attempting to examine the "typical" relationships among factors. The exact cause of each outlier was not examined in detail, but common causes included issues in parsing the site, null/missing data, and potential typos in the data (i.e., a monthly pet rent of 12,000 is assumed to accidentally contain extra 0 s). In order to avoid experimenter bias in the evaluation of what constitutes an outlier, an Isolation Forest was applied to the data to eliminate outlier points (44). The contamination proportion was determined automatically as per the original paper on the method and found to be ∼11.8% [i.e., 458/3,875 samples containing pet fees; (45)]. Note that outlier removal was only performed for the subset of the data containing pet fees as the data was complete for the no-pet-fee group.

TABLE 1 | Lists the cities, their population, and the number of samples from each in this dataset.

City	Samples	Population
Dallas	700	1,345,047
Houston	700	2,320,268
Austin	700	964,254
San Antonio	697	1,532,233
Fort Worth	696	895,008
Irving	346	242,242
Plano	327	287,677
Arlington	308	398,123
El Paso	202	682,669
Garland	195	242,507
Corpus Christi	170	326,554
Frisco	165	200,490
Grand Prairie	154	194,614
Lubbock	140	258,862
McKinney	114	191,645
Pasadena	82	153,219
Killeen	76	149,103
Amarillo	63	199,924
Laredo	41	261,639
Brownsville	35	183,392

Note that the number of samples was capped at the 700 top results for pet-friendly locations due to limitations in the pagination of the data source.

TABLE 2 | Lists the key attributes for each housing unit as well as associated census tract attributes which were used as covariates during analysis.

Attribute Name	Description	Data Source
Median Income (Census Tract)	Median income of the census tract region within which the residence resides	Census
Two Bedroom Square Footage	Square footage of a two bedroom residence in the given entity	apartments.com
Two Bedroom Monthly Rent	Monthly rent of a two bedroom residence in the given entity	apartments.com
Recurring Monthly Pet Rent	Fees assessed monthly for a single pet	apartments.com
One-Time Pet Fee	Fees assessed one-time on move-in for a single pet	apartments.com
Proportion of: • White non-Hispanic • Hispanic/Latinx • Black or African American non-Hispanic • Asian • Native American • Native Hawiian and other Pacific Islander • Some other race • Multiracial/two or more races (Census Tract)	Proportion of the census tract identified as given race	Census

When housing units did not have available data corresponding to these attributes, they were excluded from the data set. This could, of course, systematically bias the data toward higher-income housing if one assumes such housing has the funds to maintain more accurate listings. However, this is a limitation which will be present in most available online samples of housing data.

Measures

In order to assess the typical impact of a pet fee on a potential resident, a metric called "Burden" (B) is introduced. The Burden is calculated as follows:

$$B = \frac{12R_p + F_p}{I}$$

Where the following variable meanings hold:

- **B** - Burden, i.e., income-proportional financial burden of pet ownership for typical residents
- R_p - The "pet rent" (i.e., monthly recurring fee) for the residential entity in question
- F_p - The "pet fee" (i.e., one-time fee associated with initiation of lease) for the residential entity in question
- **I** - The median income in the census tract within which the residential entity in question resides.

Note that this Burden value effectively assumes an individual may move apartments as often as once a year. Although this is likely an overestimate, it can be used as a benchmark to compare impact within and across regions. The value "12" could be modified to represent regional averages of occupancy times to generate a more accurate measure of real-world costs; however, these data were not available for this analysis.

Analytic Strategy and Key Statistics

Several key questions were addressed in the analyses of these data. First, whether or not pet fees were present at residences labeled "pet friendly" was examined. As the majority of the data are not normal and not correctable to normal via typical transformations (square root, log, boxcox, etc.), and ANOVA results in non-normal residuals, a non-parametric Kruskal-Wallis H-test is employed to examine whether group differences in income, population, and racial/ethnic makeup relate to the presence of pet fees.

For evaluations of the magnitude of Burden compared to proportion of population comprised of people of color and income, because a linear model results in non-normal residuals, we employ bootstrapping, sampling 10% of the data 1,000 times and forming a distribution of linear model parameters to estimate the overall model parameters.

Significance level is set at alpha = 0.05 for all tests.

RESULTS

Presence of Pet Fees

A significant relationship between the price of a two-bedroom apartment and the presence of pet fees was observed ($H = 24.21$, $p < 0.001$) such that more expensive apartments were less likely to have pet fees. No significant relationship was observed between the presence of pet fees and the proportion of people of color within the population in a census tract ($H = 2.32$, $p = 0.13$). Similarly, no significant relationship was observed between the overall population in a census tract and the presence of pet fees

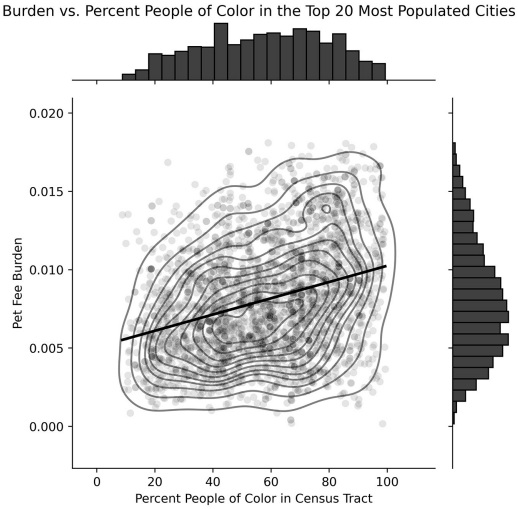

FIGURE 1 | Relationship between pet fee burden and proportion of people of color by census tract. A significant positive relationship is present between the pet fee burden of a census tract's housing and the percent of people of color in that tract ($F = 31.76$, $R^2 = 0.10$ and $P < 0.001$).

(H = 0.944, p = 0.33). A significant relationship between income and the presence of pet fees such that higher income census tracts were less likely to have pet fees was observed (H = 5.40, $p = 0.02$).

Relationships Between Burden and Communities of Color

See **Figure 1** for a visual representation of the relationship between pet fee burden and proportion people of color by census tract. Because the normality of the residuals of a linear model, bootstrapping with 1,000 iterations of 10% dataset samples was employed revealing a significant relationship between proportion of people of color in a census tract and pet burden such that census tracts with larger proportions of people of color were more likely to have a higher pet burden (F = 31.76, $R^2 = 0.10$ and $P < 0.001$).

Finally, when we examine each racial group individually, we observe that for all groups except Black/African Americans, there is a significant relationship between the pet fee burden and the proportion of that group within the census tracts observed. Note, critically, although all of the significant models were fairly weak, they did not share consistent directionality. Hispanic/Latinx populations show positive slope (increased pet burden as proportion of Hispanic/Latinx population increases) while White and Asian groups show the opposite relationship (decreased pet burden as the proportion of White and Asian populations increases). See **Figure 2** for visual representation of the relationship between model slope of proportion of people of color versus pet fee burden by racial/ethnic groups and model R^2.

Spatial Income Inequality and Pet Fee Burden Inequality

Finally, we examine the burden differences in extremely near geographic regions (<10 km) with the most extreme burdens (>1%) to examine the relationship between overall inequality in a city and the inequality as seen by Pet Fee Burdens.

In **Figures 3**, **4**, we can see that Lubbock and Austin contain the most extreme pairwise disparities in Burden among close-together census regions. The points to the far right indicate six pairs of census tract regions which each are <10 km apart while having pet burden differences around 7%. A large band of similar pairwise census tracts can be seen for Austin around 6%. It is interesting to note that if we exclude the two extremes (Austin and Lubbock), there is a significant relationship between within-city pet fees disparity and the Gini Index of that city [a measure of economic inequality (46); F = 6.05, $p = 0.03$, $R^2 = 0.335$]. This is confounded somewhat by the fact that both Gini Index and Pet Burden use Income as a factor component, however, were this to drive the relationship, strong outliers such as Lubbock and Austin would not be expected.

Moreover, when the effect size of the bootstrapped linear models for each cities census tracts (proportion people of color vs. pet fee burden) is compared to the Gini index, Houston and Lubbock are observed to have both significant relationships and high R^2 values (comparatively) in addition to high Gini indices (**Figure 5**). We can observe these cities directly to pinpoint clear regions of adjacent, unequal census tracts which might drive these effects (only Lubbock, Austin, and Houston are shown as they were the cities that were significant and/or outliers in the Gini index models) (**Figures 6A,B**, **7**).

DISCUSSION

In this study we analyzed publicly available information about rental housing listings throughout the state of Texas in order to assess the additional cost burden placed on pet owners when renting with pets. Overall, our findings indicate that, within Texas, the costs associated with housing a family that includes a pet disproportionately harm populations that are already economically disadvantaged. Specifically, pet-friendly rental units come at a higher relative cost for low-income communities and communities of color. We elaborate on these findings in the following paragraphs.

First, we hypothesized that, among rental listings that advertise as pet-friendly, less expensive listings would more frequently include an additional fee to keep pets, compared to more expensive units. This hypothesis was supported. Specifically, we found that more expensive rental units were less likely to have pet fees, compared to less expensive units. This could imply that more expensive units already incorporate a "pet fee" into normal monthly rent, regardless of whether the tenant chooses to keep a pet or not. Additionally, pet-friendly listings within higher average income census tracts were less likely than lower average income census tracts to have pet fees on top of normal monthly rent. This finding builds upon previous literature showing that, overall, pet-friendly rental housing tends to be more expensive than housing that does not allow pets (11, 22, 27, 43). We also hypothesized that census tracts with higher populations of people of color, compared to census tracts

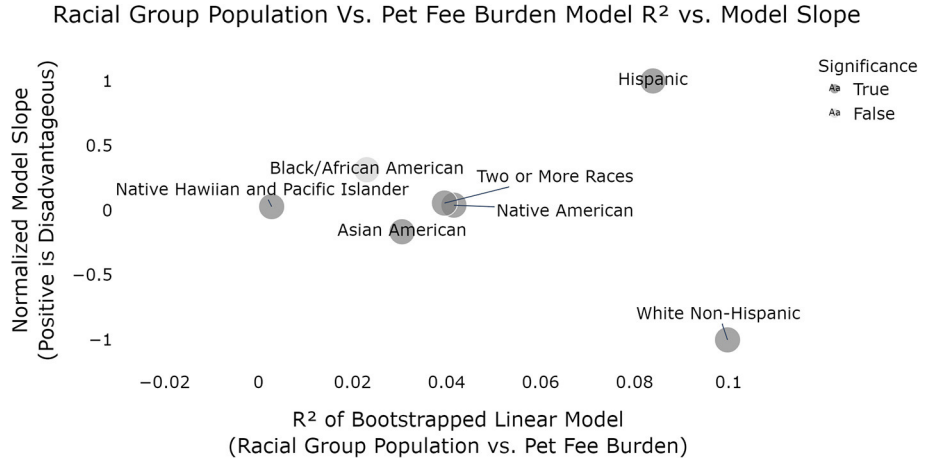

FIGURE 2 | Relationship between model slope of proportion of people of color vs. pet fee burden by racial/ethnic groups and model R^2 (dark gray is statistically significant models; $p < 0.05$). According to these models, White, Non-Hispanic populations are advantaged (in the form of lower pet fee burden) in relation to the racial makeup of their census tract while Hispanic/Latinx are the most disadvantaged. All models were significant except African Americans.

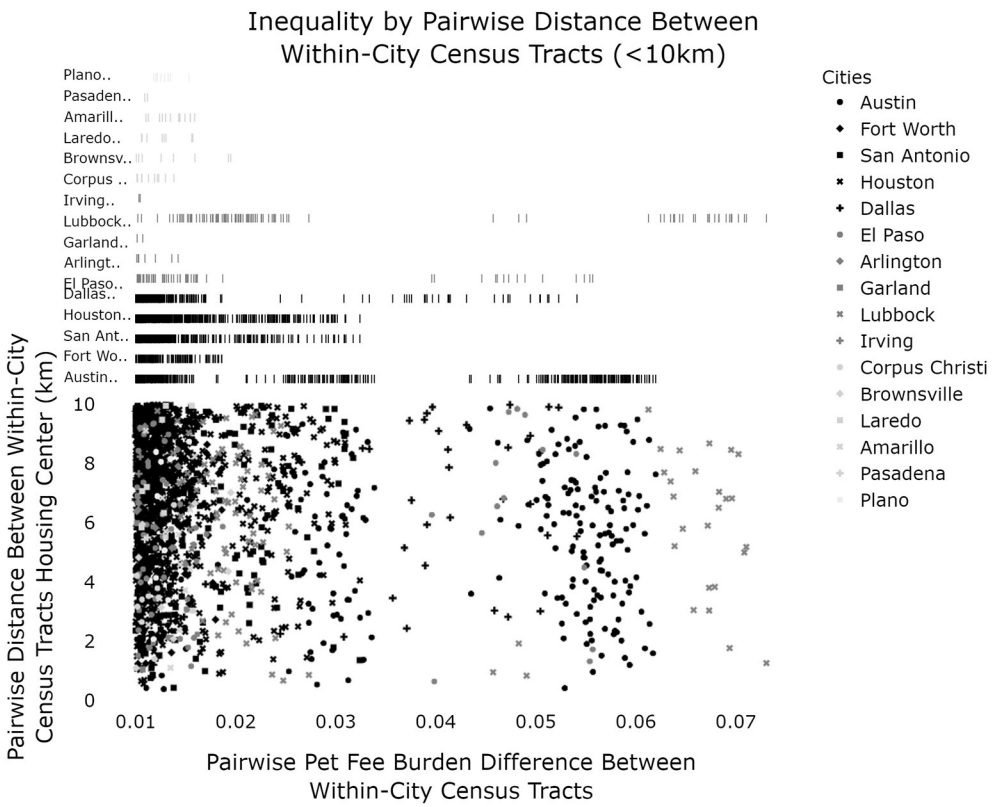

FIGURE 3 | Relationship between relative pet fee burden difference by spatial distance by census tract. Pairs of census tracts within cities that are <10 km apart (from housing centroids) are compared and clear, city-wise stratification can be seen with Austin and Lubbock as the clear outliers.

that were predominantly White, would have higher incidences of pet fees. There was no evidence of this hypothesized relationship such that the presence of pet fees among pet-friendly housing did not appear to be related to the racial/ethnic makeup of the residents. This finding somewhat contradicts a study conducted by Rose and colleagues in North Carolina that showed that pet-friendly housing was less *available* in communities of color, vs. predominantly White communities (43). As we did not assess the relative availability of all pet-friendly housing due to data limitations (discussed further below), it is possible that the lack

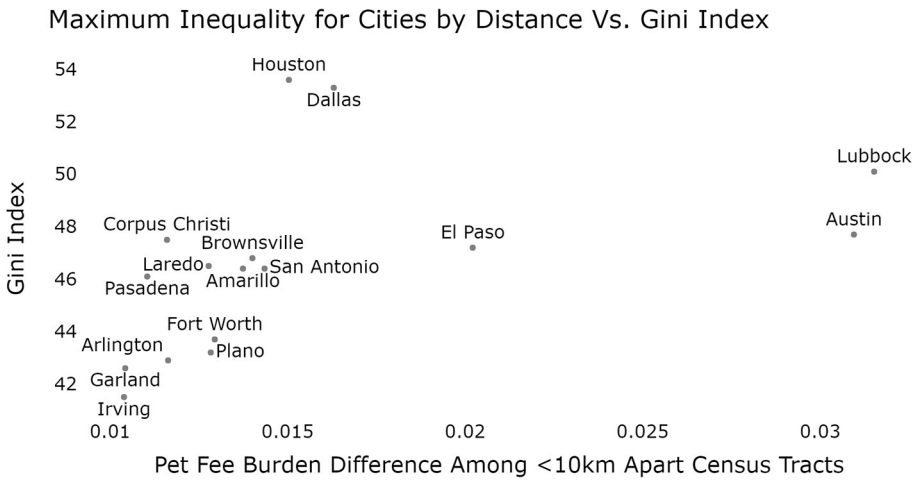

FIGURE 4 | Relationship between Gini index and pet fee burden difference for census tracts <10 km apart, by city. Austin and Lubbock can be seen as clear outliers in their spatial pet fee burden difference with El Paso also possibly representing a deviation from the typical relationship.

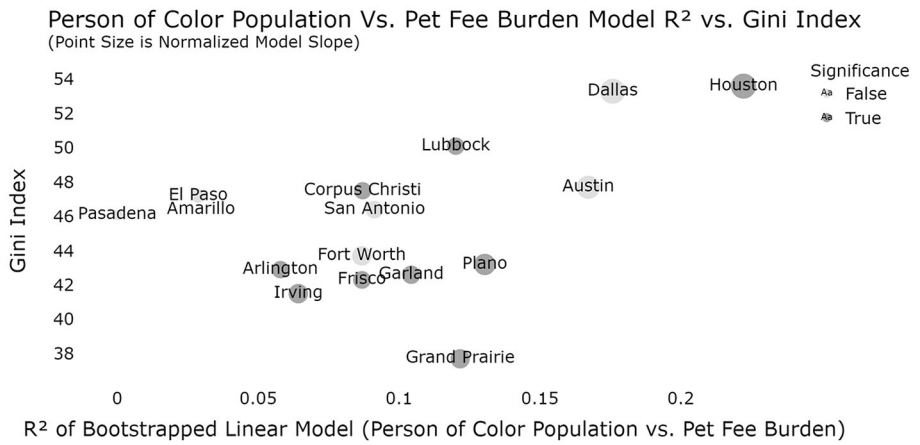

FIGURE 5 | Relationship between proportion of people of color by Gini index by city with model effect size (dark gray is significant models; $p < 0.05$). Note that Houston is the city in which the evidence is strongest that inequality may be, in some way, related to the degree to which pet fee burdens can be predicted by racial makeup of the census tract.

of relationship between race/ethnicity and presence of pet fees is at least in part due to the comparatively lower availability of pet-friendly housing, regardless of fees, in communities of color.

We defined pet fee burden as the total yearly pet-related cost (any monthly recurring fees plus any one-time fees such as those paid upon lease signing) by rental unit, divided by the median income of the corresponding census tract. This pet fee burden metric allowed us to examine the relative cost of keeping pets in homes as a function of a "typical" community member's yearly income. We hypothesized that communities of color would have greater pet fee burden among their pet-friendly rental listings, compared to communities that were predominantly White. Indeed, we found that overall, communities that were higher percentage White had lower pet fee burden, compared to communities that were higher percentage people of color. When examined by racial/ethnic group, as reported by the American Community Survey, we found that the pet fee burden was particularly pronounced for communities with higher populations of Latinx individuals. Notably, recent research has revealed the disproportionately high rent burden and concurrent barriers to access for rental assistance programs, overall, that Latinx individuals face in the U.S. (47). Taken together, Latinx individuals and families with pets may have a particularly difficult time obtaining housing. Conversely, the opposite relationship was found among both White and Asian communities: pet rent burden decreased as the communities had higher proportions of White or Asian residents. The relationship between pet rent burden and proportion of Black residents was positive in that higher percentages of Black residents indicated higher pet fee burden, though this finding should be interpreted with caution as it was not statistically significant. We suspect this non-significant

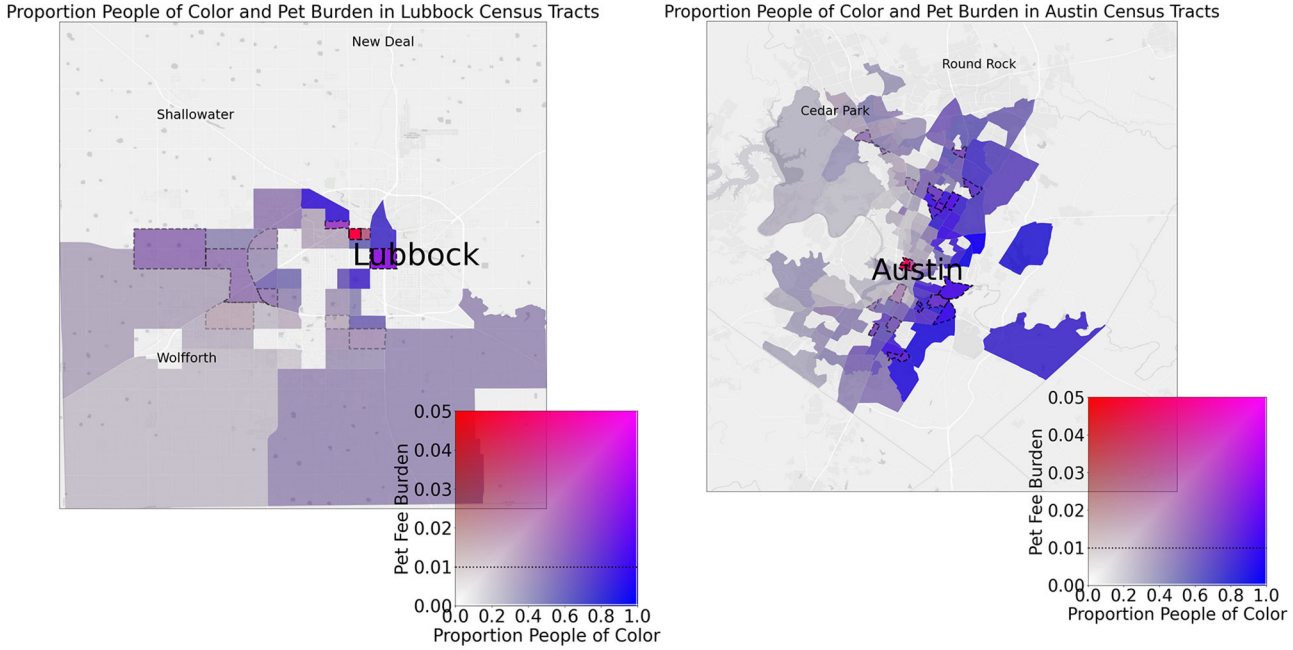

FIGURE 6 | Maps display spatial relationships between census tracts' proportion of people of color (POC) and pet fee burden in Lubbock **(A)** and Austin **(B)**. Dotted lines around tracts indicate a 1% (0.01) or greater pet fee burden. Note that highly blue tracts indicate low burden POC areas while purple regions indicate high burden POC areas. Red indicates high burden, low POC areas while transparent regions have low POC and low burden. It is interesting to note red hotspots at city centers while dotted line regions are typical of a large proportion of high POC regions.

relationship may be related to the limitations in our sample, which we discuss in more detail below.

We also hypothesized that cities with pronounced income inequality would be more likely to have greater inequality in pet fee burden among geographically close census tracts, and, given prior evidence that issues related to pets may exacerbate racial tensions [e.g., (48, 49)], this relationship would carry over to racial/ethnic disparities in pet rent burden. We find that Austin, Houston, and Lubbock show notable evidence of this relationship with respect to both income inequality and racial/ethnic disparities in pet ret burden. Specifically, Lubbock and Austin both had notable differences in pet fee burden among geographically close census tracts, and Lubbock, in particular, is among the highest in terms of overall income inequality (Gini index). However, the highest city-wide income inequality was observed in Houston and Dallas. Notably, Houston stood out in terms of pet fee burden disparities by race/ethnicity and was also represented by the highest Gini index. Houston's issues with racial housing segregation and income inequality are well-known; while Houston is the most ethnically diverse city in the U.S., it also has a long history of racial/ethnic and socioeconomic inequalities in housing and beyond (50). Houston is also especially vulnerable to severe weather events (particularly hurricanes) and it is likely that these events will grow more frequent and more severe due to climate change, which is predicted to further exacerbate racial and economic inequalities without strong policy intervention (51). There is evidence that pet ownership may be a risk factor for failure to evacuate during a disaster (52–54), and for those who do evacuate, pet owners can find it even more difficult to find rental housing following the disaster (27). Given this confluence of factors, disadvantaged and marginalized pet owners who live in Houston may be especially vulnerable to housing insecurity.

More than 15 years ago, a nationwide study on the lack of available pet-friendly housing in the U.S. concluded that opening properties up to pet owners makes "good business sense," given the ability for landlords to charge more in rent and fees and given the benefits relative to risks (24). More recently, a 2021 report also emphasized the "economic opportunity" of pet-friendly housing for landlords (55), because pet-friendly vacancies are quicker to fill and tenants with pets tend to stay longer, thus keeping turnover costs low. Housing advertised as pet-friendly may attract more applicants and reduce tenant turnover (11, 22, 24) and thus be leveraged as a marketing tactic (56); nevertheless, it is essential to ask whether families renting with pets feel that they opted into the housing they are currently living in and can opt to stay or leave, rather than simply ending up there due to lack of choice.

Although all pet owners are affected by the limited rental housing options available to them, as our findings add to the body of literature, marginalized groups are particularly burdened, not only because of the discrimination they may already face—outside of pet ownership—in trying to find affordable housing (11, 43, 57), but also because of constrained financial resources

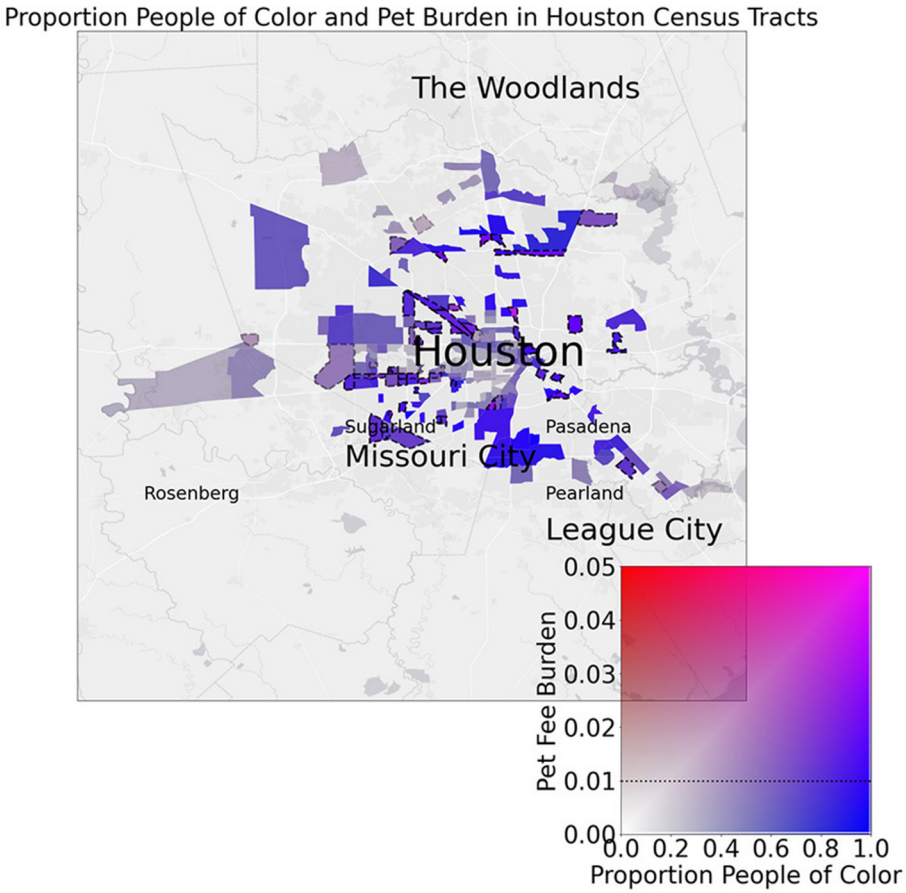

FIGURE 7 | Map displays spatial relationships between census tracts' proportion of people of color (POC) and pet fee burden in Houston. Dotted lines around tracts indicate a 1% (0.01) or greater pet fee burden. Note that highly blue tracts indicate low burden POC areas while purple regions indicate high burden POC areas. Red indicates high burden, low POC areas while transparent regions have low POC and low burden.

and lack of reserve funds needed to pay pet fees, sometimes in addition to a security deposit (11). Paying a larger proportion of one's income on rent decreases the resources available for other necessities such as food, transportation, utilities, and healthcare, both for themselves and their pets. The landlord-friendly laws in the Texas rental market mean that families who are housing cost burdened are particularly susceptible to eviction, as evidenced by Garboden and Rosen, who interviewed landlords and property managers from Dallas, TX, Cleveland, OH, and Baltimore, MD regarding eviction practices (37). The authors classified Texas as the most "pro-business" of the states studied, noting that in Dallas, "if a tenant is late on their rent, they can be evicted, a unit turned over, and a new tenant housed by the beginning of the next month" (p. 8) (37). Furthermore, even when housing is advertised as pet-friendly, only pets of certain sizes, species, or breeds are permitted. Large dogs are especially hard to house, despite a lack of evidence suggesting that larger dogs are more problematic when housed (11, 22, 24).

Our findings point to the hypothesis that pet fees are yet another discriminatory practice that inevitably leads to poorer housing security and potentially increased evictions among already disadvantaged and marginalized populations. Additionally, considering previous research showing that people with pets may move to neighborhoods they deem "less desirable" in order to secure pet-friendly housing (11), it is possible that pet-related in-city residential mobility could contribute to gentrification, thus driving up housing costs in lower-income neighborhoods (58, 59). Evidence from the condominium market shows that "no pets" policies tend to drive up prices for units that do allow pets, and thus landlords may have a monetary incentive for keeping these policies in place (60). Overall, the problem with promoting pet-friendly housing as a strategy for landlords "to increase their bottom-line profits" (24) is that doing so disproportionately impacts marginalized groups. Rather than thinking about pet-friendly housing as an economic opportunity, we should consider ways to preserve families through fair housing practices.

Limitations

This study is not without limitations. First, our sample consisted of publicly available data that was pulled from a popular online rental listing aggregator (apartments.com) and therefore

is not representative of all available rental listings. Notably, the exclusion of listings from subsidized units likely biased our results in that the full extent of inequality was not evident. Likewise, it is possible that our non-significant result related to pet rent burden and proportion Black residents was related to this sample bias. Moreover, because this is an analysis of pet-friendly housing, it is possible that communities with higher proportion Black residents have less pet-friendly housing altogether, as was found in previous research (43). Because apartments.com will not display results past 700 listings per search criteria, we were unable to assess the proportion of overall rental stock that was advertised as pet-friendly (though this limitation only impacted the three largest cities: Houston, Dallas, and Austin).

We also acknowledge that using broad categorizations for racial/ethnic groups will inevitably remove some of the nuance related to inequalities in housing. For example, residents who were categorized in the American Community Survey as Latinx/Hispanic come from a variety of Latin American backgrounds and may identify as any race (e.g., White, Black, etc.). Thus, Latinx people are certainly not a monolith in terms of experiences of inequality related to housing and pets. The same goes for those who fall into the Asian census category, as Asian Americans have lineages from over 20 countries across Asia. Future research should consider the ways in which various racial and ethnic backgrounds may experience housing inequalities related to pets, beyond broad categorizations like those we have derived from the census here.

Future Directions

Our findings point to several directions for future research. First, given our findings here, as well as those from previous research (11, 22, 56), it is likely that renting with pets may increase the risk of eviction. Future research should consider how pets may be a factor in the process of eviction, as well as the consequences of eviction for people with pets, and for the pets themselves. Relatedly, we are unaware of any research that systematically investigates the types of support available to families with pets when facing eviction. Second, considering our findings showing that pet fees are disproportionately unaffordable for low-income and marginalized individuals as a function of the area's median income, future research should interrogate whether the phenomenon of moving to lower-income neighborhoods in order to secure affordable housing that allows pets is widespread, thus potentially contributing to gentrification. Last, while Texas represents an important case study about housing inequality related to pets, future research should expand this study to explore national patterns. For example, do inequalities in pet-friendly housing differ by state, and does the political makeup of the state matter? These questions warrant investigation.

CONCLUSION

In this study we assessed the cost burden of renting with pets in Texas. We found that higher cost "pet-friendly" rental units, which were generally within higher income communities, tended to be less likely to have pet fees, while less expensive units, which were generally in lower-income communities, tended to have additional pet fees on top of monthly rent. When we viewed pet rental fees as a proportion of the community's median income, we found that communities with higher proportions of residents who were not White tended to have higher relative pet rent burden, compared to communities that were predominantly (or entirely) White. In particular, pet fee burden was the most pronounced for communities with high proportions of Latinx residents. Finally, we found that there was a relationship between overall within-city income inequality and inequality in pet fee burden between nearby communities, as well as overall within-city income inequality and inequality in pet fee burden by proportion of residents who were people of color. Houston stood out as notable in terms of high overall income inequality, moderate spatial inequality in pet fee burden, and high racial/ethnic inequality in pet fee burden. We continue here with recommendations for policy and practice.

Policy Implications

Given our findings suggesting that additional charges for pet ownership in rental housing disproportionately harm disadvantaged and marginalized pet owners, we continue here with several recommendations for housing policy. First, we strongly recommend against using the Texas Apartment Association's template Animal Addendum or other similarly punitive documents, and instead encourage landlords to adopt pet policies more reflective of the role that pets play in families. The Animal Addendum, for example, states that any single violation of the various rules as stated in the Animal Addendum or a single complaint by a neighbor can, at the sole discretion of the property manager, result in a written notice which will require a tenant to "immediately and permanently" remove the animal from the premises (61). Particularly disturbing is that the Animal Addendum allows a landlord to physically remove a pet when the tenant is not home following any rule violation or if a tenant allows their pet to "urinate or defecate where it is not allowed" (61).

Some states have much more tenant-protective, pet-prescriptive policies. In Kansas, for example, landlords can charge up to one month's rent for an unfurnished rental unit and are also allowed to charge an additional pet deposit of up to one-half of monthly rent (62). Similarly, in Nebraska, landlords can charge up to one-month's rent for a security deposit along with an additional one-quarter of a month's rent as pet deposit (63). Other states, like Arkansas, California, Maryland, Nevada, and Massachusetts, among others, simply place a maximum cap of security deposit that can be collected, regardless of how that deposit is designated. In these states, total deposits collected at the start of a tenancy range from 1 to 3 months, with some specifying whether or not the property is furnished (64). Both Montana and California prohibit non-refundable fees for any purpose, including fees for pets (65, 66).

Pet charges beyond the regular security deposit only add to the financial barriers that low-income tenants already face

when trying to find housing. Past research has found that, in the rare instances in which pet-related damages do occur, security deposits are more than sufficient in most instances (24). Furthermore, there is no evidence that landlords charging for pet ownership are using this extra income to pay for any additional costs of maintaining rental properties that allow pets; to the contrary, housing advertised as pet-friendly is often perceived to be of poorer quality (11, 22). Knowing that tenants will go to extraordinary lengths to keep their pets, landlords in this case are merely capitalizing on the bond between pets and their people. If additional pet charges must be imposed, the amount should be a percentage of total monthly rent, be capped, and be made refundable, to incentivize good tenancy (11).

Finally, we recommend a blanket prohibition on "no pet" policies (with programs that reduce potential for pets to pose threats or nuisances when housed) throughout the rental housing market in the U.S. and to require all housing subsidized by local, state, or federal funding to be pet-friendly. For example, in August 2021, Illinois Governor Pritzker signed into law a landmark bill, S.B. 154, which requires housing providers receiving funding from the Illinois Affordable Housing Trust Fund to allow two cats or one dog up to 50 pounds and prevents landlords from prohibiting a dog based on its breed (67). While this Illinois bill signifies major progress in housing justice, it still allows for discrimination based on dog size and number of pets. Notably, most breed restrictions apply to dogs that are over 50 lbs. (e.g., Rottweilers, German Shepherds, pit bull-type dogs, etc.). In Ontario, Canada, there exists a province-wide ban on pit-bull type dogs; however, it is also the only province in Canada where it is illegal for landlords to reject housing applications based on pet ownership status. That said, the law is poorly enforced so it is not uncommon to see rental ads stipulating "no pets allowed" (56, 68). Once enacted, recommended policies must therefore be actively enforced and legal aid may also be needed, to help make tenants aware of their rights.

We acknowledge the above recommendations may be challenging to implement in practice. We suggest policymakers consider the full spectrum of possible interventions presented in this paper with our discussed recommendations as ideal solutions. We continue here with implications and recommendations for practice.

Practice Implications

There is also a need to help promote a sense of security and positive community relations once families renting with pets are housed. Tenants living with a dog who barks incessantly when left alone, for example, may worry about neighbor complaints and getting evicted as a result (11, 69). Separation anxiety-related behaviors may be on the rise in the last year, as many dogs have become accustomed to being at home all or most of the day with their families during the pandemic (70, 71). Nonetheless, professional dog training services are expensive (72). One potential solution is for animal shelters to serve as resource hubs for issues related to pets in rental housing, for instance, offering a behavior helpline for tenants and landlords (11). Community outreach programs such as the Humane Society of United States Pets for Life program could also offer subsidized services including behavioral support, dog walking, and pet sitting to families renting with pets. Any such programs should address systemic issues and help build local capacity in marginalized communities so as to not cause further vulnerability or dependency. Finally, there is a need for neighborhoods to build safe and supportive outdoor spaces for dogs. Investments in sidewalks can motivate dog walking (73, 74) and access to dog parks can foster increased social interaction (75, 76), both of which can help keep dogs exercised and mentally stimulated so that they do not show problem behaviors inside.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Florida IRB. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JA, KH, and LL: conceptualization. KH: methodology and analysis. All authors writing, review, and editing.

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Inequitable Flow of Animals in and Out of Shelters: Comparison of Community-Level Vulnerability for Owner-Surrendered and Subsequently Adopted Animals

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There is increasing awareness among animal shelter professionals regarding the role of shelters in perpetuating inequities in pet ownership, although the relationship between owner vulnerabilities and animal shelter services is largely understudied. Currently, there is no literature comparing the sociodemographic conditions of communities where surrendered animals originate and communities where they are adopted. The present study compared the "flow" of surrendered animals between originating communities (incoming) and communities where they were adopted (outgoing; $n = 21{,}270$). To analyze community-level vulnerability, we used the Canadian Index of Multiple Deprivation (CIMD), which has four dimensions of social vulnerability. We found that three of the four CIMD dimensions were significantly different between surrendering and adopting communities (Ethnocultural Composition, Situational Vulnerability (SV), Economic Dependency, but not Residential Instability). For further investigation, we also grouped our analysis by intake groups (small animal $n = 2{,}682$; puppy $n = 973$; dog $n = 3{,}446$; kitten $n = 6{,}436$; cat $n = 7{,}733$) and found multiple relationships for which the incoming and outgoing CIMD quintiles were different. For example, for both puppies and kittens, the median outgoing SV quintile ranks were statistically significantly lower (less vulnerable) than incoming quintile ranks, with the effect size being moderate (puppy $r = 0.31$, kitten $r = 0.30$; $p \leq 0.0025$), supporting the concern of the flow of certain animals from more vulnerable to less vulnerable communities. The results of this research provide a basis for understanding potential inequities in the use of shelter services to surrender or adopt an animal. Furthermore, these methods allow animal shelters to assess community needs and create interventions to reduce intake and increase adoption of animals. Finally, these data provide further support that animal sheltering is best considered from a One Welfare perspective.

Keywords: adoption barriers, animal sheltering, One Welfare, social determinants, social justice

INTRODUCTION

Animal sheltering organizations are aware of the relationship between human vulnerability and the use of animal shelter services, and express interest in providing more initiatives that target community-level issues (1, 2). Many community-based interventions support owners facing challenges in caring for their animals. For example, animal shelters may offer low-cost or free spay/neuter services for low-income communities (3). Others provide mobile clinics that can reach communities that have difficulty accessing veterinary services (4). Some shelters provide emergency boarding services, wherein owners temporarily board their animals at a shelter or foster home while experiencing a crisis (5). Surrender-prevention programs also support pet owners in areas where they may otherwise relinquish their animals, such as through assistance with paying pet deposits on rental leases, pet food banks, and providing helplines for animal behavior issues (1, 6). Interventions that assist pet owners in pet care ultimately fall under the One Welfare framework, wherein the well-being of humans, animals, and the environment are interconnected (7).

Unfortunately, access to continued pet companionship may not be equal in all groups of people. Pet ownership is more likely in certain demographics such as high-income earners, home owners, and rural residents (8–10). Many studies report that owner-related issues (e.g., financial issues, difficulties finding housing) are more common reasons to surrender pets compared to animal-related reasons [e.g., animal behavior; (11, 12)]. Rose et al. (13) found that neighborhoods in the United States with predominantly African American residents had less availability of pet-inclusive housing, which likely puts people in these communities at a greater risk of surrendering a pet for housing-related reasons. Some recent studies have used measures of social vulnerability, such as the Social Vulnerability Index (SVI) in the United States, which provides a measure of social and environmental inequalities of communities (14). Dyer and Milot (15) compared animal intake and outcomes to social conditions of community members, and found that surrendered pets from more socially vulnerable households were more likely to be euthanized after intake to the shelter. Recently, a striking report by Best Friends Animal Society found that not only did high vulnerability counties within the United States (e.g., low socioeconomic status, racialized population, persons with disabilities) have a higher rate of intake overall compared to nation-wide rates, but also that adoptions, as a proportion of intake, were lower in high social vulnerability areas compared to the national average (16). In our previous work (17), we explored the relationship between community-level vulnerability and owner surrender of animals in British Columbia. This retrospective study used data from the British Columbia Society for the Prevention of Cruelty of Animals (BC SPCA), which consists of 34 animal shelters and 2 foster-based locations. To measure human vulnerability, we used the Canadian Index of Multiple Deprivation (CIMD), which is a measure of social vulnerability similar to the SVI used in previous work in the United States. The results showed that increased vulnerability predicted increased risk of surrender for particular surrender reasons, of particular species or dog breeds, and of particular health statuses upon intake. For example, we found that increased Situational Vulnerability (e.g., higher proportion of low-income individuals, individuals without a high school diploma, single parent families, among other indicators) predicted increased risk of surrendering puppies and kittens compared to cats (the most commonly surrendered animal).

Currently, there is little research investigating the connections between social vulnerability and animal outcomes. In addition to larger societal inequities, one concern within the sheltering field is that animal shelter procedures themselves may be contributing to further inequities (18, 19). Potential barriers include intensive adoption criteria that may encourage discriminatory adoption practices, such as preferentially adopting out to high-income earners who own a home. In a recent questionnaire, 30.5% of shelter organizations reported using pre-adoption home visits to screen adopters (20). The subjectivity of adoption application practices may allow for bias and discrimination against adopters (21), albeit confirmatory research is needed. Similarly, the current system of animal control/animal protection in some countries has disproportionate negative impacts on low-income communities and communities of color, including higher confiscation of animals and lower proportion of animals returned to their owner (22). Currently, animal laws are equivocal and thus may be susceptible to subjectivity, which often leads to over-enforcement for vulnerable communities (22). Perhaps another source of inequity in animal sheltering services comes from the differences between demographics of owners who surrender animals and those who adopt them. Put simply, is it possible that animal shelters are taking from the poor and giving to the rich? This may be occurring in situations where animals are "rescued" from communities where they are free-ranging (i.e., living outdoors) but cared for by community members, and then transported out of their home community for adoption (23). Perhaps it is also occurring locally, as the communities served by animal shelters may vary drastically in social vulnerability.

Despite substantial industry interest in providing more equitable services in animal shelters, research on these topics is lacking. To the best of the authors' knowledge, no study has yet compared vulnerability of communities that use intake services (e.g., owner surrender) compared to those that use outgoing services (e.g., adoption) by connecting the movement of individual animals from intake to adoption. In our previous work, we assessed only the vulnerability of communities surrendering animals. The present study continues this work, with an added layer of assessing community-level vulnerability at adoption. Understanding the "flow" of animals to and from communities of differing vulnerability levels can help animal shelters better understand potential imbalances in the use of these shelter services. Thus, the objective of this study was to understand whether surrendered animals are adopted to communities with the same or different vulnerability levels in British Columbia, Canada.

MATERIALS AND METHODS

Data

This study protocol was reviewed and approved by the University of British Columbia's Research Ethics Board (H20-02704).

TABLE 1 | The four dimensions of multiple deprivation and corresponding indicators for British Columbia (2016).

Ethnocultural composition	Situational vulnerability	Economic dependency	Residential instability
Proportion of population who self-identify as a visible minority	Proportion of population that identifies as Aboriginal	Proportion of population participating in the labor force (>15 years)*	Proportion of dwellings that are apartment buildings
Proportion of population that is foreign-born	Proportion of population aged 25–64 without a high school diploma	Proportion of population aged 65+	Proportion of persons living alone
Proportion of population with no knowledge of either official language (linguistic isolation)	Proportion of dwellings needing major repairs	Ratio of employment to population*	Proportion of dwellings that are owned*
Proportion of population who are recent immigrants (arrived in 5 years prior to Census)	Proportion of population that is low-income	Dependency ratio (population 0–14 and 65+ divided by population 15–64)	Proportion of population who moved within the past 5 years
	Proportion of single parent families		

Indicates reverse-coded measures. Data are taken from the 2016 Census of Population by Statistics Canada.

Permission for data usage was granted by the BC SPCA. The complete dataset can be found in the **Supplementary Material**. The data used in this study comes from the province of British Columbia, which in 2016 reported a population around 4.6 million (24). The majority of the population identifies as White (64%), with the second most common ethnicity being East and Southeast Asian (18%). Immigrants from China comprise the largest percentage of immigrants to British Columbia (15.5%), followed by India (12.6%), and the United Kingdom [9.6%; (24)]. In 2016, 5.9% of the population identified as Indigenous. In addition, 3.3% of the population are linguistically isolated, meaning they have no knowledge of either of the two official languages of Canada [English and French; (25)]. The median total income of households in 2015 was slightly below $70,000 CAD (24).

This study utilized the CIMD, which is a publicly available measure of social well-being that uses Canadian census data to describe specific dimensions of vulnerability in a small dissemination area [unit of area used by the Canadian census; (26)]. Although the CIMD is a geographically-based index of human social vulnerability, the dataset is also potentially useful as a proxy for individuals living in the dissemination area (27). The CIMD data are available in both raw score and quintiles. This study utilized the CIMD quintile (1–5) score data. Each community is given a raw CIMD score for each factor. Within each factor the scores are then ordered and distributed into five equal quintiles, each quintile holds 20% of the dissemination areas. A higher quintile indicates greater vulnerability based on the indicators for each of the four dimensions. The four dimensions of the CIMD are Ethnocultural Composition (EC), Situational Vulnerability (SV), Economic Dependency (ED), and Residential Instability (RI). The indicators that make up each CIMD dimension can be found in **Table 1**.

Outgoing animal data were collected from 36 animal shelter locations of the BC SPCA for all animals adopted between January 1, 2016 and December 31, 2019. The BC SPCA is a non-profit organization that operates facilities and programs to improve the lives of animals in B.C. including enforcing provincial animal protection legislation, engaging in advocacy and humane education programs, providing support in the form of pet food banks to the community, and operating 36 animal shelters, 5 animal hospitals/clinics, and a wildlife rehabilitation center (28). In 2020, BC SPCA animal shelters had an intake of ∼15,000 animals with an ∼90% live release rate [the percentage of animals that exit the shelter alive; (26–28)]. The BC SPCA animal shelters are not the only ones in the province; approximately 17 municipal animal shelters and 110 other rescue organizations also operate in the province (29). The BC SPCA has a largely managed admission system, prioritizing intakes for animal protection and animal control cases and asking surrendering owners to make an appointment [where they may be placed on a waitlist; (30)]. In 2014, the BC SPCA implemented the "Adopters Welcome" program to engage and support adopters and reduce shelter length of stay (31). The open adoptions program aims to reduce barriers to adoption by using conversation-based practices to encourage adoption rather than using traditionally restrictive screening applications (31). The BC SPCA follows this model by asking adopters to fill out an adoption application, which is used as a basis for a conversation of fit of the animal rather than for screening of the adopter (32).

The data collected for this project are similar to those utilized in our previous work (17), although the present study used data prior to 2020 to reduce the possible abnormalities that arose from the SARS-CoV-2 (COVID-19) pandemic. Whereas our previous dataset focused on incoming animals (regardless of their outcome), our present analysis used only data from animals that were surrendered by owners and subsequently adopted from the BC SPCA. Additionally, the current study excluded non-mammalian exotic animals due to low sample size. The outgoing shelter data included information for small animals (including rabbits, rats, guinea pigs, mice, gerbils, hamsters, ferrets, degus, chinchillas, and hedgehogs), cats, kittens (<6 months), dogs, and puppies (<6 months) adopted within this timeframe, and included the location from which the animal was surrendered and the location to which the animal was adopted.

The data were cleaned and analyzed using RStudio version 1.4.1106 (33). The raw dataset included 27,784 observations. To connect animal shelter data with the CIMD, all observations

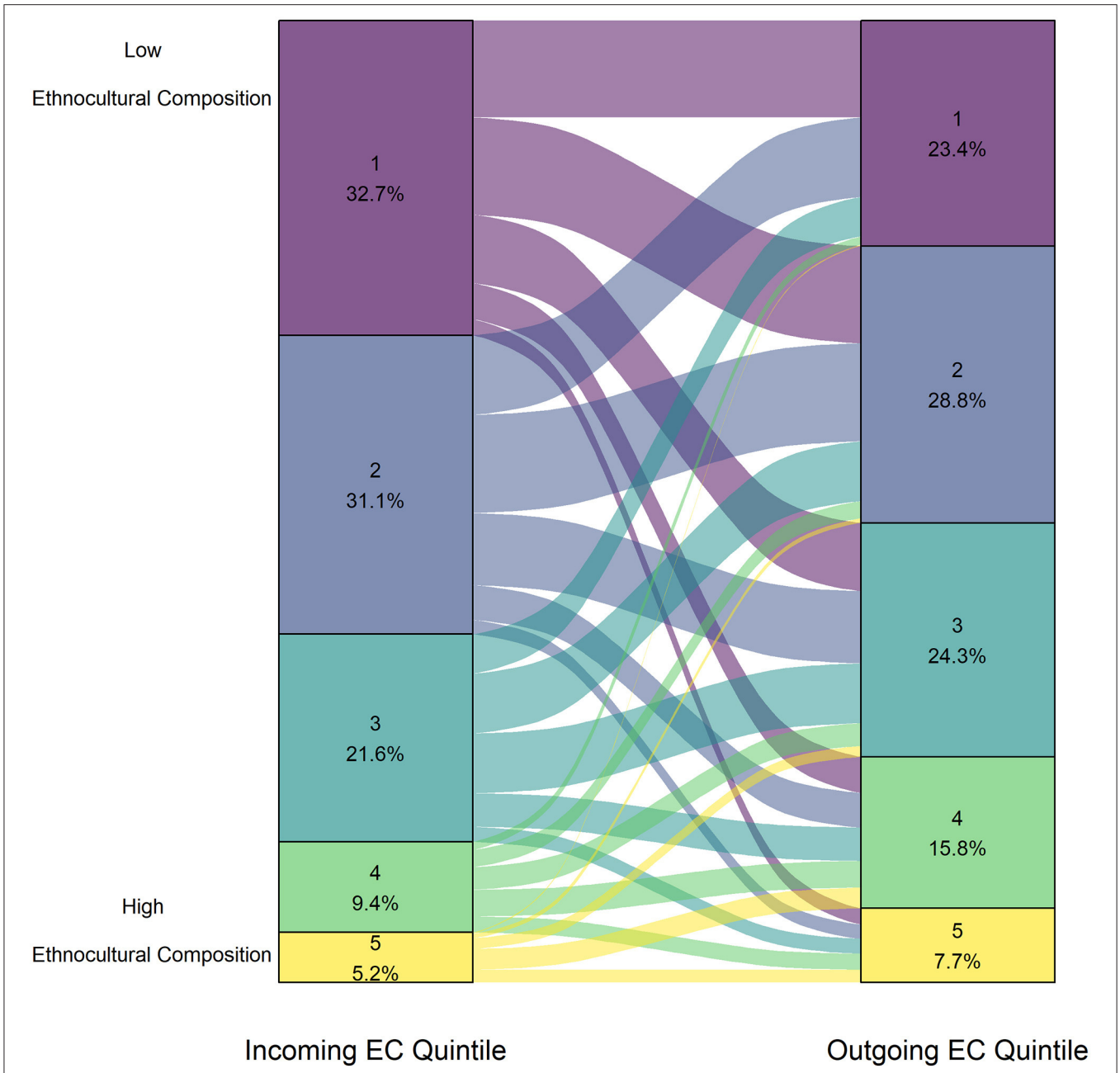

FIGURE 1 | Proportion of animals from each Ethnocultural Composition quintile upon surrender (left axis) and upon adoption (right axis) for all intake groups adopted between January 1, 2016 to December 31, 2019 ($n = 21,270$).

with incoming or outgoing addresses located outside of British Columbia were excluded ($n = 1,705$). Observations were also excluded if either the incoming or outgoing address was non-codable in a geographic information system software Quantum Geographic Information System (QGIS; i.e., incomplete or did not exist; $n = 4,809$). The cleaned, geocoded dataset included 21,270 observations (small animal $n = 2,682$; puppy $n = 973$; dog $n = 3,446$; kitten $n = 6,436$; cat $n = 7,733$).

Although the CIMD used factor analysis to create four independent factors, we verified the independence of the CIMD factors in our dataset with the incoming CIMD scores by using Spearman rank correlations on each possible pair. We found that there were only two relationships that had a weakly positive correlation: RI and EC ($r = 0.38$, $p < 0.001$) and RI and SV ($r = 0.34$, $p < 0.001$).

Analysis

The change in CIMD quintiles was visualized through histograms and alluvial diagrams, which represent changes in a network structure over time (34). The differences between incoming

TABLE 2 | The results of Wilcoxon Signed Rank Test comparing incoming and outgoing Ethnocultural Composition quintiles for each intake group.

Intake group	Wilcoxon D	*p*-value	*r* (effect size)	Effect size interpretation
Small Animal	978915	0.020	0.02	No effect
Puppy	60192	<2.20e-16*	0.23	Small
Dog	5553455	1.34e-06*	0.06	No effect
Kitten	15793665	<2.20e-16*	0.21	Small
Cat	24575292	<2.20e-16*	0.16	Small

*$p < 0.0025$.

and outgoing CIMD scores were compared using Wilcoxon Signed Rank Tests. We first performed this test on the entire dataset, and then subsequently performed the test by intake groups for each CIMD factor, resulting in a total of 20 tests. To reduce the possibility of Type I error when performing multiple repeated tests on the same dataset (35), we used a Bonferroni correction, which set the *p*-value for statistical significance at 0.0025. Additionally, a large sample size can lead to small *p*-values resulting from small differences in the data. Therefore, we also chose to evaluate effect sizes through the method of dividing the Wilcoxon Signed Rank test statistic by the square root of the sample size (36). Effect size complements *p*-values to indicate practical significance of the results (37). To determine the size of effect, we followed the guidelines proposed by Cohen (38) where effect of 0.10–0.29 is considered a small effect, 0.30–0.49 is considered a moderate effect, and ≥0.5 is considered a large effect. In order to focus on practical implications, we only discuss results with both statistical significance and at least a small effect size.

RESULTS

Ethnocultural Composition

Across all intake groups of animals, the median outgoing EC ranks were higher (more vulnerable) than incoming quintile ranks, with the effect size being small ($p < 2.20e\text{-}16$, $r = 0.14$). The distribution of animals incoming and outgoing to each EC quintile is shown in **Figure 1**.

When comparing by intake groups, the results of the Wilcoxon tests for puppies, kittens, and cats were both statistically significant and had small effect sizes (puppy $r = 0.23$, kitten $r = 0.21$, cat $r = 0.16$; $p < 2.20e\text{-}16$; **Table 2**). For puppies, kittens, and cats, the majority of incoming animals were surrendered from communities with EC quintiles of 1 or 2 (puppy = 77.3%, kitten = 74.5%, cat = 60.6%), while the outgoing proportion of EC quintiles of 1 or 2 were lower (puppy = 59.8%, kitten = 57.0%, cat = 47.3%). The full plots for these three intake groups can be found in the **Supplementary File**.

Situational Vulnerability

The median outgoing SV ranks were higher than incoming quintile ranks across all intake groups of animals, with the effect size being small ($p < 2.20e\text{-}16$, $r = 0.21$). The distribution of animals incoming and outgoing to each SV quintile is shown in **Figure 2**.

The results for the Wilcoxon test performed separately by species can be found in **Table 3**. Notably, for both puppies and kittens, the median outgoing SV quintile ranks were significantly lower (less vulnerable) than incoming quintile ranks, with the effect size being moderate (puppy $r = 0.31$, kitten $r = 0.30$; $p < 2.20e\text{-}16$). For both puppies and kittens, the majority of the incoming animals were surrendered from situationally vulnerable communities with SV scores in the 4th or 5th quintile (puppies = 60.1%, kittens = 61.1%), which is shown in **Figure 3**.

For further exploration, we calculated the change in CIMD quintile by subtracting the outgoing CIMD quintile from the incoming CIMD quintile. The distribution of change is displayed for puppies and kittens in **Figure 4**. The Fisher Pearson coefficient showed that both distributions were negatively skewed (puppy = −0.13, kitten = −0.20).

Economic Dependency

The results showing the distribution of ED quintiles is shown in **Figure 5**. Across all intake groups, the median outgoing ED ranks were statistically significantly lower than incoming quintile ranks, with a small effect size ($p < 2.20e\text{-}16$, $r = 0.11$).

When the analysis was done separately by intake group, only puppies and kittens showed a statistically significant difference with small effect size (puppy $r = 0.12$, kitten $r = 0.19$; **Table 4**). For both, the median outgoing ranks were lower than that of the incoming ranks ($p < 2.20e\text{-}16$). Both intake groups had the majority of incoming animals in ED quintiles of 4 or 5 (puppy = 52.2%, kitten = 59.5%). Full plots showing the distribution of ED quintiles for puppies and kittens can be found in the **Supplementary File**.

Residential Instability

For all intake groups of animals, RI was the only CIMD dimension for which the difference between median ranks for incoming and outgoing quintiles were not statistically significantly different and had no effect ($p = 0.91$, $r = 0.0006$; **Figure 6**).

The results of the Wilcoxon test for RI by intake groups are shown in **Table 5**. The results of the Wilcoxon test across all intake groups had no effect except for small animals, for which the effect size was small ($p < 2.20e\text{-}16$, $r = 0.14$). For small animals, the median outgoing RI quintile ranks were lower than that of the incoming ranks. The majority of incoming small animals were surrendered from communities in the 4th and 5th RI quintile (4 = 20.1%, 5 = 36.1%), whereas the small animals were adopted out to communities in a relatively balanced manner (1 = 16.7%, 2 = 18.5%, 3 = 19.8%, 4 = 22.3%, 5 = 22.7%). The plot showing the distribution of small animals can be found in the **Supplementary File**.

DISCUSSION

In our previous work, we found that the risk of owner surrender for various reasons, of various species/breeds, and of various health statuses was predicted by the different CIMD factors,

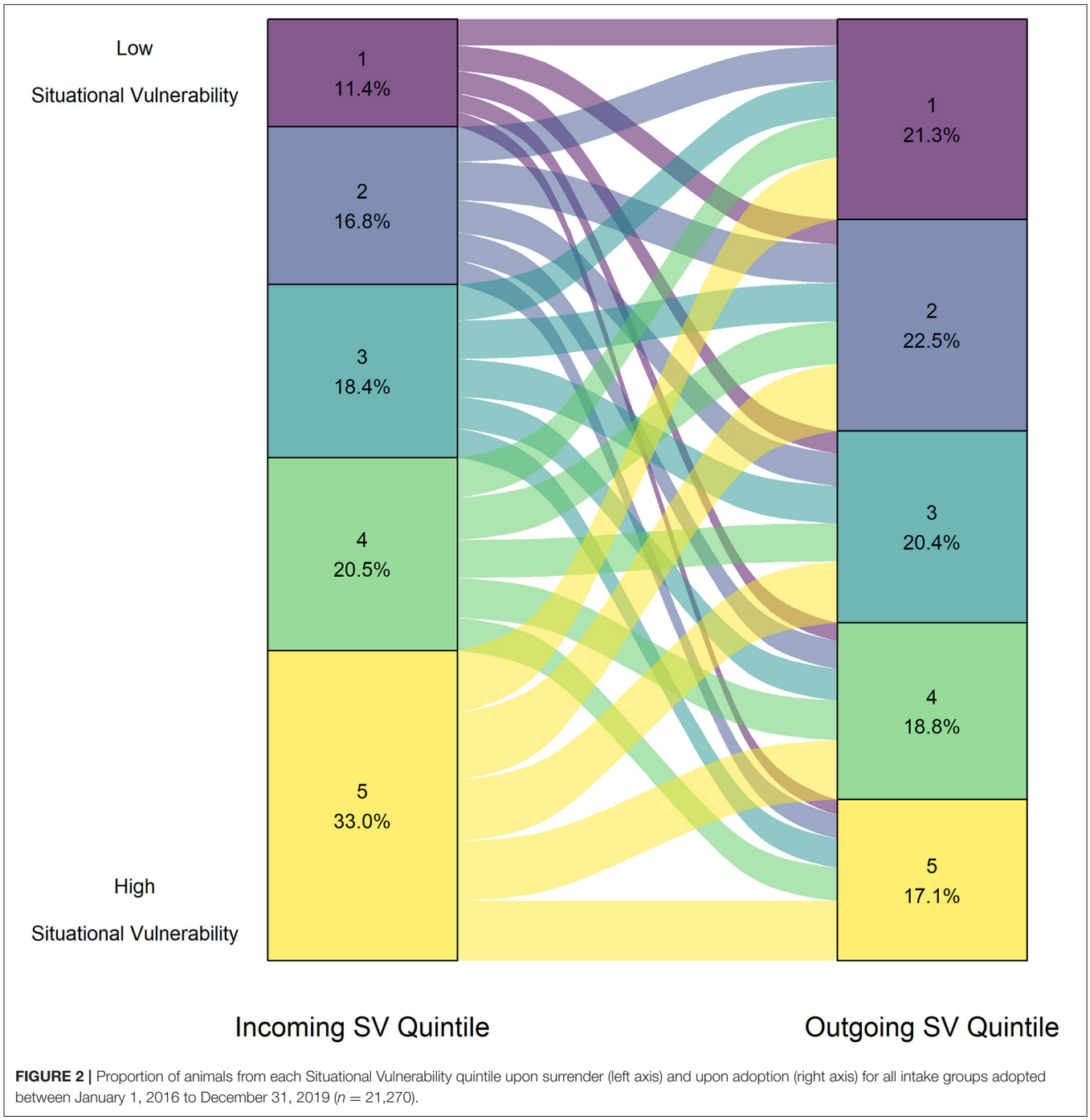

FIGURE 2 | Proportion of animals from each Situational Vulnerability quintile upon surrender (left axis) and upon adoption (right axis) for all intake groups adopted between January 1, 2016 to December 31, 2019 ($n = 21,270$).

showing that community vulnerability affects animal surrender (17). In our present analysis, we tracked the movement of animals from surrendering to adopting communities in order to understand potential imbalances in the use of shelter services. We found that there were multiple statistically significant differences between the incoming and outgoing CIMD quintiles. Our data revealed that in most instances, except for Ethnocultural Composition, the imbalance was largely due to disproportionate intake of animals from more vulnerable communities, rather than an imbalance at adoption. This is the first study to explore the "flow" of animals in this sense and will help animal shelters better understand the use of shelter services by vulnerable communities.

Ethnocultural Composition

A larger proportion of animals both originated from and were adopted to communities of low EC, indicating less presence of racialized and immigrant populations in both surrendering and adoptive communities overall. However, there was still a

large difference between incoming and outgoing EC quintiles; a further disproportionate number of incoming animals were surrendered from areas with low EC, even lower than areas into which animals were subsequently adopted. In Canada, the phrase "visible minority" refers to those who are non-White (39). The phrase "racialized populations" is used to replace the term "visible minority," in recognition that race is a social construct rather than a biological one (40). Furthermore, in some parts of the country, former "minority" populations now comprise a majority (40). Many immigrants are also from racialized communities, as such, these components constitute the Ethnocultural Composition facet of the CIMD. For our dataset, results may be explained by differences in ethnic composition between rural and urban areas of the province. In Canada, the majority of racialized populations live in large urban areas (24). In British Columbia, the largest urban centers are along the coast of the province, while smaller communities are spread throughout the North and Interior of the province (25). Therefore, in our study, this result may be due to transfer of animals from rural communities to urban communities. The BC SPCA has an active internal animal transfer program that moves ∼5,000 animals a year from shelters in areas in the province with overpopulation to shelters in areas with more adoption capacity. The source communities are largely in Northern and Interior British Columbia, where many rural communities have less racial/ethnic diversity. The shelter intake per capita of the Northern region is 12 times higher than that of the coastal metropolitan areas (41). Animals are typically transferred to the coastal metropolitan areas, where the majority of the province's population resides.

TABLE 3 | The results of Wilcoxon Signed Rank Test comparing incoming and outgoing Situational Vulnerability quintiles for each intake group.

Intake group	Wilcoxon D	*p*-value	*r* (effect size)	Effect size interpretation
Small Animal	1340980	2.65e-13*	0.10	No effect
Puppy	239395	<2.20e-16*	0.31	Moderate
Dog	2343185	<2.20e-16*	0.16	Small
Kitten	27507833	<2.20e-16*	0.30	Moderate
Cat	35976729	<2.20e-16*	0.18	Small

*$p < 0.0025$.

As we previously found, puppies and kittens were less likely to be surrendered from areas with high EC; this result is expected as the metropolitan areas of British Columbia are largely comprised of communities with high EC (17). Indeed, previous studies in other regions have found that dog and cat ownership is more prevalent in rural communities (42, 43). Previous research also shows that people in rural communities are less likely to have spayed/neutered their animals (44, 45). Gaps in veterinary services for rural communities may be contributing to increased litters of puppies and kittens that are subsequently surrendered to animal shelters.

Across all animal intake types, the EC quintiles of adopter communities were imbalanced, with a large number of animals being adopted to communities with low EC. One explanation may be that the imbalance stems from differences in the

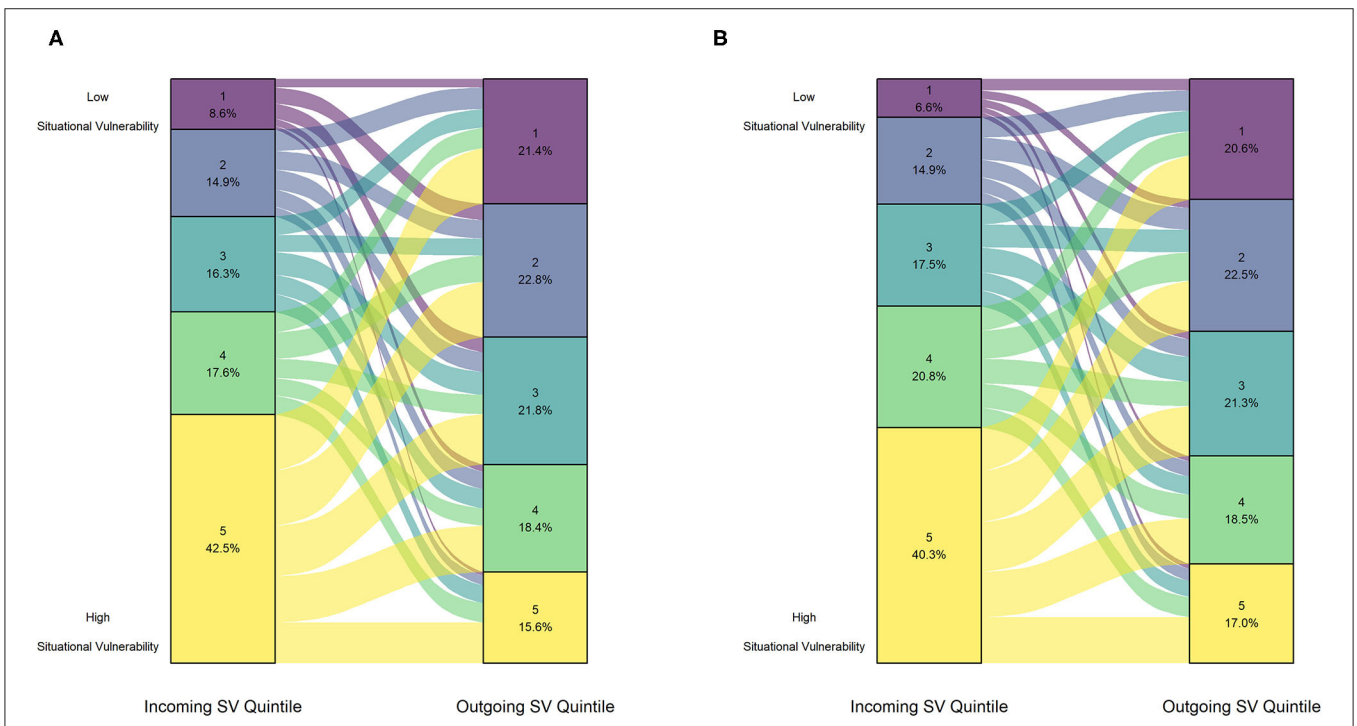

FIGURE 3 | Proportion of animals from each Situational Vulnerability quintile upon surrender (left axis) and upon adoption (right axis) for **(A)** puppies ($n = 973$) and **(B)** kittens ($n = 6,436$).

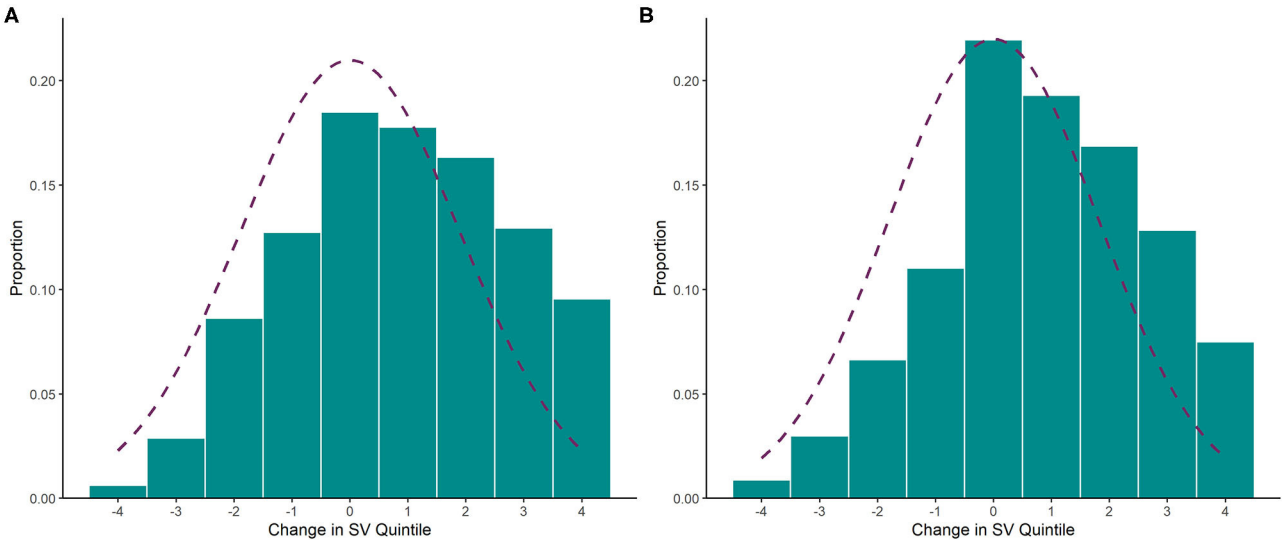

FIGURE 4 | Histogram showing the distribution of change in Situational Vulnerability quintile between the community the originating and adoption community for **(A)** puppies ($n = 973$) and **(B)** kittens ($n = 6{,}436$). Negative change indicates that the animal moved to a more vulnerable community upon adoption, while positive change indicates that the animal moved to a less vulnerable community upon adoption. The dotted purple line indicates a normal distribution where the mean = 0 and the standard deviation is the same as that of the distribution (1.9).

overall likelihood of companion animal ownership between rural and urban communities. In Ontario, Canada, those who live in rural areas or on properties that were greater than one acre were more likely to own pets (9). Owning a companion animal in a rural environment may be easier than in an urban environment due to less restrictive housing policies. While there is limited research directly comparing pet-friendly housing and ethnicity, initial research by Rose et al. (13) found that fewer than half of the landlords in predominantly African American neighborhoods in the United States allowed pets in rental units.

The procedures of the sheltering system itself may pose barriers to adoption. The criteria that are outlined in restrictive pet adoption processes (e.g., owning a home, standalone home, fenced yard, minimum income requirement) are likely to disproportionately affect racialized populations (19), although this area is vastly understudied. Moreover, it is possible that adoption decisions may be impacted by implicit bias, wherein most people have an unconscious bias against individuals of traditionally marginalized groups (46). Implicit bias has been studied in many settings such as health care services (47), law enforcement [including animal control; (21, 48)], and educational institutions (49, 50). As such, it is likely that animal shelters may unconsciously perpetuate societal bias in their intake and adoption procedures.

Questions that remain on less restrictive adoption applications, although not directly discriminatory, may still be subject to differences between cultures. For example, adoption applications may ask questions regarding caretaking behaviors, such as where an animal will spend time and sleep (20). Contemporary pet caretaking behaviors may differ between cultures, as the history of companion animals vary widely (51, 52). One survey in Malaysia found that 87% of respondents reported feeding outdoor-roaming cats, although research in the United States report varied estimates of outdoor cat-feeding behaviors ranging from 10 to 26% of respondents (45, 53, 54). In many national parks, leashing dogs is mandatory, although compliance was found to vary slightly based on country (55–57). One qualitative study found that American residents described several "norms" of pet ownership, such as multiple daily walks and inside access, although these practices do not necessarily reflect pet ownership practices universally (58). For example, crating dogs when left alone is acceptable and encouraged by the Canadian Veterinary Medical Association (59) but is not permitted in many countries like Sweden (60). Thus, the answers to the adoption application may be judged based on the cultural context of the shelter staff member or volunteer, rather than the adopter. Although the BC SPCA implemented the Adopters Welcome procedures prior to data collection, our results show that animals are still disproportionately adopted to communities with low EC. Further research is needed to understand whether conversation-based adoptions are subject to implicit bias or judgements based on cultural context.

Previous research and industry statements have noted that racialized populations are underrepresented in animal welfare professions (61–63). This under-representation may result in animal shelters unknowingly creating uncomfortable environments for racialized populations due to linguistic or cultural differences. Another explanation for our data may be that animal shelters have not placed sufficient effort in reaching out to communities with high EC to offer services, including pet surrender and adoption. The EC dimension also includes measures such as linguistic isolation, wherein one has no knowledge of either of the two official languages of

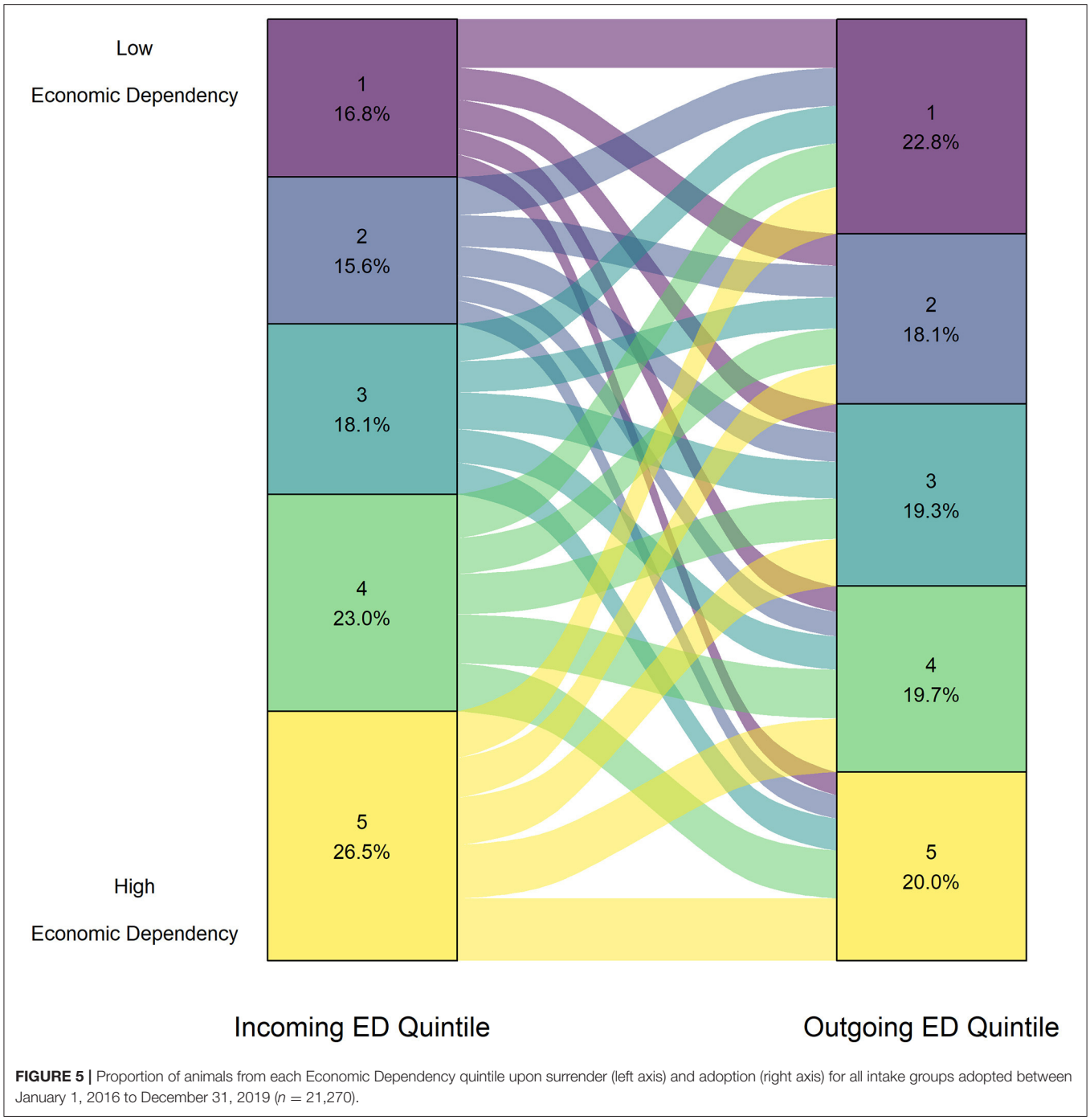

FIGURE 5 | Proportion of animals from each Economic Dependency quintile upon surrender (left axis) and adoption (right axis) for all intake groups adopted between January 1, 2016 to December 31, 2019 ($n = 21,270$).

Canada (English or French). Perhaps interventions related to education or pet care resources could be made available in other languages to connect linguistically isolated communities with animal shelter services. In public health literature, language barriers can lead to patients having decreased confidence in the services received (64). Even among Canadians who do speak English as a second language, some report discomfort with seeking health care services, and tend to visit health care services less frequently (65). In the health sector, the term "cultural competency" aims to improve the accessibility and effectiveness of health care for racialized populations, and interventions to improve cultural competency include improving knowledge and attitudes of cultures and increasing diversity of the workplace (66). Comparable literature in the animal welfare field is lacking, although Poss and Everett (67) found that providing bilingual, mobile veterinary services in a county that bordered Mexico and the United States increased use of the services. Future animal welfare research should focus on cultural

TABLE 4 | The results of Wilcoxon Signed Rank Test comparing incoming and outgoing Economic Dependency quintiles for each intake group.

Intake group	Wilcoxon D	*p*-value	*r* (effect size)	Effect size interpretation
Small Animal	1213199	1.13e-5*	0.06	No effect
Puppy	182442	9.01e-15*	0.17	Small
Dog	1783682	0.027	0.02	No effect
Kitten	24961823	<2.2e-16*	0.19	Small
Cat	32748074	<2.2e-16*	0.08	No effect

*$p < 0.0025$.

competency and use of services, particularly for areas with high Ethnocultural diversity.

Situational Vulnerability

Our study found that puppies and kittens were disproportionately surrendered from communities with high situational vulnerability (e.g., low-income, fewer years of education, high proportion of Indigenous peoples). In our previous study, companion animals from areas of high SV were at an increased risk of being surrendered due to the owner having "too many" animals, surrendering animals that were intact upon intake, and surrendering puppies and kittens (17). Indeed, previous research outlines the relationship between socioeconomic factors and ownership of intact animals. One Australian study found that the greatest intake of puppies and kittens came from unwanted litters (68). Cost is a significant barrier to owners spaying or neutering their animal. White et al. (3) found that pet owners who used low-cost spay/neuter clinic services had significantly lower median income compared to the general population of the United States. Spay/neuter programs are primary examples of animal shelter services aiming to tackle owner-related issues in order to reduce intake to animal shelters (69). In our geographic area of study, there are only two dedicated spay/neuter clinics in the entire province (although there are several organizations operating spay/neuter programs in partnership with community general practices). Disproportionate surrender of puppies and kittens from areas of high SV may be due to the limited presence of spay/neuter clinics and programs. On the other hand, our results revealed that the distribution of SV quintiles for communities that adopted puppies and kittens was relatively equal, suggesting that the BC SPCA's adoption practices posed few financial barriers. In our study, equal SV distribution of adopting communities may indicate that the adoption processes of the shelters did not lead to discrimination based on factors such as income, educational level, and Indigenous status, all of which are factors in determining the SV score of a community. While some animal shelters report collecting "financial means" information from potential adopters as part of the screening process, this concept is dependent on multiple complex factors such as the pet owners' priorities and cost of living. As such, Griffin et al. (20) suggest that measuring "financial means" to screen adopters is not an objective or beneficial measure of the animals' potential quality of life. One example of reducing financial barriers to adoption is low-cost or no-cost animal adoptions. Despite traditional beliefs that low- or no-cost animal adoptions may lead to devaluation of an animal and subsequently lower quality of life for the animal, there is evidence that the adoption fee does not make a difference in subsequent attachment to the pet (70).

Economic Dependency

The difference between incoming and outgoing ED quintiles was largely driven by puppies and kittens, where most animals were surrendered from high ED communities. The ED factor also indicates that the community has a high proportion of unemployed individuals, which includes those who are collecting a pension, those who are too young to participate in the workforce, and those who are receiving income assistance. As previously mentioned, cost is a significant barrier to accessing veterinary care (4, 71). Although there are limited initiatives that do provide low-income veterinary services in BC, there is still overwhelming need for assistance, particularly in vulnerable demographics such as seniors, who may find it difficult to reach veterinary services (71). While it may be expected that communities with high unemployment are closely related to those with low-income, we did not find that the SV and ED factors of the CIMD were strongly correlated. Job insecurity may lead to working unconventional hours (72), which may lead to challenges raising a puppy or kitten. However, the relationship between employment status and pet ownership challenges has not been widely studied. Overall, high ED indicates potential employment-related challenges that may lead to unwanted litters of puppies and kittens that are subsequently relinquished.

Although the ED dimension indicates non-employment or income from non-employment sources, it also describes the presence of two specific populations—seniors (>65) and children (<15). There are possible challenges that arise from pet ownership for seniors. In senior care homes, pet ownership may be discouraged due to risk of zoonotic disease and extra workload (73). Both dogs and cats may increase risk of falling (74, 75). Older adults with pets could be at increased risk of avoiding or neglecting their own health care due to fear of losing the animal (76). Children and adolescents also experience an increased risk of dog bites (77). The highest risk of dog bites in the United States is reported in children from ages 5–9 (78). However, companion animals also play an important role. Older adults show high levels of attachment to their pets, and they may substitute or complement human companionship following the death of friends and family members (79). Research also shows that pet ownership may buffer stressful situations, improve physical activity, and increase resiliency against depression and cognitive decline (80–83). For children, pet ownership may improve the development of empathy, enhance self-esteem, increase learning abilities and reduce symptoms of loneliness (84–86).

In our study, ED quintiles of adopted animals were relatively equal in distribution, which may indicate that the conversation-based adoption procedures do not discriminate based on family composition or employment status. Questions related to family composition are anecdotally important to animal shelter staff when screening potential adopters. Some animal shelters require a minimum age requirement for children in a home, typically

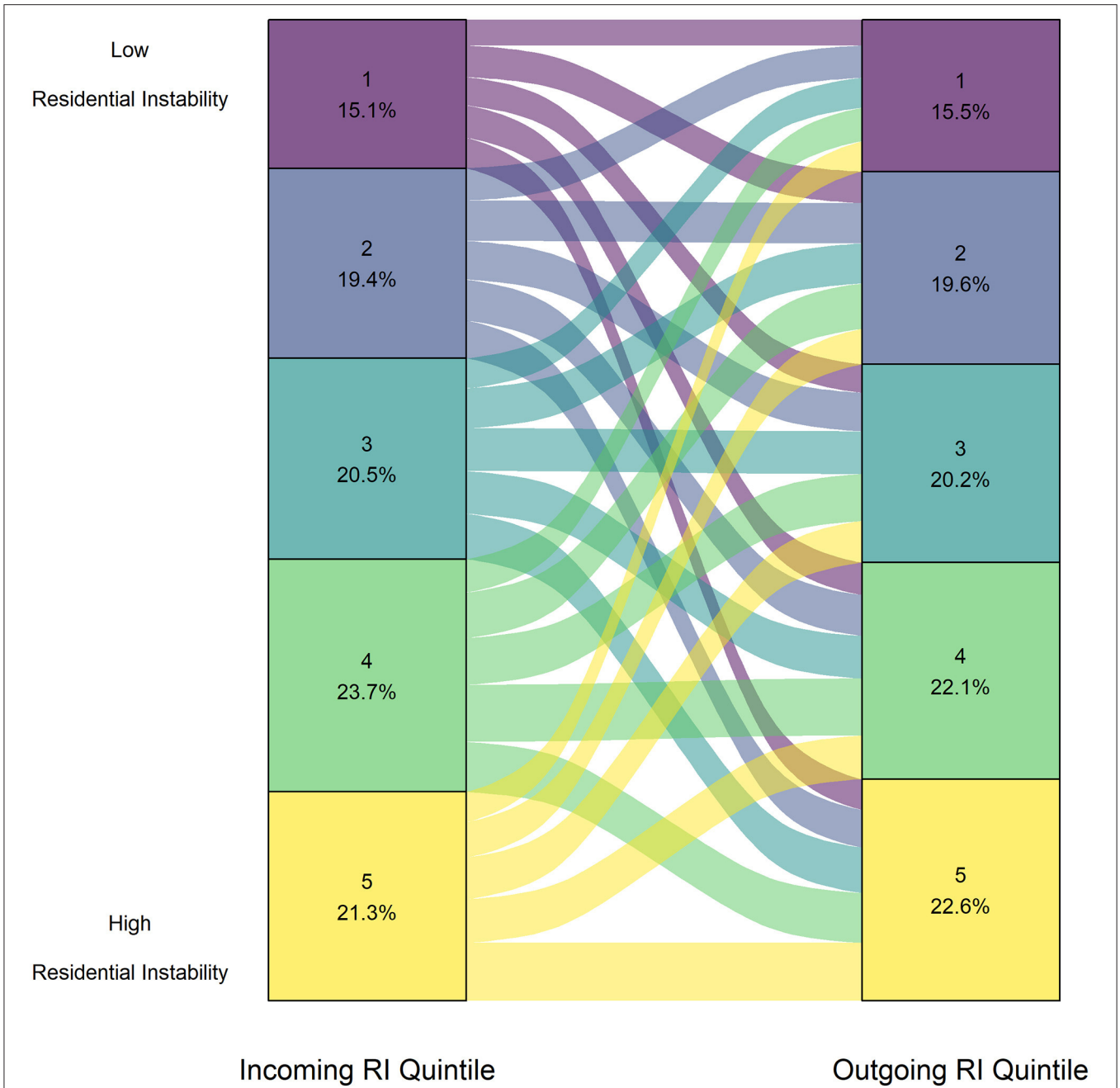

FIGURE 6 | Proportion of animals from each Residential Instability quintile upon surrender (left axis) and upon adoption (right axis) for all intake groups adopted between January 1, 2016 to December 31, 2019 ($n = 21{,}270$).

around 4 or 5 years old (20). However, several studies have found that increased number of family members and households containing children are more likely to own a companion animal (9, 42, 87). Families with children, who are interested in owning a companion animal, may seek other means rather than an animal shelter to acquire an animal. Because families with children are likely to own companion animals, perhaps it is more effective for animal shelters to not exclude this demographic from adopting animals, but rather provide resources and support for pet owners.

Residential Instability

In our dataset, differences between outgoing and incoming RI quintiles had a statistically significant but small effect for small animals only. Housing-related issues are a commonly reported surrender reasons for companion animals (88). A study in Australia found that the most common *owner-related* reason for surrender of adult cats was lack of pet-inclusive housing (89). A scoping review by Coe et al. (88) found that the rental housing and moving issues were the most commonly investigated

TABLE 5 | The results of Wilcoxon Signed Rank Test comparing incoming and outgoing Residential Instability quintiles for each intake group.

Species	Wilcoxon D	*p*-value	*r* (effect size)	Effect size interpretation
Small Animal	1374335	<2.2e-16*	0.14	Small
Puppy	471019	0.85	0.004	No effect
Dog	6048219	0.17	0.02	No effect
Kitten	20480374	0.89	0.001	No effect
Cat	7728866	1.88e-11*	0.06	No effect

*$p < 0.0025$.

owner-related reason in primary literature. There is significantly less literature on surrender reasons for species of animals other than dogs and cats. In the United States, Cook and McCobb (90) reported the primary reason for owner surrender of rabbits was the inability to care for rabbits (27%), although housing-related issues were also commonly cited (22%). Ellis et al. (91) found that housing-related issues of the owner were the second most common surrender reason of rabbits in the United Kingdom. A recent report found that only 29% of surveyed property managers allow small animals in their buildings, which potentially increases risk of surrender of these species for housing-related issues (92). Our study suggests that housing issues are a relevant cause for surrender for small companion animal species, which warrants further investigation into the relationship between pet-inclusive housing policies and small animal ownership.

Although the relationship between RI and animal flow was weak for dogs and cats, it is possible that housing-related issues are still barriers to retention of animals in homes for these species on an individual level, as many studies have found that housing-related issues are a significant reason for surrender for dogs and cats (88, 89, 93). In Canada, surveys of multiple animal shelters show that housing is a primary reason for relinquishment (94), with owners citing concerns such as landlord restrictions on pet ownership or high costs of pet-friendly housing (95–97).Whereas the present study did not analyze reasons for relinquishment, our previous work showed that in areas of British Columbia (i.e., Kamloops), RI predicted increased risk of surrender for owner-related reasons—including housing issues—across all species (17). It is possible that housing-related challenges were not captured when comparing RI quintiles between intake to adoption, but may be revealed by alternative (i.e., qualitative) analyses; in fact, previous reports of BC SPCA data have shown that animal owners directly cite lack of pet friendly housing is a significant contributor to cat and dog surrender (98). While the RI dimension captures both neighborhood and familial aspects of housing insecurity, it does not measure pet-specific challenges such as restrictive landlords. Finally, rental housing is becoming a larger proportion of accommodations in British Columbia (99, 100), which may lead to more housing-related challenges for pet owners of all species. As such, housing-related issues are still relevant for other companion animal species and should continue to be addressed by animal shelters.

Animal shelters often survey potential adopters regarding their home environment, and even conduct home visits to personally evaluate the home environment (20). Griffin et al. surveyed 269 animal shelter organizations in the United Kingdom and found that almost half of the adopters' characteristics deemed "most important" by animal shelters were characteristics about the adopter's accommodation, including the type of home, home ownership, the presence of a yard, and other physical characteristics of the home environment. Some of the adopter screening questions described by Griffin et al. (20) were quite specific, such as the shelter asking potential adopters about the type of flooring in their house; however, the only housing-related characteristic that has shown to increase risk of relinquishment is living in an apartment (101). On the other hand, housing type and environment have not been associated with decreased pet welfare or increased risk to human safety (20).

Our study did not find disproportionate outgoing quintiles as a result of adoption across all animals, which potentially suggests that discrimination of adopters is not directly occurring due to housing environments in the BC SPCA sheltering system's adoption processes. This may be due to the implementation of conversation-based adoption procedures at the BC SPCA, where potentially discriminatory housing-related factors such as landlord checks, and home visits were removed. Further research may be necessary to understand the implication of housing requirements on pet adoption, as some continue to use accommodation-related questions to screen potential adopters.

The RI dimension of the CIMD is relevant to the discussion of inequities as pet-inclusive housing is an ongoing topic of concern among both pet owners and animal shelters (88, 92). It may be difficult for shelters to directly intervene in housing-related challenges because this likely requires approaches that change rules and legislation related to pet-inclusive rental agreements or other accommodations (68). Some animal shelters do have initiatives to tackle housing issues. For example, the BC SPCA has educational resources and sample documents for pet owners, property managers, renters, and owners to encourage pet-inclusive housing (98). Other initiatives include paying for pet deposits for renters, and assisting with the construction of fencing so the pet can spend time outdoors safely (102, 103). Some shelters' temporary boarding programs accommodate pets whose owners are in-between housing situations (104); the BC SPCA offers up to 2 weeks of free emergency boarding for such owners. Ongoing research is needed in this area to reduce surrender from communities with high housing insecurity, particularly for homes with small animal species.

General Discussion and Limitations

Many vulnerable populations are predisposed to risks of multiple vulnerabilities, as such; it is difficult to isolate community vulnerabilities. For example, the most common source of income for those experiencing homelessness in British Columbia is income assistance (99). While housing insecurity is captured by the RI dimension of the CIMD, income assistance is represented by the ED dimension. This relates to public health research that uses the social determinants of health, which are upstream factors such as income, education, employment, housing, and race, that are thought to impact health outcomes (105). The relationship between sociodemographic conditions and health are multifactorial and complex, and do not imply a linear

relationship (106). However, much like in public health research, our study provides the basis for further exploration of small portions of the causal web between sociodemographic conditions and animal shelter services.

The use of a geographically based index such as the CIMD may limit the findings as relative to the surrenderers' and adopters' locations rather than the current sociodemographic status of the individual owner. This index may be subject to ecological fallacy, where an inference regarding an individual is based on the findings from a group-level analysis, since an individual living in a dissemination area identified as deprived may not necessarily be vulnerable (107). However, the CIMD uses the smallest unit for which all census data are collected—this same data is not available on an individual level. Thus, we believe that the CIMD is a meaningful proxy as a starting point for understanding challenges that may be faced by individuals in these dissemination areas.

The geographical nature of the CIMD also limits the analysis of the present study to a population-level, as such, these findings may not capture the lived experience of the communities in question. Using population-level analysis is beneficial, as previous studies have used this to identify community needs and create interventions (3); however, further success of community programs could be accomplished by understanding the needs of individuals who may use these programs. Future studies could also use both population-level and individual-level measurements. For example, Spencer et al. (2) used GIS maps to select areas of high intake of stray dogs and used census data and child maltreatment data and subsequently performed qualitative interviews with members of the identified communities to understand possible reasons for high levels of stray dog intake. Understanding the lived experience of individuals in vulnerable communities may increase the efficacy of community-based interventions beyond that of population-level analysis.

This study limited analysis to animals that were surrendered by the owner. For other avenues of intake (e.g., stray animals), analyses were limited because many incoming community animals only have general finder locations (e.g., neighborhood, roads) rather than exact addresses, and therefore could not be geocoded. However, inclusion of other incoming animals may have impacted results. For example, in India, a study found that communities with low socioeconomic status had a higher mean number of free-ranging dogs (57.4) per neighborhood compared to communities with middle (39.8) and high (17.0) socioeconomic statuses (108). Spencer et al. (2) found that communities with high intake (including strays) overlapped with areas with a high-density of child maltreatment cases. Further research could similarly compare proportions of animals through intake and adoption while including other avenues of animal intake.

The data used in this study were only for animals that were both surrendered from and adopted to communities within the province. Transferring animals between shelters (or states in the United States) is a common method to improve animal outcomes, as ownership of pets and adopter preferences vary by region (109, 110). Transfer programs are important for animal shelters with strict euthanasia policies, high intake pressure, and limited capacity for care (111). Transfer of animals may pose challenges to creation of interventions that reduce intake and increase adoption in the source community because of geographic distance between the source and destination communities. Therefore, to effectively serve the immediate community, targeted research in a shelters' served community may be necessary, as communities may differ in demography, legislation, animal shelter services, or culture surrounding pet ownership. Dolan et al. (69) found that reasons for relinquishment in the Los Angeles county differed from that of studies in other communities, possibly due to the mandatory spay/neuter laws in California. Weiss et al. (5) found that the use of animal shelters to re-home pets varied by community. Miller et al. (112) used geospatial techniques to identify communities with high intake to create a targeted intervention that reduced the intake of owned cats. The BC SPCA is a large system of shelters with an established program to transfer within the province, and these findings may differ from that of other types of organizations in different regions. Overall, further research should be conducted in other areas of interest, as understanding an animal shelters' served community could help identify needs and create useful support for pet owners.

Our study may suggest support for the practice of open adoptions as we found only limited evidence of inequity at adoption, albeit experimental data are needed. In 2014, the BC SPCA implemented open adoption practices that may have contributed to the balanced distribution of adopting communities for three of the CIMD factors. The CIMD factor which did show unequal distribution (EC) may be the least impacted by open adoption practices, which are more focused on removing barriers related to factors such as housing, income, and prior pet experiences (31). Open adoption practices do not explicitly address racial, ethnic, or cultural issues such as implicit bias, systemic oppression, or cultural competency. Although these issues are impacted by the removal of other barriers, our study did not directly assess the impact of Adopters Welcome practices on adoption outcomes. Therefore, animal shelters should pursue further direct work regarding services for racialized, immigrant, and linguistically isolated populations. Furthermore, from the present analysis, we do not know the proportion of interested adopters from each quintile who had successful adoptions. It is possible that the proportion of interested adopters at animal shelters varied by CIMD quintile, although the resulting distribution of successful adoptions was even. Future research could explore adoption applications by sociodemographic factors to understand potential avenues of bias in animal shelters and rescues.

In many areas, shelters emphasize adoption of animals in ways typically believed to reduce risk of re-relinquishment (113), which often manifests as restrictive adoption practices. This may be at odds with the principles of "capacity for care," which broadly include managing intake and outcomes in order to maintain a shelter population that can feasibly be cared for, safeguarding animal welfare and health (114) and decreasing owner and animal stress resulting from relinquishment (112). Capacity for Care (C4C) is also a formal management model that aims to improve the welfare of shelter animals by improving housing and ensuring that populations remain within the capacity of the institution to provide humane care (115, 116). Another

primary goal to remain under capacity is to preserve shelter resources to respond to community needs, as animal shelters serve as a safety net for pet owners and animals who need it most (114). To meet the aforementioned goals, animal shelters have also begun providing services that help pet owners and reduce risk of surrender, such as low-cost spay/neuter clinics and pet food banks. Due to the undeniable connection between pet owners and companion animals, actions to safeguard or improve the human-companion animal bond fall under the One Welfare framework, where the well-being of humans, animals, and the environment are interconnected (7). Whether or not animal shelters recognize the One Welfare approach, pet owner-oriented interventions provide evidence that One Welfare strategies do help reduce intake to animal shelters (117). Our study provides further evidence that animal shelters can focus on human support services in order to reduce relinquishment. While further research is needed on adoption services, animal shelters can also consider evaluating their own adoption screening practices to promote non-discriminatory adoption of animals. Overall, animal shelters should continue to explore community-specific methods to support pets, owners, and interested adopters to reach their goal of maintaining a robust safety net and optimizing the mental and physical health of shelter animals.

CONCLUSION

Our data showed that, from 2016 to 2019, there were multiple differences in the vulnerabilities between owners' surrendering communities and adopters' communities. However, the imbalance in CIMD quintiles was mainly due to disproportionate surrender of animals from more vulnerable communities, with a notable exception for Ethnocultural Composition. The results add to previous work on social vulnerability and animal shelter services by including comparisons to outgoing communities of animals in order to identify possible barriers or discrimination. Although barriers to adoption were another potential source of inequity, our study locations did not show evidence of unevenly distributed adoption of animals based on most sociodemographic factors. Our findings may be due to open adoption policies enacted specifically to reduce adoption barriers prior to the study period, although this was not experimentally addressed. There was uneven adoption of animals based on Ethnocultural Composition, with a higher proportion of animals being adopted out to low vulnerability communities, which could imply direct or indirect discrimination based on race/ethnicity or culture. However, further research is needed to understand whether the uneven adoption distribution is driven by lack of access to animal shelters, an unwelcoming environment of the shelter, or other factors. As this work is also location-specific, animal shelters and rescues should investigate these differences in their own communities. Identifying CIMD dimensions which are different between incoming and outgoing communities does not necessarily imply a causal association, as the nature of systemic issues of vulnerability is complex. However, the results of this study can be used to help animal shelters reflect on practices related to owner surrender and adoption. Furthermore, the results can help inform interventions to reduce shelter intake and maintain the human-animal bond.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of British Columbia Behavioural Research Ethics Board. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

LL, EG, and AP contributed to the conception of the study and the subsequent study design. LL acquired the database, organized and visualized the data, and wrote the first draft of the manuscript. LL and AP performed the statistical analysis. All authors contributed to the manuscript, further revisions, and approved the final version of the manuscript for submission.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2021.784389/full#supplementary-material

GitHub for R Code used in the manuscript "Inequitable flow of animals in and out of shelters: comparison of community-level vulnerability for owner-surrendered and subsequently adopted animals"

https://github.com/lexisly/flow-CIMD

Supplementary Data Sheet 1 | Adopted animals from BC SPCA shelters from January 1, 2016 and December 31, 2019.

Supplementary Data Sheet 2 | Supplementary alluvial plots showing the flow of animals with small effect size.

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Characterizing Pet Acquisition and Retention During the COVID-19 Pandemic

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In March 2020, Americans began experiencing numerous lifestyle changes due to the COVID-19 pandemic. Some reports have suggested that pet acquisition and ownership increased during this period, and some have suggested shelters and rescues will be overwhelmed once pandemic-related restrictions are lifted and lifestyles shift yet again. In May 2021, the ASPCA hired the global market research company Ipsos to conduct a general population survey that would provide a more comprehensive picture of pet ownership and acquisition during the pandemic. Although pet owners care for a number of species, the term pet owner in this study specifically refers to those who had dogs and/or cats. One goal of the survey was to determine whether data from a sample of adults residing in the United States would corroborate findings from national shelter databases indicating that animals were not being surrendered to shelters in large numbers. Furthermore, this survey gauged individuals' concerns related to the lifting of COVID-19 restrictions, and analyses examined factors associated with pet owners indicating they were considering rehoming an animal within the next 3 months. The data showed that pet ownership did not increase during the pandemic and that pets may have been rehomed in greater numbers than occurs during more stable times. Importantly, rehomed animals were placed with friends, family members, and neighbors more frequently than they were relinquished to animal shelters and rescues. Findings associated with those who rehomed an animal during the pandemic, or were considering rehoming, suggest that animal welfare organizations have opportunities to increase pet retention by providing resources regarding pet-friendly housing and affordable veterinary options and by helping pet owners strategize how to incorporate their animals into their post-pandemic lifestyles.

Keywords: COVID-19, pet ownership, pet acquisition, pet retention, companion animal, dog, cat

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INTRODUCTION

In March 2020, quarantine recommendations were enacted in the United States due to the novel coronavirus SARS-CoV-2, which causes coronavirus disease 2019 (COVID-19). Several studies have reported that as many businesses shifted their employees to remote, work-from-home schedules, public demand for acquiring, or fostering a new pet grew (1–4). This apparent increase in demand likely was driven by a number of factors, including calls from animal welfare

organizations to help "clear the shelters" (5, 6). With so many businesses, including restaurants and gyms, shut down during the early months of the pandemic and many employees working from home, individuals, and families had more time to spend at home with their pets. Furthermore, dog walking remained an accessible form of physical activity, and people may have sought out pets to reduce levels of stress, anxiety, and loneliness caused by the pandemic and the lifestyle changes it necessitated.

Despite people commonly spending more time at home during the pandemic and many reports indicating that the demand for pets grew as a result of COVID-19, shelter data shows that raw numbers of adoptions from shelters and rescues were actually lower in 2020 than in 2019 (7, 8). Furthermore, data collected by the American Pet Products Association (APPA) in December 2020 and March 2021 indicate that the percentage of households with cats decreased from 38% in their 2017–2018 report to 35% (9). The APPA reported that the prevalence of dog ownership, however, increased from 48% of households to 54% of households during that same period.

Data from the APPA's 2017–2018 national survey characterize pet acquisition trends leading up to the COVID-19 pandemic (10). Thirty-four percent of dogs and 37% of cats were adopted from a shelter or rescue. Furthermore, 25% of dogs and 26% of cats came from friends and relatives, and 29% of dogs and 5% of cats came from breeders and pet stores.

Some pandemic-related factors may have made pet acquisition and retention more challenging. During the early months of the pandemic, pet owners commonly expressed concerns about the availability and cost of veterinary care (11–13). A large-scale survey of pet owners in the US conducted during spring and summer 2020 reported that pet owners expressed difficulties securing pet supplies and dealing with their pet's behavioral issues (14). Participants in that survey also had concerns about what would happen to their pet if they became incapacitated with COVID-19, and they indicated they were preoccupied with managing familial and professional responsibilities and adjusting to working from home. Some pet owners who worked from home reported their pets created disruptions during the workday (14, 15), and about 9% of dog owners in one study reported their dogs displayed more attention-seeking behaviors during the pandemic (3).

Even with the challenges associated with pet-keeping during the pandemic, national data sources, including Shelter Animals Count in the US and Yad4 in Israel, did not show any noteworthy uptick in animal shelter intake or surrender rates in 2020 (3, 7). Indeed, in the US shelter intake numbers actually decreased from 2019 to 2020 (7). Additionally, national data aggregated from the shelter software system PetPoint indicated that in March and April 2021, cat intake numbers were merely approaching the range they were at during March and April 2019, while dog intake numbers remained uncharacteristically low (16). A number of factors contributed to reductions in shelter intakes, which thereby reduced the number of animals available for adoption. For instance, shelters commonly restricted intakes to animals in serious need and required that individuals make appointments to relinquish their animals. Additionally, the pandemic reduced the number of transports that moved dogs and cats from crowded shelters in one part of the country to less crowded ones elsewhere (17). Prior to the pandemic, robust transport programs helped ensure shelters featured a variety of dogs and cats for adoption, even in areas where local shelter intake rates were low (18).

Reductions in shelter intakes during the pandemic do not necessarily mean that overall rehoming rates were lower during this period. Animal shelters and rescues are not the only places where people turn when they can no longer keep their pets. In the APPA's 2017–2018 national survey of pet owners, over 70% of dog and cat owners indicated they would rehome their animals with a friend or family member if they could no longer keep them (10). Similarly, a study examining the re-homing of dogs and cats prior to the pandemic reported that while 36% were taken to a shelter, 37% were given to a friend or family member (19).

With shelter and rescue adoptions and intakes representing only part of the full picture of pet acquisitions and rehoming, in May 2021, the ASPCA hired the global market research company Ipsos to conduct a general population survey. The goals of the survey included the following: (1) To provide a more comprehensive picture of dog and cat ownership and acquisition during the COVID-19 pandemic; (2) To determine whether data from a sample of adults residing in the US would corroborate findings from national shelter databases indicating that dogs and cats, including those acquired during the pandemic, were not being surrendered to shelters in large numbers; (3) To gauge individuals' concerns associated with the lifting of COVID-19 restrictions and to assess whether any of these concerns, as well as demographic factors, were associated with dog and cat owners indicating they were considering rehoming a pet within the next 3 months.

METHODS

A national sample of 10,044 individuals 18 years and older residing in the continental United States, Alaska, and Hawaii were interviewed online in English as part of an omnibus poll conducted by Ipsos (ipsos.com) between May 17-June 1, 2021. To recruit participants, Ipsos used address-based sampling. If a household did not have the internet, Ipsos provided participants with free internet access and a tablet so they could complete the survey. Forty-one individuals were excluded from analyses due to inconsistencies in their responses, leaving a sample of 10,003 individuals. As the ASPCA received no identifying information about survey participants from Ipsos, the Advarra Institutional Review Board (IRB) deemed that the project (protocol number Pro00056183) did not meet the Department of Health and Human Service's definition of human subjects research under 45 CFR 46 and, therefore, did not require IRB oversight.

The survey included questions about the ownership of dogs and cats (referenced as "pets" or "animals" from here on) prior to March 2020, whether individuals owned any of these animals at the time of the survey, whether they had rehomed any animals since March 2020, and whether they were considering rehoming any animals within the upcoming 3 months. In addition, the survey asked individuals whether they had acquired and/or fostered animals during the pandemic. Those who indicated

they had acquired an animal were then asked from where the animal was sourced (e.g., from a breeder; from a shelter or rescue organization; from an individual, friend, family member, or neighbor) and whether they still had the animal. If they no longer had the animal, they were asked where the animal was (e.g., with a friend, family member, or neighbor; at a shelter or rescue; deceased; lost). All participants were asked about their current work status (e.g., employed and working fully remotely, temporarily; employed and working fully remotely, permanently; employed and working fully away from home). In addition, participants were asked to rate on a 5-point Likert scale their degree of concern in relation to 7 statements (e.g., "I'm worried about being able to afford veterinary care for my animal"; "I'm worried about my employment and job security"; "I'm worried that I may not be able to stay in my home"). A score of 1 indicated no concern at all, and 5 indicated extreme concern. All participants provided demographic information, including their gender, age, race, household income, education level, and presence of children in the household. As an omnibus survey, the questionnaire also included questions from other Ipsos clients. The questions described above are the ones for which the ASPCA received data. The questionnaire has been included in the **Supplementary Materials**.

Data Analysis

All analyses were conducted using R version 3.6.3 (20). Given the descriptive nature of the data, univariate analyses were comprised of frequency calculations and chi-square tests. When a chi-square test had more than 1 degree of freedom, a False Discovery Rate (FDR) *post-hoc* test was performed. Responses to the 7 questions regarding concerns were categorized as either no to low concern or moderate to high concern. That is, individuals who rated their level of concern as 1 or 2 were categorized as having no to low concern, and those who rated their level of concern as 3–5 were categorized as having moderate to high concern.

Binomial logistic regression modeling using the "lme4" package version 1.1–26 (21) assessed factors associated with acquiring an animal during the pandemic. The model contained demographic factors, including participant gender, age (18–34, 35–54, 55 years and older), whether there were children in the home, race (White, Asian American/Pacific Islander, Black or African American, Hispanic or Latino), household income (<$50,000, $50,000–$100,000, >$100,000), region of the country (South, Northeast, Midwest, West), community type (rural, suburban, or urban), and whether individuals had pets (i.e., dogs and/or cats) in the household prior to March 2020. The ANOVA function tested whether this model had a significantly better fit than the null model. The "car" package version 3.0–10 (22) was used to test for multicollinearity.

The same process was repeated to examine factors associated with having rehomed an animal during the pandemic. All factors included in the animal acquisition model were included in the rehoming model, with the exception that the factor examining pet ownership prior to March 2020 was replaced with a factor that divided pet owners (i.e., dog and cat owners) into the following three categories: had pets prior to March 2020 but did not acquire pets during the pandemic; had pets prior to March 2020 and acquired pets during the pandemic; and did not have pets prior to March 2020 but acquired pets during the pandemic.

Hierarchical binomial logistic regression was used to examine factors associated with whether those who had animals at the time of the survey were considering relinquishing them within the upcoming 3 months. All predictors described in the rehoming model were included in Model 1. Model 2 included the variables in Model 1, as well as the degree of participants' concerns regarding employment and job security, housing security, financial security, ability to afford veterinary care, pet behavior, having time to care for the pet, and pets impacting travel plans. Model 3 included all factors in Model 2 plus work status at the time the survey was completed (i.e., working from home or not). Finally, Model 4 included all variables in Model 3 and tested for an interaction between work status and household income. Individuals who indicated they did not need to work or selected "other" in response to the work status question were not included in these four models. The ANOVA function tested whether each model had a significantly better fit than the prior model. If there were no significant differences between models, the model with the lowest Akaike information criterion (AIC) value was chosen as the final model.

RESULTS

The demographic characteristics of the sample are summarized in **Table 1**. Just over half (53%) of the participants were female. Twenty-seven percent of participants were between 18 and 34 years old; 36% were between 35 and 54 years old, and the remaining individuals (38%) were over 55 years old. Children under the age of 18 years were present in 24% of households. The racial identities most frequently represented in the sample were White (77%), Black or African American (8%), Hispanic or Latino (8%), and Asian American or Pacific Islander (4%). Thirty-eight percent of participants reported annual household incomes under $50,000, and 22% reported household incomes over $100,000. The sample included individuals from all regions of the US, and just over half (52%) of the participants resided in suburban communities. At the time the survey was completed, 27% of participants were working fully away from home, 26% were working fully remotely, and 7% were working partly from home and partly away from home. Additionally, 13% were unemployed, and 19% were retired.

Of note, the likelihood of working from home fully or part-time at the time of the survey was significantly higher for those with household incomes >$100,000 compared to those in either of the lower-income categories [$\chi^2_{(2)} = 244.27$, $p < 0.001$]. Thirty-three percent of those with household incomes over $100,000 reported working from home, whereas 21% of those with household incomes between $50,000 and $100,000 and 16% of those with household incomes <$50,000 reported working from home. **Supplementary Table 1** provides the breakdown of the numbers and percentages of individuals within the categories included in **Table 1** who had acquired an animal since March 2020, rehomed an animal since March 2020, and were considering rehoming an animal in the upcoming 3 months.

TABLE 1 | Description of the survey sample.

	N (%)
Gender	
Male	4,668 (46.7%)
Female	5,335 (53.3%)
Age	
18–34	2,674 (26.7%)
35–54	3,548 (35.5%)
55+	3,781 (37.8%)
Children in household	
Yes	2,358 (23.6%)
No	7,645 (76.4%)
Race	
Asian American/Pacific Islander	419 (4.2%)
Black or African American (not Hispanic or Latino)	837 (8.4%)
Hispanic or Latino	791 (7.9%)
Native American, Alaska Native, Aleutian	120 (1.2%)
White (not Hispanic or Latino)	7,666 (76.6%)
Other	79 (0.8%)
Prefer not to answer	91(0.9%)
Household income	
<$50,000	3,765 (37.6%)
$50,000–$100,000	4,063 (40.6%)
More than $100,000	2,175 (21.7%)
Region	
Midwest	2,375 (23.7%)
Northeast	1,835 (18.3%)
South	3,788 (37.9%)
West	2,005 (20.0%)
Community type	
Rural	2,391 (23.9%)
Suburban	5,177 (51.8%)
Urban	2,435 (24.3%)
Work status at time of survey (percentages based on 6,562 individuals who acquired dogs and/or cats before and/or since March 2020)	
Currently employed and working fully away from home	1,750 (26.7%)
Currently employed and working fully remotely, permanently	699 (10.7%)
Currently employed and working fully remotely, temporarily	1,026 (15.6%)
Currently employed and working partly remotely, partly away from home	459 (7.0%)
Currently unemployed	853 (13.0%)
Retired	1,242 (18.9%)
I don't need to work	194 (3.0%)
Other	339 (5.2%)

Unless otherwise noted in the table, the percentages are based on the total sample of 10,003 participants.

TABLE 2 | Pet ownership statistics.

	N (%)
Pets pre-pandemic	
Dogs	4,699 (47.0%)
Cats	3,329 (33.3%)
Dogs and/or cats	6,342 (63.4%)
Pets acquired during pandemic	
Dogs	1,284 (12.8%)
Cats	924 (9.2%)
Dogs and/or cats	1,901 (19.0%)
Fostered animals during pandemic	180 (1.8%)
Rehomed pets since March 2020 (percentages based on 4,905 dog owners, 3,526 cat owners, and 6,562 dog and/or cat owners)	
Dogs	508 (10.4%)
Cats	385 (10.9%)
Dogs and/or cats	783 (11.9%)
Pets acquired during pandemic still with owner (percentages based on 1,284 dog owners, 924 cat owners, and 1,901 dog and/or cat owners)	
Dogs	1,160 (90.3%)
Cats	799 (86.5%)
Dogs and/or cats	1,671 (87.9%)
Pets at time of survey	
Dogs	4,524 (45.2%)
Cats	3,265 (32.6%)
Dogs and/or cats	6,175 (61.7%)
Considering relinquishing pet in next 3 months (percentages based on 4,524 dog owners, 3,265 cat owners, and 6,175 individuals with dogs and/or cats)	
Dogs	360 (8.0%)
Cats	276 (8.5%)
Dogs and/or cats	532 (8.6%)
Pet owners who indicated a moderate to high level of concern (percentages based on 6,175 individuals who owned dogs and/or cats at the time of the survey)	
I'm worried about my employment and job security.	2,416 (39.1%)
I'm worried that I may not be able to stay in my home.	1,865 (30.2%)
I'm worried about my financial security.	3,492 (56.6%)
I'm worried about being able to afford veterinary care for my animal.	2,799 (45.3%)
I'm worried my animal will have behavior problems as a result of a change in schedule.	2,067 (33.5%)
I'm worried I won't have as much time to care for and/or spend with my animal.	2,257 (36.6%)
I'd like to travel more and I feel limited by my animal.	2,836 (45.9%)

Unless otherwise noted in the table, the percentages are based on the total sample of 10,003 participants.

As depicted in **Table 2**, prior to March 2020, 47% of participants had dogs, and 33% had cats. At the time of the survey, 45% had dogs, and 33% had cats. This suggests the proportions of households with dogs and/or cats did not increase from prior to the pandemic to May 2021. Moreover, only 4% of individuals who did not have dogs prior to the pandemic had dogs at the time of the survey, and 8% who had dogs prior to the pandemic no longer had them. Similarly, 3% of individuals who did not have cats prior to the pandemic had cats at the time of the survey, and 8% who had cats prior to the pandemic no longer had them. **Table 2** also includes the proportion of pet owners who expressed moderate to high concern in response to

TABLE 3 | Sources of the 1,284 dogs and 924 cats acquired during the pandemic.

	Dog *N* (%)	Cat *N* (%)
From a breeder (did not see where the animal was raised)	126 (9.8%)	61 (6.6%)
From a breeder (saw where the animal was raised)	336 (26.2%)	111 (12.0%)
From a pet store	183 (14.3%)	136 (14.7%)
From a shelter or rescue organization	288 (22.4%)	217 (23.5%)
From an individual, friend, family member, or neighbor (for free)	166 (12.9%)	242 (26.2%)
From an individual, friend, family member, or neighbor (purchased)	148 (11.5%)	64 (6.9%)
Other	37 (2.9%)	93 (10.1%)

TABLE 4 | Results of binary logistic regression model assessing factors associated with having acquired a dog and/or cat during the pandemic.

Predictors	Model		
	Odds ratios	CI	*p*
(Intercept)	0.14	0.11–0.17	**<0.001**
Gender (ref: Male)			
Female	0.65	0.58–0.72	**<0.001**
Age category (ref: 18–34 years)			
35–54 years	0.56	0.49–0.63	**<0.001**
55+ years	0.24	0.21–0.29	**<0.001**
Children in household (ref: No)			
Yes	1.83	1.61–2.07	**<0.001**
Race (ref: White, not Hispanic or Latino)			
Asian American/Pacific Islander	0.84	0.62–1.12	0.244
Black or African American (not Hispanic or Latino)	1.11	0.90–1.35	0.321
Hispanic or Latino	1.29	1.07–1.55	**0.007**
Household income (ref: <$50,000)			
$100,000+	1.04	0.89–1.21	0.611
$50,000–$100,000	0.87	0.77–0.99	**0.038**
Region (ref: South)			
Midwest	0.77	0.66–0.89	**<0.001**
Northeast	0.73	0.62–0.86	**<0.001**
West	0.78	0.67–0.92	**0.002**
Community type (ref: Suburban)			
Rural	1.26	1.10–1.45	**0.001**
Urban	1.70	1.49–1.94	**<0.001**
Dog/cat ownership (ref: Did not have animal prior to March 2020)			
Had animals prior to March 2020	4.71	4.04–5.52	**<0.001**
Observations	9,713		
−2LL	7,944.8		
AIC	7,676.8		
R^2 Tjur	0.160		

The bold values represent p-values less than 0.05.

questions related to the lifting of COVID-19 restrictions. As can be seen in the table, these concerns were shared by many pet owners. Notably, 57% of pet owners were concerned about their financial security, and 45% were concerned about their ability to afford veterinary care.

Animal Acquisition During the Pandemic

Two percent of individuals reported having fostered an animal since March 2020, 13% had acquired one or more dogs, and 9% had acquired one or more cats (**Table 2**). Pets acquired during the pandemic came from a variety of sources (**Table 3**). The most common sources from which dogs were acquired included breeders (36%); individuals, including friends, family members, and neighbors (24%); shelters or rescues (22%); and pet stores (14%). Cats most commonly came from individuals, including friends, family members, and neighbors (33%); shelters or rescues (24%); breeders (19%); and pet stores (15%).

Given similarities in patterns observed regarding dog and cat acquisition and ownership during the pandemic, dogs and cats were combined in the model that tested which factors were associated with having acquired an animal during the pandemic. They were also combined in models examining factors associated with (1) having rehomed an animal during the pandemic and (2) considering rehoming an animal in the upcoming 3 months. The pet acquisition model had a significantly better fit than the null model (Δ-*2LL* = 1542.6, Δdf = 15, $p < 0.001$). As **Table 4** depicts, numerous factors were associated with having acquired an animal since March 2020. Females were less likely to have acquired an animal than males ($OR = 0.65$), and those in the older two age groups were less likely to have acquired an animal than those 18–34 years (35–54: $OR = 0.56$, 55+: $OR = 0.24$). Those with children in the household were 1.83 times more likely to have acquired an animal than those without, while those with incomes $50,000–$100,000 were less likely to have acquired an animal than those in the lowest income group ($OR = 0.87$). Compared to White participants in the sample, those of Latino or Hispanic descent were 1.29 times more likely to have acquired an animal. In addition, compared to those living in the South, those living in the Midwest, Northeast, and West were significantly less likely to have acquired an animal (Midwest: $OR = 0.77$, Northeast: $OR = 0.73$, West: $OR = 0.78$). Additionally, individuals living in rural and urban areas were significantly more likely to have acquired an animal than those living in the suburbs (rural: $OR = 1.26$, urban: $OR = 1.70$). Finally, those who had dogs and/or cats prior to the pandemic were 4.71 times more likely to have acquired an animal than those who did not.

Outcomes for Animals Acquired During the Pandemic

Of the animals acquired during the pandemic, 90% of dogs and 87% of cats were still with their owners (**Table 2**). Details regarding outcomes for animals no longer with their owners at the time of the survey are provided in **Table 5**. Half of the dogs in this situation went to a friend, family member, or neighbor;

TABLE 5 | Outcomes regarding the 124 dogs and 125 cats acquired during the pandemic that are no longer with their owners.

	Dog *N (%)*	Cat *N (%)*
I sold my animal	15 (12.1%)	16 (12.8%)
My animal died	16 (12.9%)	16 (12.8%)
My animal got lost	7 (5.6%)	8 (6.4%)
They are at a shelter or rescue	21 (16.9%)	33 (26.4%)
They are with a friend, family or neighbor	62 (50.0%)	46 (36.8%)
Other	3 (2.4%)	6 (4.8%)

17% went to a shelter or rescue; 13% had died; and 12% were sold. Similarly, 37% of cats went to a friend, family member, or neighbor; 26% went to a shelter or rescue; 13% had died; and 13% were sold.

Factors Associated With Rehoming a Dog or Cat During the Pandemic

Since March 2020, 12% of pet owners reported having rehomed a dog and/or cat (**Table 2**). The binomial logistic model that tested which factors were associated with having rehomed an animal during the pandemic had a significantly better fit than the null model (Δ-$2LL = 1098.3$, $\Delta df = 16$, $p < 0.001$). As **Table 6** shows, females were less likely to have rehomed an animal than males ($OR = 0.47$). Individuals in the older two age categories were less likely to have rehomed an animal than those aged 18–34 (35–54: $OR = 0.63$, 55+: $OR = 0.40$). Having children in the household increased the odds of having rehomed an animal ($OR = 1.78$). Additionally, compared to White participants, Black participants were 1.42 times more likely to have rehomed an animal, and those who reported household incomes >$50,000 were less likely to have rehomed an animal than those with household incomes below $50,000 ($50,000–$100,000: OR = 0.70, $100,000+: OR = 0.77). Individuals living in urban communities were more likely to have rehomed an animal than those residing in suburban communities ($OR = 1.80$), and those living in the Northeast were less likely to have rehomed an animal than those living in the South ($OR = 0.75$). Compared to dog and cat owners who had not acquired dogs and/or cats since March 2020, those who had acquired dogs and/or cats both prior to March 2020 and since March 2020 were 7.18 times more likely to have rehomed a pet, and those who did not have dogs or cats prior to March 2020 and had acquired one or more since March 2020 were 3.31 times more likely to have done this.

Factors Associated With Potential Future Relinquishment

Approximately 9% of participants with dogs and/or cats indicated they were considering rehoming an animal in the upcoming 3 months (**Table 2**). Of the four models that assessed factors associated with participants indicating they were considering rehoming an animal, Model 3 had the best fit. The table comparing all four models has been included as **Supplementary Table 2**.

TABLE 6 | Results of binary logistic regression model assessing factors associated with rehoming a dog and/or cat during the pandemic.

Predictors	Model		
	Odds ratios	CI	*p*
(Intercept)	0.09	0.07–0.12	**<0.001**
Gender (ref: Male)			
Female	0.47	0.40–0.56	**<0.001**
Age category (ref: 18–34 years)			
35–54 years	0.63	0.52–0.76	**<0.001**
55+ years	0.40	0.30–0.53	**<0.001**
Children in household (ref: No)			
Yes	1.78	1.47–2.16	**<0.001**
Race (ref: White, not Hispanic or Latino)			
Asian American/Pacific Islander	0.76	0.44–1.26	0.310
Black or African American (not Hispanic or Latino)	1.42	1.06–1.90	**0.016**
Hispanic or Latino	1.28	0.98–1.67	0.069
Household income (ref: <$50,000)			
$100,000+	0.77	0.61–0.98	**0.032**
$50,000–$100,000	0.70	0.57–0.86	**0.001**
Region (ref: South)			
Midwest	0.98	0.78–1.22	0.857
Northeast	0.75	0.58–0.97	**0.029**
West	0.83	0.65–1.06	0.132
Community type (ref: Suburban)			
Rural	1.18	0.94–1.48	0.151
Urban	1.80	1.47–2.19	**<0.001**
Dog/cat ownership (ref: Acquired animals before March 2020 but not since)			
Animals acquired before March 2020 and during pandemic	7.18	5.97–8.67	**<0.001**
Animals acquired during pandemic but not before	3.31	2.21–4.86	**<0.001**
Observations	6,375		
−2LL	3588.0		
AIC	3622.0		
R^2 Tjur	0.206		

The bold values represent p-values less than 0.05.

According to Model 3, females were less likely to be considering rehoming than males ($OR = 0.48$), and individuals over 55 years of age were less likely to be considering rehoming than individuals 18–34 years ($OR = 0.65$). Having children in the household increased the odds of individuals indicating they were considering rehoming ($OR = 1.79$). There was no association between race and likelihood of considering rehoming. Individuals with household incomes >$100,000 were 1.42 times more likely to indicate they were considering rehoming an animal than those with incomes <$50,000. Additionally, those in rural and urban areas were more likely to indicate they were considering rehoming an animal than those in suburban areas (rural: $OR = 1.59$, urban: $OR = 1.92$), but no regional differences were observed. Compared to dog and cat owners who had not

acquired dogs and/or cats since March 2020, those who had acquired dogs and/or cats both prior to March 2020 and since March 2020 were 4.80 times more likely to indicate they were considering rehoming. Furthermore, those who did not have dogs or cats prior to March 2020 and had acquired one or more since March 2020 were 3.02 times more likely to indicate this. Individuals with concerns regarding housing security were more likely to say they were considering rehoming ($OR = 1.84$), as were individuals with concerns regarding being able to afford veterinary care ($OR = 1.79$). Moreover, working from home was associated with being more likely to indicate one was considering rehoming ($OR = 1.90$).

DISCUSSION

Although several prior studies have indicated that pet acquisitions increased during the COVID-19 pandemic (1–4), the national survey data collected in May 2021 did not show that ownership of dogs or cats had increased. While the percentage of survey participants who indicated having dogs and/or cats prior to March 2020 closely matches dog and cat ownership statistics reported in the APPA's 2017–2018 national survey of pet owners (10), we observed a slight decline in those numbers from the period prior to March 2020 to when survey data were collected in May 2021.

The APPA's 2021–2022 survey, for which data were collected in December 2020 and March 2021, showed that cat ownership had decreased since the APPA's 2017–2018 report (9). However, their data indicated the percentage of households with dogs had increased. That we found a slight decrease in dog ownership and the APPA found an increase from their 2018–2019 survey to their 2021–2022 survey is puzzling. It is possible that the timing of data collection contributed to the differences between our survey and the APPA's most recent survey. When the 2021–2022 APPA data were collected, vaccinations to protect against COVID-19 were not widely available, and many social distancing protocols were still in place. By the time our survey data were collected at the end of May 2021, vaccinations were readily available to adults across the US, and much of the population had begun returning to pre-pandemic school, work, and social routines. The shift in lifestyle may have made dog keeping more challenging and led to an uptick in rehoming. The timing of these surveys may also contribute to why we found that 10% of dog owners and 11% of cat owners had rehomed an animal during the pandemic, whereas the APPA's 2021–2022 report concluded that COVID-19 had caused 6% of dog owners and 7% of cat owners to rehome their animals.

The pandemic appears to have resulted in some changes to how pets were acquired. This may have been due to reductions in the overall number of animals available for adoption during the pandemic, as well as to the public's limited accessibility to shelters during this period. In comparison to the APPA's 2017–2018 report (10), the proportion of cats and dogs acquired from shelters and rescues decreased during the pandemic while the proportion of cats and dogs acquired from pet stores and breeders increased. As fewer animals were relinquished to shelters during the pandemic (16), the demand for shelter animals may have outpaced the numbers of animals available for adoption. Slowdowns in shelter and rescue operations due to pandemic-related restrictions and protocols also may have contributed to the decline in numbers of animals taken into and adopted from shelters and rescues. Adoption facilities around the country limited community members' opportunities to relinquish animals, closed their facilities to walk-in visitors, and required that both intakes and adoptions occur via appointment.

Many of the factors that were associated with having acquired an animal during the pandemic aligned with the APPA's 2017–2018 findings regarding characteristics of pet owners (10). For instance, the organization reported that pet ownership was more common among younger individuals and in households that included children. We found that individuals within these categories also were more likely to have acquired a dog and/or cat during the pandemic.

The regional differences we observed in pet acquisition during the pandemic may relate to regional differences in the availability of animals. Animal shelters in the South tend to have more animals in need of rehoming than shelters in other parts of the US (23). Furthermore, many of the transports that, prior to the pandemic, had moved dogs and cats from crowded shelters in the South to less crowded ones elsewhere were halted (17). Additionally, the South consistently had less stringent COVID-19 mitigation strategies than most other US regions (24), and so this is yet another factor that may have made it easier to acquire a new pet in the South during the pandemic.

Pet acquisition rates reported in this survey also differed by gender. That is, men were more likely to report having acquired a pet during the pandemic than women. This disparity may relate to systemic gender inequalities that contributed to the pandemic's differential impacts on men and women. During this period, more women than men lost their jobs, worked essential jobs that increased their risk of exposure to COVID-19 and its associated stressors, and experienced significant increases in familial responsibilities (25, 26). Furthermore, the switch to remote work that many experienced during the pandemic may have impacted men and women differently. A prior study concluded that men found telecommuting to be more restorative than did women (27). Additionally, women who telework commonly report they have less leisure time (28). Thus, men may have viewed pandemic-related changes as increasing their capacity to care for a pet while women may have experienced the opposite. These perceptions may have been short-lived, though. More men than women reported rehoming an animal during the pandemic, and men were more likely to indicate they were planning to do so in the upcoming 3 months.

The strongest predictor of having acquired an animal during the pandemic was pet ownership prior to the pandemic. Specifically, those who had dogs and/or cats prior to March 2020 were significantly more likely to have acquired one during the pandemic than were those who entered the pandemic without a pet. This aligns with prior research suggesting that the decision to acquire a pet commonly is influenced by prior pet ownership (29, 30).

Ninety percent of individuals who acquired a dog during the pandemic still had their animal, as did 87% of those who acquired a cat. Moreover, 88% of pet owners, including those who acquired their pets before the pandemic, reported they did not rehome an animal during this time period. While these findings indicate that pets were not being rehomed in massive numbers, the percentages of animals that were rehomed may be larger than is typical during economically stable times. A national survey conducted by Weiss et al. prior to the pandemic found that only 6% of individuals reported having rehomed a dog and/or cat within the 5-year period spanning 2009–2014 (19). Like the COVID-19 pandemic, the Great Recession of 2008 had a destabilizing effect on the economy and countless Americans' lives. A comparison of shelter intake records in the Chicago area prior to and during the recession showed an uptick in the numbers of dogs relinquished during the recession, although this trend was not observed for cats (31). Importantly, however, that study did not include the number of animals that were rehomed without ever entering the shelter system and so likely underestimated the number of animals rehomed during that challenging period. As was observed in the current study, Weiss et al. found that pet owners commonly rehome their animals with friends, family members, and neighbors (19).

Individuals who did acquire new animals during the pandemic were more likely to report they had rehomed an animal during the pandemic than were pet owners who did not acquire new animals during that period. In some cases, a participant may have found themselves needing to rehome their pre-pandemic pet due to pandemic-inspired difficulties (e.g., job loss, illness) and then acquired a new one as their situation improved. Another potential explanation for this finding is that those who acquired a pet during the pandemic may have had trouble securing the resources and training assistance they needed to keep their animals. In a large-scale survey of pet owners conducted in the US during spring and summer 2020, participants expressed difficulties obtaining pet supplies and dealing with their pets' behavioral issues (14). As our survey did not ask participants about the timing of pet rehoming and acquisition, we were unable to determine how often rehoming preceded vs. followed pet acquisition and whether the majority of pets rehomed were those acquired during the pandemic.

Participant age also was associated with the likelihood of rehoming an animal. Adults under 35 years old were more likely to have rehomed a pet during the pandemic than were older adults. Prior research on animal shelter relinquishment indicates that, even prior to the pandemic, younger adults were at greater risk of rehoming their pets than were older adults (32). This pattern may relate to the reality that younger adults disproportionately rent rather than own their housing and commonly face challenges finding pet-friendly housing (33). Even before the pandemic, the dearth of pet-friendly, affordable housing was a leading cause of pet relinquishment (19, 34–36). The pandemic would have made access to pet-friendly housing particularly difficult for young adults who lost their job or had their wages and/or work hours reduced.

Housing-related concerns may at least partially explain why Black participants were more likely to report having rehomed an animal during the pandemic than White participants. COVID-19 highlighted and exacerbated racial inequalities in the US (37), including longstanding racial inequalities in the availability of pet-friendly housing (34). Individuals belonging to racial or ethnic minority groups not only were more vulnerable to severe illness from COVID-19 (38) but also were disproportionately impacted by pandemic-related layoffs and reductions in wages and hours (39).

Analyses regarding which pet owners were considering rehoming an animal in the upcoming 3 months provided additional insights into challenges pet owners faced because of the pandemic. Compared to those not considering rehoming, these individuals were more likely to express a moderate to high degree of concern about housing security and their ability to afford veterinary care. This finding is in line with those from a recent report that 61% of pet owners polled within the US were very concerned about their finances over the upcoming year (40).

An unanticipated finding was that those with household incomes above $100,000 were more likely to indicate that they were considering rehoming a pet than those in the lowest income group, even though they were not more likely to have acquired a pet during the pandemic. This was true even after including in the model whether individuals were working from home (i.e., workplace location). Additionally, adding to the full main effects model an interaction term between household income and workplace location did not improve the model fit. This suggests that those in households with incomes >$100,000 may have had pet-related concerns that were independent of their workplace location and the other variables included in the model. It is possible individuals in this income category were anticipating bigger lifestyle changes with the lifting of COVID-19 restrictions compared to individuals in the lower-income group.

Although behavioral concerns were not a significant predictor in the model examining factors associated with considering rehoming, it is notable that one-third of pet owners surveyed in the current study were concerned about their pets developing behavioral problems. During periods of lockdown and working from home, pet owners indicated their pets were rarely alone, and they were worried about how pets would handle being left alone (41, 42). The breakdown in predictable pandemic-related routines, such as lunchtime dog walks, that occur as schedules revert back to what they were prior to March 2020 may result in pets expressing behaviors indicative of anxiety, boredom, and frustration (43). Symptoms of anxiety, boredom, and frustration may manifest as destructive behaviors and increased vocalizations and attention-seeking behaviors.

Findings regarding pet owners' concerns and which pet owners rehomed an animal during the pandemic, or were considering rehoming an animal, suggest that some individuals may need assistance planning how to incorporate their pets into their evolving lifestyle. To reduce the number of animals entering shelters, animal welfare organizations have devised

numerous ways to help pet owners. Prior to the pandemic, many animal shelters and rescues already offered safety net programs, such as behavior helplines, preventative veterinary care clinics, and pet food pantries, to reduce relinquishments (44). Some animal welfare organizations also help individuals with housing-related concerns. Organizations, such as Pet Housing Help AZ in Arizona (https://pethousinghelpaz.org/) and Fulton County Animal Services in Georgia (https://www.fultonanimalservices.com/resources-services/pet-help), that offer short-term, free or low-cost pet housing options for pet owners in transition from one housing situation to another may prove especially important to reduce the numbers of animals in need of permanent rehoming. Shelters also can reduce intakes by helping owners rehome their animals without having to surrender them to the shelter. For example, shelters can maintain a website of pet profiles featuring animals that are currently in homes and need a new place to live (45). As of August 2021, 473 organizations had partnered with the coalition Human Animal Support Services, which has the mission of keeping people and their pets together (46). This suggests that many animal welfare organizations are prioritizing efforts that reduce the number of animals in need of rehoming.

Strengths and Limitations

While the data reported herein represent findings from a large national sample of pet owners and non-pet owners across the US, the study did have some limitations. Ipsos, the company that collected the data, attempted to minimize sampling bias by using address-based sampling and provisioning those who needed it with internet access and a tablet so they could complete the survey. Nevertheless, the sample was not entirely representative of the US population. Based on 2020 US Census Bureau data (47), White participants were overrepresented in the sample while other racial groups were underrepresented. This may have been due in part to collecting responses solely from English-speaking individuals. US Census Bureau data also indicate that individuals in households earning over $100,000 per year were underrepresented in the sample while those in households earning $50,000–$100,000 were overrepresented (48). Moreover, the 2020 US census data show that the survey underrepresented households that included children under 18 years (49). Additionally, the total number of dogs and cats participants owned and/or rehomed prior to and during the pandemic is unknown, as was detailed information about these animals. Furthermore, the survey did not ask about household pets other than cats and dogs.

While some pandemic-related restrictions had been lifted when the data were collected in May 2021, many were still in effect. Consequently, it is hard to predict how pet ownership trends will change and how many individuals will actually rehome their animals once restrictions are lifted completely. When individuals express intentions regarding future behaviors, they commonly do not follow through with the planned behavior (50). In the case of rehoming pets, perhaps many of those who stated they were considering rehoming their pets will not actually do so; however, the percentages of individuals who have rehomed animals over the past year and who indicated they are considering rehoming pets suggest that some pet owners would benefit from pet retention resources and support. Despite the unknowns regarding future behavior, this study provided new insights into factors associated with both acquiring and rehoming dogs and cats during the COVID-19 pandemic.

CONCLUSION

The COVID-19 pandemic presented unique challenges to pet acquisition and ownership, and while some reports have suggested that pet ownership increased, findings from this study reflect that pet ownership numbers are actually slightly below what they were prior to March 2020. The pandemic adversely affected housing security, thereby exacerbating challenges to maintaining a pet in the household. Moderate to high degrees of concern in this domain, as well as concerns about being able to afford veterinary care, increased the likelihood of participants indicating they were considering rehoming their animal in the near future. Other risk factors associated with individuals who were considering rehoming pets in the near future included having children in the home and working from home. These findings suggest that individuals who fall into these categories might benefit from the assistance of animal welfare organizations and animal care professionals who can help them strategize ways to meet their pets' physical and psychological needs as they transition into a post-pandemic lifestyle.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

CH: formal analysis, methodology, writing—original draft and revision, and data curation. MT: conceptualization, investigation, and writing—review and editing. JH: conceptualization. All authors contributed to the article and approved the submitted version.

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Measuring Changes in Perceptions of Access to Pet Support Care in Underserved Communities

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Understanding social, economic, and structural barriers to accessing pet care services is important for improving the health and welfare of companion animals in underserved communities in the U.S. From May 2018-December 2019, six questions from the validated One Health Community Assessment were used to measure perceptions of access to pet care in two urban and two rural zip codes. One urban and one rural community received services from a pet support outreach program (Pets for Life), while the other served as a comparison community. After propensity score matching was performed to eliminate demographic bias in the sample (Urban = 512 participants, Rural = 234 participants), Generalized Estimating Equations were employed to compare the six measures of access to pet care between the intervention and comparison communities. The urban community with the Pets for Life intervention was associated with a higher overall measure of access to pet care compared to the urban site that did not have the Pets for Life intervention. When assessing each of the six measures of access to care, the urban community with the Pets for Life intervention was associated with higher access to affordable pet care options and higher access to pet care service providers who offer payment options than the community without the Pets for Life intervention. Further analyses with a subset of Pets for Life clients comparing pre-intervention and post-intervention survey responses revealed statistically significant positive trends in perceptions of two of the six measures of access to pet care. This study provides evidence that community-based animal welfare programming has the potential to increase perceptions of access to pet support services.

Keywords: companion animals, access to care, animal welfare, social determinants of health, generalized estimating equations

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INTRODUCTION

Access to veterinary care and other pet supportive services (e.g., grooming, behavior training, pet supplies) has been increasingly recognized within the animal welfare sector as a substantial barrier to the health and welfare of companion animals (henceforth referred to as "pets"). Early academic definitions of access to care in the human health sector consisted of five dimensions, including: availability (e.g., the quantity and types of services); accessibility (e.g., the geographic location);

accommodation (e.g., the hours of operation, service models, and facility types); affordability (e.g., options for low-cost services and insurance coverage); and acceptability (e.g., high quality services that consider a client's unique preferences or needs) (1). However, developing programs that address all five of these dimensions are likely insufficient without also incorporating the important distinction between an individual "having access" to services, meaning an individual has the potential to access a particular service, and an individual "gaining access," referring to an individual's actual utilization of the service (2). Within this broadened definition, an individual's ability to "gain access" depends on additional social and community factors included in the social determinants of health framework (2).

The Centers for Disease Control and Prevention, defines social determinants of health as "conditions in the places where people live, learn, work, and play that affect a wide range of health risks and outcomes" (3). These determinants include an individual's social and community context, economic stability, neighborhood and built environment, education access and quality, and healthcare access and quality. There have been increased efforts to improve human health trajectories by addressing the influence of social determinants of health. These efforts are operationalized as interventions to address a number of potential systemic barriers to accessing human healthcare, including: housing and built environment (e.g., Gautreaux Residential Mobility Program, Healthy Food Financing Initiative, Project U-Turn; Scattered-Site Public Housing Program, Moving to Opportunity for Fair Housing Demonstration Program); low socioeconomic status (e.g., Great Smoky Mountain Study, Supplemental Security Income Program, New Hope Random Assignment Experiment, Conditional Cash Transfer Programs, Special Supplemental Nutrition Program for Women, Infants and Children, Earned Income Tax Credit); education (e.g., Perry Preschool Project, Carolina Abecedarian Project, Nurse Family Partnership, Harlem Children's Zone); and employment (e.g., Civil Rights Policies, Supported Employment). Research indicates that these programs have resulted in reduced health disparities, improved population health, decreased morbidity and mortality, and lower medical care costs in historically marginalized communities (e.g., Black, Indigenous, or People of Color, LGBTQ+ individuals, individuals living in poverty or experiencing homelessness, individuals with disabilities, and aging adults) (4–6).

Like human healthcare, social determinants of health, such as access to care, also impact the health and welfare of pets. Several factors that inform access to pet support services have been identified, including service provider-client relationships and communication, cultural or language barriers, client perceptions of the necessity of veterinary and other pet support services, transportation barriers, clinic hours of operation, a client's disability or medical condition, client education, and affordability of services (7–10). In a recent study, qualitative interviews with pet-owning residents in a community with low socioeconomic status identified affordability of pet care services, geographic proximity to pet care services, availability of pet care services in an individual's preferred language, and access to pet care information as the most important components of accessing pet supportive programming (11). Among these barriers, affordability is the most frequently discussed in current literature, with over 25 previous studies focusing on this challenge [e.g., (7–9, 11–19)]. A number of programs have been initiated to improve access to basic veterinary care and pet support services (8, 20–31); including service-learning programs that strive to prepare veterinary students to address barriers to accessing pet care (10). Unfortunately, many of these programs view barriers to accessing care as a personal issue, opt to address only one dimension of access (e.g., affordability, geographic accessibility), or determine program efficacy by evaluating just one measurement of success, such as number of services provided (12). Furthermore, research examining the efficacy of interventions addressing the social determinants of health that disproportionately impact pets and their owners in historically marginalized communities is still limited. However, it is likely that incorporating an understanding of both the individual and structural factors that inform human health outcomes in historically marginalized communities into the development of pet support service programs will improve animal welfare organizations' engagement with these traditionally underserved populations.

One of the most well-established and longest running programs to improve access to pet support services in historically marginalized communities is The Humane Society of the United States' Pets for Life (PFL) program. PFL addresses the issue of access to pet support services by offering no cost or heavily subsidized pet care services, providing transportation to and from appointments, employing bilingual staff members, building relationships with pet owners in the community, and partnering with local companion animal service organizations to provide services. Since 2011, PFL has served over 200,000 pets by providing over 600,000 veterinary services, supplies, and medications in 50 communities in the U.S. and Canada (32). The PFL model provides an opportunity to study the impacts of community-based animal welfare programming. In the present study, questions from the One Health Community Assessment (OHCA) instrument were used to evaluate community members' perceptions of their access to pet support services. It was hypothesized that community members in historically underserved communities that received the PFL intervention would have more positive perceptions of their access to pet support services than community members living in a similar community that was not receiving PFL services.

MATERIALS AND METHODS

Data Collection

The data for this study were collected as part of an ongoing four-year study to assess the impacts of the PFL intervention in historically underserved communities. To assess the effectiveness of PFL in addressing access to pet support services, four communities (comprised of single zip codes) were selected for the study. Several factors impacted the study site selection criteria. First, due to the regional focus of the funder, only

Abbreviations: CBRA, Community-Based Research Assistant; GEE, Generalized Estimating Equations; OHCA, One Health Community Assessment; MCAR, Missing Completely at Random; MAR, Missing at Random; PFL, Pets for Life; PSM, Propensity Score Matching; SPSS, Statistical Package for the Social.

TABLE 1 | 2017 Demographic data of the four study communities (34).

Study site	Population (2017)	Ethnicity							Median household income	Percentage of individuals below the poverty level
		Native American	Asian	Black	Latino/a	White	Multi-ethnic	Other		
Granger, WA (98932)	5,335	2.9%	0.3%	0.9%	76.7%	17.6%	1.6%	0%	$47,302	27.3%
Wilder, ID (83676)	4,511	0.3%	0.2%	0%	35.7%	62.5%	1.0%	0.2%	$45,645	15.4%
Seattle, WA (98108)	24,134	0.6%	37%	18.7%	10.1%	26.4%	5.8%	1.3%	$55,314	23.3%
Madison, WI (53713)	23,097	0.6%	7.6%	15.6%	25.6%	46%	4.5%	0.1%	$38,843	27.8%

eight states (AK, ID, MT, MN, ND, OR, WA, WI) were considered in the selection process. Second, communities were evaluated based on meeting the specific criteria describing an underserved community. These criteria included the absence of local veterinarians and pet service providers (e.g., pet supply stores). Geographic Information System (GIS) mapping of veterinary clinics and other pet service providers listed in local business registries was used to determine the study communities' limited geographic proximity to pet care resources (ArcGIS—Environmental Systems Research Institute, Redlands, CA, USA). Third, demographic factors (e.g., median household income, poverty rate, unemployment rate) were evaluated amongst the list of communities to identify similarities. Within the eight states, this narrowed the search to 27 rural communities and 30 urban communities. An urban community was defined as an area within a large city that contains highly concentrated residential and commercial properties, and a rural community was defined as a region of undeveloped land with a low population size and density (33).

To allow for an initial assessment of the generalizability of findings across communities, the four study sites included two urban and two rural communities. The pair of urban study sites chosen were in Madison, WI (53713) and Seattle, WA (98108), and the pair of rural sites were Granger, WA (98932) and Wilder, ID (83676). When selected for the study in 2017, the urban and rural pairs were found to have similarities across the following demographic characteristics: population size, race/ethnicity composition, poverty rate, and median household income level [**Table 1**; (34)]. Each site has a greater number of households living below the federal poverty line and higher racial and ethnic diversity than the U.S. averages (34). To understand the total number of pets who could potentially benefit from PFL services, a detailed assessment of pet ownership was conducted during the first year of the study in each of the four study communities. The measured rate of pet ownership in each of the study sites was: Madison 58.6%, Seattle 48.1%, Granger 64.7%, and Wilder 64.9% (35). Using a wait list control design, one site in each of the pairs received the PFL intervention (Madison, WI and Granger, WA), while the other site served as a comparison community (Seattle, WA and Wilder, ID).

The data for this study were collected in each of the study sites by grant-funded community-based research assistants (CBRAs) following a University of Denver IRB approved consent and data collection protocol (DU IRB protocol 1234950). The CBRAs were employed by the local animal welfare organizations (Dane County Humane Society for Madison, WI, Seattle Humane for Seattle, WA, Yakima Humane Society for Granger, WA, and Idaho Humane Society for Wilder, ID) and received intensive training on culturally appropriate research methods from the research team. Regular fidelity checks were conducted with each of the CBRAs to ensure data collection was implemented consistently across the four study communities. Fidelity checks were conducted by full time research staff members at the University of Denver, who have prior experience and certification in conducting survey-based research and were responsible for designing this study. These fidelity checks were conducted yearly with the CBRAs. During a fidelity check, the research staff member observed a CBRA provide an explanation of the study, execute the informed consent process, and conduct the survey. Some of the key areas assessed during a fidelity check included the research staff members' ability to build rapport with the community member, their accuracy in reading the questions, and their explanation and reporting of the Likert scale responses. The research staff member provided coaching and feedback to the CBRA for improvement in the future. The CBRAs live in or near their focus community and were hired based on their previous experience in community-based data collection, including their skills in building rapport with diverse community members. The CBRAs collected the data using systematic sampling grids to guide their door-to-door recruitment efforts. These systematic sampling grids included half of the households in the urban communities and all of the households in the rural communities. To maximize response rates, CBRAs made three contact attempts at every household, with each attempt occurring on different days of the week and times of day. When contact was established at a household, the CBRA explained the study goals and assessed if the resident met the inclusion criteria.

The inclusion criteria for individuals participating in the study included: living in a household within one of the four study community zip codes (53713, 98108, 98932, 83676) and if they currently owned pets or had owned pets within the previous 12 months. For those who were eligible and consented to participate, the CBRA began by collecting human and pet demographic data. This included information about the pet owner's household income, ethnicity, and housing type, and data on their pet(s) names, type and breed of their pet(s), and where

TABLE 2 | Demographics of the sample before and after propensity score matching.

	Pre-PSM: urban sites (*N* = 598)	Pre-PSM: rural sites (*N* = 404)	Post-PSM: urban sites (*N* = 512)	Post-PSM: rural sites (*N* = 234)
PFL				
Intervention group	299 (50%)	238 (58.9%)	256 (50%)	117 (50%)
Comparison group	299 (50%)	166 (41.1%)	256 (50%)	117 (50%)
Preferred language				
English	565 (94.5%)	299 (74%)	488 (95.3%)	189 (80.8%)
Spanish	22 (3.7%)	105 (26%)	19 (3.7%)	45 (19.2%)
Other	8 (1.3%)	0	5 (1%)	0
Prefer not to answer	3 (0.5%)	0	0	0
Sex				
Male	238 (39.8%)	124 (30.7%)	206 (40.2%)	66 (28.2%)
Female	351 (58.7%)	280 (69.3%)	301 (58.8%)	168 (71.8%)
Other	3 (0.5%)	0	2 (0.4%)	0
Prefer not to answer	6 (1%)	0	3 (0.6%)	0
Age (years)				
60 or older	113 (18.9%)	95 (23.5%)	95 (18.6%)	61 (21.6%)
30–60	358 (59.9%)	194 (48%)	309 (60.4%)	103 (44%)
18–30	124 (20.7%)	109 (27%)	107 (20.9%)	67 (28.6%)
Prefer not to answer	3 (0.5%)	6 (1.5%)	1 (0.2%)	3 (1.3%)
Ethnicity				
White	387 (64.7%)	140 (34.7%)	347 (67.8%)	89 (38%)
Latino/a	54 (9%)	234 (57.9%)	46 (9%)	129 (55.1%)
Black	75 (12.5%)	2 (0.5%)	67 (13.1%)	2 (0.9%)
Other (Asian, Native American, multi-ethnic)	78 (13%)	27 (6.7%)	51 (10%)	14 (6%)
Prefer not to answer	4 (0.8%)	1 (0.2%)	1 (0.2%)	0
Household income ($)				
0–15,000	88 (14.7%)	52 (12.9%)	80 (15.6%)	32 (13.7%)
15,000–30,000	74 (12.4%)	70 (17.3%)	69 (13.5%)	39 (16.7%)
30,000–45,000	61 (10.2%)	73 (18.1%)	50 (9.8%)	42 (17.9%)
45,000–60,000	66 (11%)	42 (10.4%)	57 (11.1%)	20 (8.5%)
60,000 or more	207 (34.6%)	64 (15.8%)	179 (35%)	44 (18.8%)
Prefer not to answer	102 (17.1%)	103 (25.5%)	77 (15.1%)	57 (24.4%)
Education				
Less than a high school degree	52 (8.7%)	97 (24%)	46 (9%)	50 (21.4%)
High school degree or equivalent	291 (48.7%)	241 (59.7%)	249 (48.6%)	144 (61.5%)
College degree	244 (40.8%)	58 (14.4%)	209 (40.8%)	35 (15%)
Prefer not to answer	11 (1.8%)	8 (1.9%)	8 (1.6%)	5 (2.1%)
Housing status				
Homeowner	146 (24.4%)	113 (28%)	123 (24%)	76 (32.5%)
Renter	75 (12.5%)	51 (12.6%)	66 (12.9%)	29 (12.4%)
Unstably housed	9 (1.5%)	19 (4.7%)	8 (1.6%)	13 (5.6%)
Other	8 (1.3%)	2 (0.5%)	7 (1.4%)	2 (0.9%)
Prefer not to answer	360 (60.2%)	219 (54.2%)	308 (60.1%)	114 (48.6%)
Born in the U.S.				
Yes	523 (87.5%)	284 (70.3%)	463 (90.4%)	178 (76.1%)
No	72 (12%)	115 (28.5%)	47 (9.2%)	55 (23.5%)
Prefer not to answer	3 (0.5%)	5 (1.2%)	2 (0.4%)	1 (0.4%)

they obtained their pet(s) from. The CBRA then administered the OHCA instrument. The OHCA is a validated instrument measuring community members' perception of numerous factors contributing to community-wide One Health (Cronbach's alpha = 0.9, 11), the interconnected health of people, other animals, and the environment (36). This instrument was developed using an exploratory sequential mixed methods approach and piloted with over 100 community members in a PFL community in Denver, CO. In the present study, six of the 115 questions from the OHCA were used to assess components of access to care, including an individual's perceptions of the affordability of their pet care services (e.g., veterinarians, grooming, behavior support, pet supply retailers), geographic proximity to pet care services, availability of services in the individual's preferred language, and availability of information regarding pet healthcare. The questions were structured on a 5-point Likert scale with 1 = "Strongly Disagree," 2 = "Disagree," 3 = "Neutral," 4 = "Agree," 5 = "Strongly Agree," and a response option for "prefer not to answer." CBRAs asked all questions verbally in the preferred language of the participant (Spanish or English). All responses were entered using electronic tablets into a HIPAA-compliant data management system hosted at the University of Denver (REDCap) (37).

Two time points of data collected from the individuals living in the study communities were analyzed in this study. The first time point was collected from May 2018 to April 2019 when the PFL interventions were initiated in Madison, WI and Granger, WA, and the second time point was collected from May 2019 to December 2019. Data from the intervention sites (Madison, WI and Granger, WA) and comparison sites (Seattle, WA and Wilder, ID) were used to explore how the presence of PFL in a community (but not necessarily direct participation as a PFL client) influences measures of access to pet care. Participating households were included in the analyses if they completed at least one time point of data collection during the study period.

Propensity Score Matching

The PSmatching3 tool in Statistical Package for the Social Science (SPSS) version 25 was used to execute propensity score matching of the dataset to create balance in respect to potentially confounding demographic variables between the

intervention and comparison communities. Propensity score matching is used to reduce bias in a study's assessment of how the intervention (presence of PFL in a community) impacts the measured outcome (perceptions of access to pet care) (38). The propensity score is a balancing score, which allows a nonrandomized study design to mimic some characteristics of a randomized control trial. The demographic variables included in the propensity score matching were gender, ethnicity, age, preferred language, household income, highest level of education completed, born in the U.S., and current housing status. Multiple propensity score models (matching order largest, smallest, and random) were tested with the 1-to-1 nearest neighbor approach (caliper 0.2), and the model with the best overall balance was selected to estimate the intervention effect. Demographics of the sample before and after propensity score matching can be found in **Table 2**.

Exploratory Analyses

Missing data were common for participants in this dataset due to challenges associated with conducting door-to-door data collection. In the urban sites, 337 (65.8%) participants completed the survey for one time-point only (year one or year two). In the rural sites, 127 (54.3%) participants completed the survey for one time-point only (year one or year two). To assess if the missingness mechanism differed between the intervention and comparison communities, Little's Missing Completely at Random (MCAR) tests were performed using data on the availability to complete a follow-up survey after year one. This test assesses whether the missingness depends on the observed and unobserved variables within the dataset (39). Results of Little's MCAR tests provided reason to reject the null hypothesis that the data were missing completely at random in the urban sites ($p < 0.001$) and rural sites ($p = 0.001$), respectively. Additional analysis using Chi-Square tests comparing the availability for a follow-up survey after the first year of data collection demonstrated that there was no significant difference in missingness proportions between the two urban communities. This point of similarity in availability for follow-up supports the assumption that comparison of the response variables over time between these communities is not biased by differing availability for follow-up. However, the Chi-Square test reflected differences in availability to follow-up in the rural sites, with survey participants in Wilder, ID associated with greater participation in the survey after year one ($p < 0.001$). Further modeling with linear regressions of the year-one responses for all six items of the survey based on the participants' availability to follow-up in year two revealed no significant relationship. This finding that availability for a follow-up survey does not depend on year one responses provides qualitative evidence that the follow-up survey response data is missing at random (MAR), where the propensity for data to be missing is not inherent to the missing data, rather dependent on another variable (40). This supports the modeling approach that differences in missingness between the rural sites did not create different biases in the responses over time.

Generalized Estimating Equations

Generalized Estimating Equations (GEE) were used to analyze changes in the measures of access to pet care resources over the study period. GEE is a statistical method used to analyze longitudinal data while considering multiple relevant covariates, even when the mathematical relationship between independent and dependent variables contains biased coefficients and parameter estimations (41, 42). GEE can account for individual and environmental variations that occur within repeated observations and controls for unobservable differences between individuals by allowing researchers to estimate the variation within individuals based on a few observations per individual (42, 43). This method of analysis is used for correlated data with binary, discrete, or continuous outcomes and is especially helpful when correlations are not specified/structured because it allows for selection of a correlation matrix when setting up the model (40, 43). Further benefits of using GEE include: the ability to appropriately handle time varying and time-invariant predictors; being more flexible with missing data compared to traditional repeated measure ANOVA's; and a robustness to the misspecification of the correlations structure (41, 43–45). In this study, the exchangeable correlation structure was employed so correlations between subsequent measures were assumed to be the same, regardless of the length of time of the interval (40). The main effects feature of GEE was utilized in this study to capture the nuanced relationship between one independent variable (e.g., preferred language, household income, study site) and the measures of access to pet care services at a specified time (46).

GEE analyses assessing how the presence or absence of PFL in the two urban and rural communities influences measures of access to pet care were conducted using SPSS version 25. The following independent factors were included in the model: preferred language, gender, age, ethnicity, household income, highest level of education completed, born in the U.S., study site, and survey date. The variables for preferred language were Spanish and "other," with English being the reference category. Gender was measured as Female and "other," with Male being the reference category. Age was measured in a range of years, including 18–30, 30–60 and a reference of 60 or older. The dichotomous variables for ethnicity included Latino/a, Black, and "other," with White as the reference category. Household income was measured as $60,000 or more, $45,000–$60,000, $30,000–$45,000, $15,000–$30,000, with $0–15,000 as the reference category. Highest level of education was measured as college degree and high school degree or equivalent, with less than a high school degree as the reference category. Response options for the discrete variable, born in the U.S., were yes or no, with no serving as the reference category. For all demographic questions, "prefer not to answer" was provided as a response option. The variables for study site were the PFL intervention site (Madison, WI or Granger, WA) and comparison site (Seattle, WA or Wilder, ID), which provided the reference. Survey date was measured as a continuous variable. The demographic variables were included in the model because they could potentially affect the access to care outcome. Survey date is included to help

TABLE 3 | Propensity score matching results of the overall balance test (48) for the intervention and comparison groups.

	Chi-square	df	*p*-value
Urban sites	3.420	8.000	0.905
Rural sites	2.148	8.000	0.976

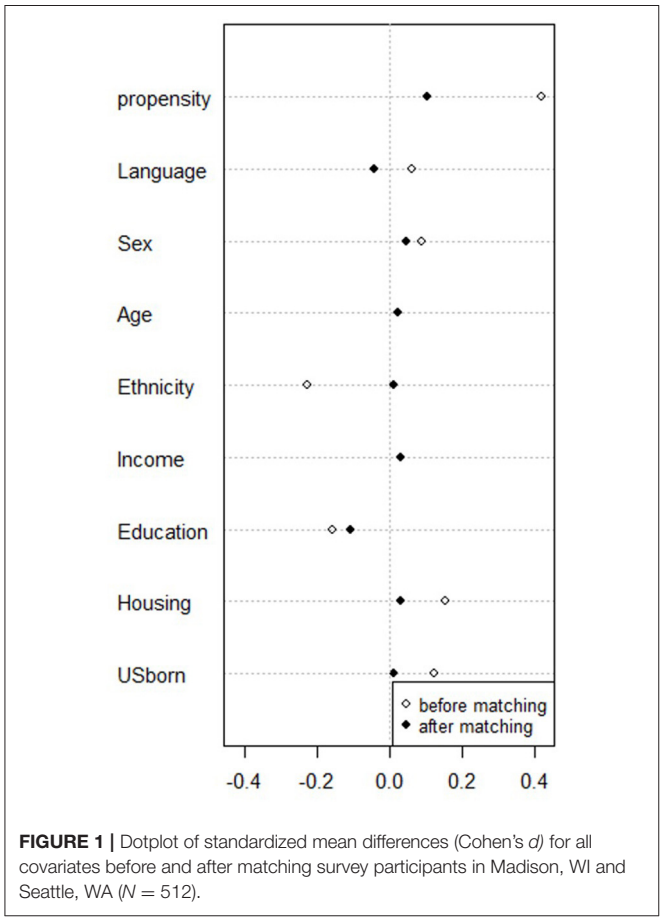

FIGURE 1 | Dotplot of standardized mean differences (Cohen's *d)* for all covariates before and after matching survey participants in Madison, WI and Seattle, WA (*N* = 512).

analyze changes over time. GEE was then run for the dataset on the aggregated and disaggregated measure of access to pet resources. The disaggregated measures of access to pet care included six individual questions about affordability of services, geographic proximity to services, services in an individual's preferred language, and availability of pet healthcare information. Aggregate measures of access to pet resources were generated by taking the average of participants responses to all six of the questions. The negative numbers reported in the tables on GEE findings indicate lower access to care, while the positive numbers indicate higher access to care.

Wilcoxon-Signed Rank Test

To integrate multiple lines of correlation, the influence of engagement with the PFL program on perceptions of access to pet care resources was also assessed for the subset of participants who were PFL clients in one of the two intervention sites (Madison, WI and Granger, WA). Data on the community members who engaged with the PFL program were transferred from PFL's client database into REDCap. Study participants were identified as PFL clients when there was a match between the address provided by the study participant and the address on file for the client in the PFL client database. Pre-intervention data were collected at the first time point, while post-intervention data were collected during the second year of data collection. The Wilcoxon-signed rank test was used to measure any changes in the six OHCA survey questions measuring perceptions of access to pet care between pre-intervention and post-intervention. The Wilcoxon-signed rank test was selected because it is a non-parametric statistical approach for within-group comparison. It is a paired-difference test, meaning repeated measurements on a single sample are compared to assess whether their population mean ranks differ (47).

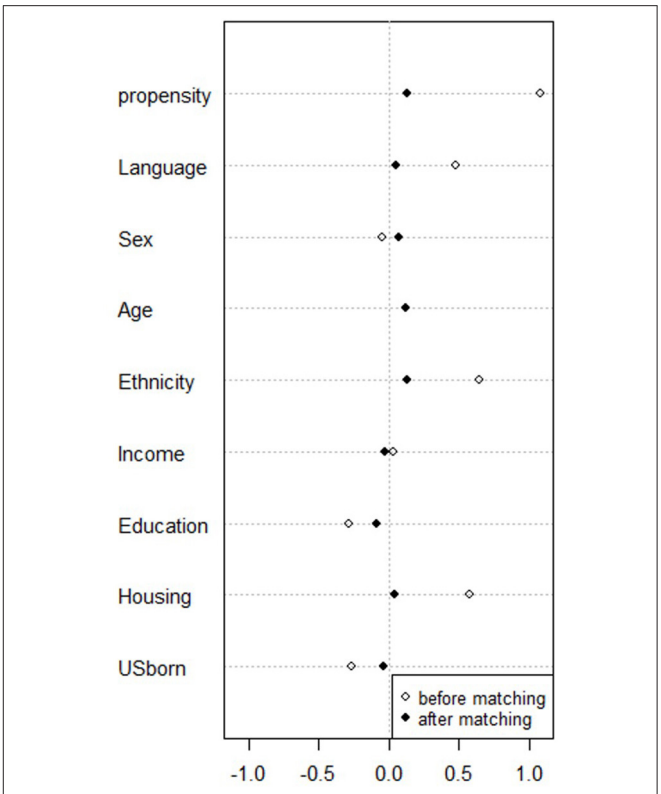

FIGURE 2 | Dotplot of standardized mean differences (Cohen's *d)* for all covariates before and after matching survey participants in Granger, WA and Wilder, ID (*N* = 234).

RESULTS

Propensity Score Matching

Propensity score matching resulted in a final sample size of 512 participants from the urban sites and 234 participants from the rural sites (**Table 2**). Results of the overall balance test (48) are reported in **Table 3**. For both matched groups, no covariates demonstrated a large imbalance ($|d| > 0.25$). **Figures 1**, **2** present the standardized mean differences (Cohen's *d*) for all covariates before and after propensity score matching.

Impacts of PFL on Overall Perceptions of Access to Pet Care

Results of the GEE analysis for the aggregate measure of access to pet care are presented in **Table 4**. The urban site that received the PFL intervention was associated with a higher aggregate measure of access to pet care compared to the urban site that does not have PFL present ($p = 0.001$). In the urban sites, people who spoke Spanish were associated with lower access to pet care than English speakers ($p = 0.003$). Participants who identified as Latino/a ($p = 0.023$) or an ethnicity categorized as "other" ($p = 0.014$) in the urban sites were associated with lower access to pet care than those who identified as White. The presence of PFL in a rural community did not have a statistically significant association with the aggregate measure of access to pet care. In the rural sites, people who were born in the U.S. were associated with higher access to pet care than individuals who were not born in the U.S. ($p = 0.034$). People with household incomes over $60,000 ($p = 0.021$), between $30,000 and $45,000 ($p = 0.032$), and between $15,000 and $30,000 ($p = 0.043$) were associated with higher access to pet care than people with a household income range of $0-$15,000.

Impacts of PFL on Perceptions of the Individual Components of Access to Pet Care

Results of the GEE analysis for the disaggregated measures of access to pet care in the urban communities are presented in **Table 5**. The urban community with the PFL intervention was associated with higher access to affordable pet care options than the urban community without PFL present ($p < 0.001$). The urban community with PFL was associated with higher access to pet care service providers who offer payment options than the urban community without PFL ($p < 0.001$). The presence of PFL in an urban community was associated with lower access to pet care services in a participants' preferred language than the urban community without PFL present ($p = 0.013$). There were several demographic factors that also impacted the disaggregated measures of access to pet care services in the urban communities. Household incomes of $45,000-$60,000 were associated with lower access to affordable pet care options than household incomes of $0-$15,000 ($p = 0.042$). Those who identified their sex as "other" were associated with higher access to affordable pet care options than those who identified as male ($p = 0.025$). Participants with a college degree were associated with lower access to pet care service providers who offer payment options than participants with less than a high school degree ($p = 0.044$). Participants reported higher access to pet care services nearby earlier in the study period in comparison to later in the study period ($p = 0.045$). People who identified with an "other" ethnicity were associated with lower access to places nearby to buy pet supplies than people who identified as White ($p = 0.016$). Participants had higher access to places nearby to buy pet supplies earlier in the study period in comparison to later in the study ($p = 0.001$). Spanish speakers ($p < 0.001$) and those who spoke an "other" language ($p < 0.001$) were associated with lower access to pet care services in their preferred language than English speakers. Those who identified their sex as "other" were associated with higher access to pet care services in their preferred language than those who identified as male ($p < 0.001$). Participants who were 30–60 years old were associated with higher access to pet care services in their preferred language than participants who were more than 60 years old ($p = 0.005$). Those who identified as Latino/a ($p = 0.006$), Black ($p = 0.027$), or an "other" ethnicity ($p = 0.015$) were associated with lower access to pet care services in their preferred language than individuals who identified as White. Household incomes of >$60,000 ($p = 0.023$) or between $15,000 and $30,000 ($p = 0.036$) were associated with higher access to pet care services in their preferred language than household incomes of $0–$15,000. People born in the U.S. were associated with lower access to pet care services in their preferred language than people who were not born in the U.S. ($p = 0.03$). Spanish speakers ($p = 0.04$) and those who spoke an "other" language ($p < 0.001$) were associated with lower access to information for their pet's healthcare than English speakers.

TABLE 4 | Generalized Estimating Equations to examine how the presence of PFL in an urban and rural community influences aggregated measures of perceived access to pet care.

	Urban communities ($N = 512$)	Rural communities ($N = 234$)
Preferred language		
Spanish	**−0.562 (−0.937, −0.186)**	−0.242
Other	−0.370	0
Sex		
Female	−0.012	0.118
Other	0.506	0
Age		
18–30 years old	0.024	−0.225
30–60 years old	0.053	−0.217
Ethnicity		
Other (Asian, Native American, multi-ethnic)	**−0.177 (−0.318, −0.035)**	0.001
Black	−0.038	0.054
Latino/a	**−0.256 (−0.475, −0.036)**	0.068
Household income		
> $60,000	0.095	**0.350 (0.052, 0.648)**
$45,000–$60,000	−0.094	0.161
$30,000–$45,000	−0.085	**0.319 (0.027, 0.610)**
$15,000–$30,000	0.032	**0.308 (0.010, 0.607)**
Education		
College degree	−0.089	0.136
High school degree or equivalent	−0.053	0.148
Born in the U.S.		
Yes	−0.155	**0.258 (0.020, 0.495)**
Study site		
PFL Intervention Site	**0.133 (0.052, 0.214)**	−0.079
Survey date	−0.073	0.112

All significant findings are bolded ($p < 0.05$), and 95% confidence intervals are reported in parenthesis for all significant findings. The reference categories are described in greater detail in section Generalized Estimating Equations.

Those who identified their sex as "other" were associated with higher access to information for their pet's healthcare than those who identified as male ($p = 0.025$).

Results of the GEE analysis for the disaggregated measures of access to pet care in the rural communities are presented in **Table 6**. The presence of the PFL intervention in a rural community did not have a statically significant association with any of the six disaggregated measures of access to pet care. However, there were several demographic factors that impacted the disaggregated measures of access to care in the rural communities. Participants who identified as Latino/a were associated with higher access to affordable pet care options than participants who identified as White ($p = 0.046$). Household incomes of >$60,000 were associated with higher access to affordable pet care options than individuals with a household income of $0-$15,000 ($p = 0.015$). Responses that occurred later in the study period were associated with higher access to pet care service providers who offered payment options in comparison to responses earlier in the study period ($p = 0.002$). Participants with a high school degree or equivalent were associated with higher access to pet care services nearby than participants with less than a high school education ($p = 0.029$), and Spanish speakers were associated with lower access to nearby places to buy pet supplies than English speakers ($p = 0.011$). Spanish speakers were associated with lower access to pet care services in their preferred language than English speakers ($p = 0.037$). People who were born in the U.S. reported higher access to pet care services in their preferred language than individuals who were not born in the U.S. ($p = 0.014$). Participants who identified as Latino/a were associated with higher access to information about pet's healthcare than individuals who identified as White ($p = 0.038$). A household income of $0-$15,000 was associated with lower access to information about pet's healthcare than household incomes >$60,000 ($p = 0.002$), between $45,000 and $60,000 ($p = 0.011$), and between $30,000 and $45,000 ($p = 0.007$). People who were born in the U.S. were associated with higher access to information about their pet's healthcare than individuals who were not born in the U.S. ($p = 0.013$).

Impacts of PFL Client Status on Perceptions of the Individual Components of Access to Pet Care

Results of the Wilcoxon signed-rank test demonstrated that participants in Madison, WI ($N = 37$) had higher perceptions of access to affordable pet cares services after becoming a PFL client in comparison to before they were a PFL client ($p = 0.027$). In Granger, WA ($N = 61$) the results of this test revealed that participants had higher perceptions of access to pet care services in their preferred language after becoming a PFL client in comparison to before they were a PFL client ($p = 0.048$) (**Table 7**).

DISCUSSION

The findings of this study demonstrate how a program that focuses on addressing the structural barriers to accessing pet support services (e.g., affordability, geographic proximity, availability of services in an individual's preferred language) can drive community-wide changes in perceptions of the accessibility of services. This study builds on previous research that found when structural barriers to accessing pet care services were addressed through a community-level intervention, the individual-level factor of pet owners' race and ethnicity were not a primary determinant for seeking pet support services (13). The development and validation of the OHCA, which includes a subset of questions to assess perceptions of access to pet support services, represents a potentially significant advancement in the animal welfare field's ability to develop and evaluate programs that can address historic and ongoing exclusion of marginalized populations. To our knowledge, this study is the first to measure the impacts of a pet support program on community members' perceptions of four dimensions of access to care. A detailed discussion of the measured impacts of PFL on the four dimensions of access to care identified during the development of the OHCA are included below.

Affordability

Cost of services is the most frequently cited barrier to accessing pet support services [e.g., (7–9, 11–19)]. In this study, PFL was associated with higher access to affordable pet care services at both the community-level and in the pre-and post-intervention analyses for the urban site (Madison, WI). PFL's programming focuses on addressing affordability of pet support services by offering no or low-cost procedures (e.g., spay and neuter), services (e.g., microchips), medications (e.g., vaccines and de-worming treatment), and supplies (e.g., food, treats, litterboxes, collars, and leashes) in historically underserved communities, providing training and mentorship support to animal service organizations, and engaging in policy advocacy on the national level to increase the understanding of how systemic poverty impacts pet owners. Unfortunately, some of the literature has undermined efforts to address affordability of services by associating a pet owner's willingness to pay for services with the strength of their emotional attachment to their companion animal (49–51). This narrative has reinforced implicit bias against individuals living in poverty and justifies the assertion that pet ownership is—or should be—reserved for individuals who can afford all aspects of pet ownership under all circumstances (17, 20, 24, 52). In contrast, PFL engages in their work with historically underserved communities through a social justice perspective that asserts that pet ownership should be available to anyone who wishes to access the benefits of the human-animal bond (53). This program philosophy aligns with more recent research that has discussed other problematic systemic factors contributing to high costs of veterinary care, such as an increase in veterinary education program costs (54), an increased demand for veterinary healthcare services that mimic those offered in the human healthcare field (20), the disproportionate growth between cost and pet owners' perceived worth of services (20), and economic downturns (24). Within this framework that recognizes the broader community-level factors driving the lack of affordability of services, some animal welfare programs are advocating for, and modeling, a shift in

TABLE 5 | Generalized Estimating Equations to examine how the presence of PFL in an urban community influences disaggregated measures of perceived access to pet care ($N = 512$).

	Affordable options	Affordable options (payment plans)	Geographic proximity (pet care services)	Geographic proximity (pet supplies)	Preferred language	Pet healthcare information
Preferred language						
Spanish	−0.495	−0.311	−0.478	−0.076	**−1.147 (−1.723, −0.572)**	**−0.356 (−0.695, −0.016)**
Other	0.155	0.125	0.056	−0.081	**−1.528 (−2.283, −0.774)**	**−0.511 (−0.797, −0.226)**
Sex						
Female	−0.049	0.000	−0.057	−0.047	0.028	0.020
Other	**0.971 (0.120, 1.822)**	−0.378	0.174	0.116	**1.094 (0.677, 1.511)**	**0.582 (0.074, 1.090)**
Age						
18–30 years old	0.016	0.131	0.065	0.083	0.004	−0.008
30–60 years old	0.044	0.022	0.063	0.026	**0.155 (0.046, 0.265)**	0.059
Ethnicity						
Other (Asian, Native American, multi-ethnic)	−0.228	−0.226	−0.155	**−0.323 (−0.586, −0.059)**	**−0.216 (−0.391, −0.041)**	−0.013
Black	0.039	−0.017	0.057	−0.032	**−0.135 (−0.255, −0.015)**	−0.104
Latino/a	−0.219	−0.277	−0.175	−0.205	**−0.408 (−0.697, −0.120)**	−0.150
Household income						
> $60,000	−0.075	0.131	0.090	0.138	**0.177 (0.024, 0.330)**	0.092
$45,000–$60,000	**−0.325 (−0.637, −0.012)**	0.038	−0.115	−0.059	−0.059	0.012
$30,000–$45,000	−0.278	−0.213	−0.061	0.112	0.047	0.058
$15,000–$30,000	−0.154	0.115	−0.099	0.133	**0.187 (0.012, 0.361)**	0.082
Education						
College degree	−0.208	**−0.298 (−0.587, −0.009)**	−0.117	0.146	0.005	0.084
High school degree or equivalent	−0.054	−0.071	−0.061	0.145	−0.103	0.040
Born in the U.S.						
Yes	−0.194	0.036	−0.172	−0.144	**−0.234 (−0.446, −0.023)**	−0.136
Study site						
Madison, WI	**0.342 (0.191, 0.494)**	**0.340 (0.169, 0.510)**	0.101	0.027	**−0.121 (−0.217, −0.026)**	−0.003
Survey date	0.026	−0.101	**−0.140 (−0.276, −0.003)**	**−0.174 (−0.280, −0.068)**	**−0.109 (−0.208, −0.010)**	−0.060

*Refer to **Table 4** caption.*

the definitions of "minimum acceptable level of caretaking" and "upmost level of medicine and surgery" in the veterinary medicine profession (24). Future research could gain greater insights into the findings of the present study by examining which specific components of the PFL program drive the greatest improvements in perceptions of the affordability of care.

Perceived availability of payment options to pay for care were also higher in the urban intervention site (Madison, WI) in comparison to the site without PFL. The option to utilize different payment options is often cited as a deciding factor for which service provider a pet owner chooses (55). While possession of pet health insurance is one approach that has increased pet owner spending for veterinary care, it has not been documented as having a significant impact on the frequency of veterinary visits (56). Other programs being piloted to address the affordability of pet support services by offering alternative payment options include "Pet Health Care Credit Cards" (20), "pay what you can" models (20, 57), or subsidizing basic

TABLE 6 | Generalized Estimating Equations to examine how the presence of PFL in a rural community influences disaggregated measures of perceived access to pet care ($N = 234$).

	Affordable options	Affordable options (payment plans)	Geographic proximity (pet care services)	Geographic proximity (pet supplies)	Preferred language	Pet healthcare information
Preferred language						
Spanish	−0.308	−0.283	−0.049	**−0.440 (−0.778, −0.101)**	**−0.368 (−0.713, −0.023)**	−0.156
Sex						
Female	0.167	−0.139	0.464	−0.052	0.038	0.024
Age						
18–30 years old	−0.039	0.207	−1.068	−0.101	−0.054	−0.158
30–60 years old	−0.050	−0.155	−0.740	−0.010	−0.056	−0.102
Ethnicity						
Other (Asian, Native American, multi-ethnic)	0.353	0.043	−0.303	0.075	−0.117	0.133
Black	0.084	0.297	−0.241	0.083	0.225	−0.070
Latino/a	**0.287 (0.005, 0.568)**	0.185	−0.144	0.041	−0.096	**0.159 (0.009, 0.310)**
Household income						
> $60,000	**0.499 (0.099, 0.899)**	0.153	0.409	0.021	0.244	**0.365 (0.131, 0.599)**
$45,000–$60,000	0.119	0.099	0.140	0.112	0.046	**0.406 (0.094, 0.718)**
$30,000–$45,000	0.326	0.415	0.349	0.033	0.153	**0.304 (0.083, 0.526)**
$15,000–$30,000	0.357	0.411	0.567	0.219	0.092	0.178
Education						
College degree	0.064	−0.193	0.307	0.205	0.260	0.226
High school degree or equivalent	0.036	0.038	**0.522 (0.052, 0.991)**	−0.021	0.101	0.083
Born in the U.S.						
Yes	0.230	0.155	0.378	−0.006	**0.335 (0.068, 0.601)**	**0.179 (0.037, 0.321)**
Study site						
Granger, WA	−0.148	0.003	−0.169	0.119	−0.006	−0.024
Survey date	0.033	**0.284 (0.107, 0.460)**	0.121	0.080	0.070	0.050

*Refer to **Table 4** caption.*

preventive care (e.g., spay/neuter, vaccinations). While there are some concerns that these alternate payment systems could negatively impact the revenue of private veterinarians, initial research indicates that many of the clients who utilize these alternate payment options were not previously utilizing any veterinary care services (54).

Geographic Proximity

In this study, there were no significant differences in perceptions of proximity to pet care services or pet supplies stores between the intervention and comparison communities. The negative impacts of transportation barriers on service utilization have been well-documented in historically marginalized communities (58). Previous research indicates that geographic proximity to pet support service providers is an important factor in a pet owner's ability to obtain care for their pet (7–9, 13, 18, 55, 59). To explain this issue, Cromley and McLafferty (60) discuss the concept of "distance decay," in which as an individual's cost, time, and effort increase, their willingness and ability to travel to access care decreases. The intention of the PFL program is not to create new service providers in the community, but instead to connect community members with services that already exist outside of the focus area. PFL does this by proving transportation for pets and their owners to and from appointments and offering to deliver no-cost pet supplies (e.g., food, treats, litterboxes, collars, and leashes) directly to people's homes. Another strategy to overcome this barrier are mobile clinic models, but they are largely offered infrequently and unpredictably (21). Rauktis et al. (25) proposed the alternative strategy of hosting both pet and human food bank events in a common location to promote greater access to basic pet supplies for vulnerable populations. Future research could assess how these approaches or other strategies help overcome the barrier of geographic proximity to care.

TABLE 7 | Wilcoxon-signed rank test to examine perceptions of access to pet care pre-intervention and post-intervention for PFL clients.

	p-value	Negative ranks	Positive ranks
Madison (*N* = 37)			
Affordable options	**0.027**	0	6
Affordable options (payment plans)	0.221	1	4
Geographic proximity (pet care services)	0.157	0	2
Geographic proximity (pet supplies)	0.739	3	3
Preferred language	0.783	3	2
Pet Healthcare information	0.102	0	3
Granger (*N* = 61)			
Affordable options	0.296	3	7
Affordable options (payment plans)	0.118	2	6
Geographic proximity (pet care services)	0.571	4	6
Geographic proximity (pet supplies)	0.586	3	6
Preferred language	**0.048**	1	7
Pet healthcare information	0.165	1	6

p-values are bolded to indicate significant findings ($p < 0.05$).

Preferred Language

In this study, the urban community with the PFL intervention was associated with lower access to pet care services in the pet owners' preferred language than the comparison community. However, this particular finding may have been driven by a relative lack of language diversity present in the intervention site (Madison, WI), while residents of the comparison site (Seattle, WA) were documented as speaking a much wider range of languages, including Spanish, Cambodian, Vietnamese, Russian, Chinese, Japanese, and Albanian. In contrast, this study found an increase in perceptions of access to pet care services in the pet owner's preferred language for the pre-intervention and post-intervention analyses in the rural intervention site (Granger, WA). This was an important programmatic finding, given a significant portion of the sample in the rural sites reported their preferred language as Spanish (**Table 2**). While there is some research indicating that availability of services in the pet owner's preferred language is a barrier to accessing veterinary care (7, 9), this body of evidence is significantly less robust than other components of accessibility that were explored in this study. PFL works to address language-related barriers by employing bilingual staff members and providing written materials (e.g., fliers, information sheets) in multiple languages. These findings may indicate a need for additional research to identify strategies that would have a greater measurable impact for overcoming language-based barriers to care. Future research should also explore how both cultural and linguistic considerations in discussing animal ethics and care practices inform the perceived accessibility of services (7, 61).

Pet Healthcare Information

In this study, there were no measurable changes in perceived access to information for the intervention sites. PFL potentially addresses this dimension of access by serving as a non-veterinary source of information that strives to be both knowledgeable and trustworthy. Their service providers focus on providing thorough explanations of a pet care procedure/visit and ensuring they address any concerns of the pet owner before providing transport to the appointment. These findings may indicate a need for additional research to identify strategies that would have a greater measurable impact for overcoming language-based barriers to care. Identified sources of information for pet owners include veterinarians, veterinary technicians, animal shelter professionals, animal control officers, non-veterinary animal experts, friends/family members, the internet, and advertisements/campaigns (8, 19, 62–65). Concerns about the credibility of pet care information that is obtained from online sources and non-veterinarian professionals has led to an increased value placed on information obtained from a veterinarian (63, 64). However, several studies have discussed challenges associated with obtaining information from veterinarians, including a lack of cultural competence training in the veterinary profession, feeling as though the veterinarian does not have time to answer additional questions, concern that by asking for additional information the veterinarian will think the client did not listen close enough to the information previously given, or fear that disclosing that they use online sources to find pet health information will harm the client's relationship with the veterinarian (16, 61, 64, 65). Additionally, some pet owners express a distrust of veterinary professionals, including believing that veterinarians are promoting preventative products and services for financial gain and believing that their veterinarian lacks education on alternate pet healthcare options (9, 17, 62). This lack of trust of veterinarians as a source of information may result in different levels of understanding the importance for routine veterinary care that result in less desirable trajectories of pet health (7). Future research should examine how accessing information regarding pet care through sources other than veterinarians impacts pet health outcomes and how client misperceptions of veterinarians' advice can be improved.

Limitations and Future Directions

Several limitations should be considered when interpreting the findings of this study. First, it is important to note that the correlations observed in this study between the presence of PFL in a community and higher perceived access to care are not evidence of direct causation. It is possible that the observed differences between the intervention and comparison communities could be driven by community-level differences that existed before PFL was present and/or developed during the study period, such as differences in baseline pet ownership rates (35) or demographic differences (e.g., cultural, linguistic) between the sites that were not controlled for within the original site matching criteria. The site matching criteria limited the study sites to communities with high rates of poverty and high racial/ethnic diversity, which limits the generalizability of these findings to communities with differing demographic profiles. Propensity score matching was employed to control for the demographic differences between individuals in the intervention and comparison communities in this study. However, with the reduced sample size that resulted from propensity score matching, there is potential the urban and rural samples

may not be representative of the demographic profile of the entire study sites' zip code. Replicating this study in additional communities served by PFL could improve the animal welfare field's understanding of the extent to which these findings are generalizable to other communities.

Additionally, while multiplicity of testing can potentially result in type 1 errors, the exploratory nature of this study encouraged multiple tests to measure the impacts of "having access" to services and "gaining access" to services (2, 66). The primary focus was on exploring how the presence of PFL in a community (but not necessarily direct engagement with PFL as a client) impacts perceptions of access to pet care. While data were collected on individuals in the community who specifically engaged with PFL as clients, a small number of clients in the available sample size for the study period limited statistical power for conducting the GEE analysis using this sample. To address potential false positives, exploratory analyses were conducted using the Wilcoxon signed-rank test and presented in this study to provide an initial assessment of the influence of PFL client status on the measures of access to care (**Table 7**). Although not all statistically significant, almost every one of the disaggregate measures of access to care increased after a study participant became a PFL client. This is a promising indicator that the observed differences in the present study might also be detectable at the individual level when statistical power is sufficient. Of note, more statistically significant findings were generated in the datasets with more statistical power. The number of separate analyses performed within the current study, however, creates the possibility of type 1 error, therefore the relationships identified in this study should be further examined in future research. Future studies should expand upon analyses of how engagement with a pet supportive intervention or awareness of the program affect perceptions of access to pet care and attempt to isolate which of the specific components of the PFL model create the highest impacts on perceived access to care and pet health and welfare outcomes. Furthermore, given the structural nature of the issue of access to pet support care, driving significant changes in perceptions of access likely requires more than just 2 years of programming. Future studies might consider longitudinally measuring the impacts of programs designed to address access to care issues over a longer period of time to assess if any changes in perceived access to care occur and are sustained.

Conclusion

Together, these findings provide some of the first evidence that effective pet support programming aiming to increase the accessibility of services for historically marginalized populations must engage communities with recognition of the variety of both individual and structural barriers they might experience.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Denver IRB protocol 1234950. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

TH, SH, KE, JW, and KM: conceptualization and original draft preparation. KE and JW: literature review. SH, TH, AA, SN, and KM: additions, edits, and review. All authors have read and agreed to the published version of the manuscript.

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Where Are We on the Animal Welfare Map? Using GIS to Assess Stakeholder Diversity and Inclusion

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Inequities exist in all facets of society, and animal welfare organizations (AWOs) and their communities are no exception. These organizations interface with multiple stakeholder groups. An active analysis of stakeholder groups to identify under-served areas and communities has not been performed. Using stakeholder data from Toronto Humane Society (THS) from 2015–2019, this study performed a retrospective spatial analysis to identify well served and under-served geographic areas for adopters, surrenders, public veterinary service (PVS) clients, volunteers and foster parents, using Hot Spot analysis. Correlation analysis was performed to determine whether the spatial distribution of the groups correlated with the four socioeconomic metrics of the 2016 Ontario Marginalization Index (residential instability, material deprivation, dependency, and ethnic concentration), and a metric representing the distribution of Indigenous residents. For each stakeholder group, there were well served areas, typically in central Toronto where THS is located, and under-served areas, typically in the north-west and north-east corners of Toronto and in the surrounding cities of the Greater Toronto Area. The area served by THS PVS extended further north than the other hot spot areas. The number of adopters increased as the residential instability metric increased, whereas the number of adopters decreased as the ethnic concentration metric increased. The rate of surrenders increased as the Indigenous metric increased. Public Veterinary Service clients increased as the residential instability, material deprivation, and Indigenous metrics increased. One of the primary limitations of this study was the confounding factor of distance from THS. Individuals living further from THS are less likely to utilize its services, particularly if there is another accessible AWO nearby, and therefore may appear to reflect an under-served population that may not truly be under-served. A regional approach would help to overcome this limitation. The results provide useful insights into stakeholder engagement and provide a foundation for analysis of more targeted areas, as well as for strategies to reach under-served demographics. Similar analyses by other AWOs would be helpful to address inequities in a larger geographic area. Animal welfare organizations can improve program effectiveness by adding data analytics skills to the more traditional skills associated with this sector.

Keywords: animal welfare, diversity, inclusion, geographic information system, GIS, stakeholders, Ontario marginalization index

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INTRODUCTION

The COVID-19 pandemic has exposed and exacerbated deep and chronic societal inequities, many of which are directly related to race and class (1). The murder of George Floyd in May 2020 was the catalyst for sustained protests by Black Lives Matter and other movements, primarily in the U.S. but also in other countries, including Canada. This defining moment has led to seismic changes in social awareness, causing many individuals and organizations to examine their role and culpability in perpetuating systemic inequities, and their responsibility to acknowledge and address past mistakes. This has prompted many animal welfare organizations (AWOs) to consider the role of diversity, equity, and inclusion (DEI) in the design of support services and general operations (2). Since the start of the pandemic, AWOs have increasingly focused on supporting the human-animal bond by providing and promoting support for both pet parents and their pets, similar to traditional social service supports[1] (3). Additionally, new organizations have formed to promote inclusivity and combat biases[2]. Animal welfare organizations interface with, and create a community of, multiple stakeholder groups. These include those who derive meaning and belonging from giving (volunteers, foster parents), those who welcome and cherish new non-human family members (adopters), and those who utilize other services provided by AWOs (surrenders, public veterinary services). This culture of compassion and giving is difficult to reconcile with the statement that "the animal welfare industry lives at the intersection of white privilege and systemic racism" (4).

Conversely, stakeholders include those who may be punished by and discriminated against by existing systems[3,4]. Strays and surrenders are the largest sources of shelter intakes (75–80%) (5). Members of some communities are disproportionately more likely to surrender animals to AWOs, for reasons that are often directly related to poverty and social vulnerability (6, 7), or to be declined for adoption (8). In some jurisdictions, low-income and racialized individuals may be fined for their inability to comply with local ordinances such as compulsory spay/neuter (8). In one study, pet parents with lower income and less education were less likely to be able to find their lost pets (9). While many AWOs and some community clinics provide free or low-cost veterinary care, in particular vaccination and spay/neuter (10), these services are only available to those who are aware of them, understand their benefits, and have physical and financial access to them (11, 12).

Community-driven organizational activities require inclusion and representation of the community within organizations

TABLE 1 | The four metrics of marginalization comprising the 2016 Ontario Marginalization Index (17).

Metric	Description	Indicators
Residential Instability	This measure refers to people who experience high rates of family or housing instability. Indicators focus on the type and density of residential accommodations, as well as certain family structure characteristics.	• Proportion of the population living alone • Proportion of the population who are not youth (age 5–15 years) • Average number of persons per dwelling • Proportion of dwellings that are apartment buildings • Proportion of the population who are single/divorced/widowed • Proportion of dwellings that are not owned • Proportion of the population who moved during the past 5 years
Material Deprivation	This measure relates closely to low income levels and refers to the individual and community's inability to access and attain basic material needs.	• Proportion of the population aged 20+ without a high-school diploma • Proportion of families who are single parent families • Proportion of total income from government transfer payments for population 15+ • Proportion of the population aged 15+ who are unemployed • Proportion of the population considered low-income • Proportion of households living in dwellings that are in need of major repair
Dependency	This measure refers to people who do not have employment income, including children, adults, and seniors whose work is not compensated.	• Proportion of the population aged 65+ • Dependency ratio (total population 0-14 and 65+/total population aged 15-64) • Proportion of the population not participating in the labor force
Ethnic Concentration	This measure refers to people who are recent immigrants and those who self-identify as being members of a racialized community (not including Indigenous peoples).	• Proportion of the population who are recent immigrants (arrived in the past 5 years) • Proportion of the population who self-identify as being part of a racialized community

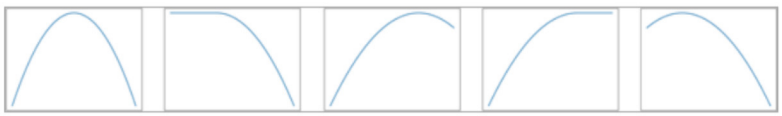
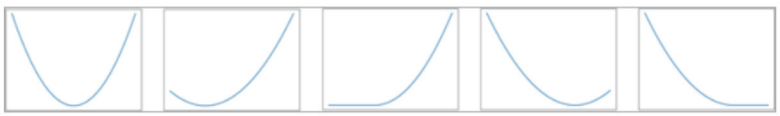
[1]Examples of human-animal bond support statements: Toronto Humane Society (https://www.torontohumanesociety.com/purpose/human-animal-bond/), American Pets Alive! Human Animal Support Services (https://www.humananimalsupportservices.org/).

[2]Companions and Animals for Reform and Equity (CARE) (https://careawo.org/).

[3]Finch L. Best Friends Staff Open Up About Their Experiences with Racism in Animal Welfare. Best Friends blog. Available online at: https://network.bestfriends.org/tools-and-information/programs-spotlight/staff-experiences-racism-animal-welfare

[4]Black Lives Matter: racism in animal rescue—The Sniff. Available online at: http://www.thesniff.com/blm/

TABLE 2 | The six relationship types defined by the Local Bivariate Relationship tool in ArcGIS (23).

Relationship	Definition	Examples (see text footnote 7)
Not significant	There is no significant relationship between the variables.	NA
Positive linear	The dependent variable increases linearly as the explanatory variable increases.	Conventional linear curve
Negative linear	The dependent variable decreases linearly as the explanatory variable increases.	Conventional linear curve
Concave	The dependent variable forms a concave curve as the explanatory variable increases. While the explanatory variable values are low, they form a positive relationship with the dependent variable, but as they increase, the relationship inverts and they then form a negative relationship with the dependent variable.	
Convex	The dependent variable forms a convex curve as the explanatory variable increases. While the explanatory variable values are low, they form a negative relationship with the dependent variable, but as they increase, the relationship inverts and they then form a positive relationship with the dependent variable.	
Undefined complex	The two variables are significantly related, but the nature of the relationship is different from any of the other defined relationship types.	Variable, do not fit conventional curves

NA, not applicable.

providing these services. Stakeholders such as volunteers and foster parents, who benefit from participating in and supporting organizational activities, may not represent the diversity of the community being served. Low-income and racialized communities may be overlooked in fundraising drives and searches for new volunteers, despite the fact that members of these communities have the means and desire to participate (13). Animal welfare organization staff in the U.S. and Canada are overwhelmingly white (14). Historically, the sector has not prioritized training around effective, non-judgmental engagement with non-English-speaking immigrants and marginalized and vulnerable individuals and communities. Animal welfare organizations, especially those with animal control responsibilities, can be seen as unwelcoming and threatening authority figures (3).

There is little Canadian data regarding social justice and equity in the animal welfare sector.

Passive or non-existent stakeholder analysis could perpetuate inequities and limit the effectiveness of support services. In contrast, an active analysis of service gaps and stakeholder composition would allow for strategically targeted remediation in under-served areas. In June 2020, Toronto Humane Society (THS), an independent charitable AWO in downtown Toronto, Canada, published a statement[1] in support of Black Lives Matter, and committed to specific actions to redress inequities. One of these commitments was to examine the spatial patterns of different stakeholder groups served by the organization.

The main objective of this study was to use geographic information systems (GIS) to identify and analyze geographic areas and communities currently under-serviced by our organization, in order to create targets for future programs and interventions. Geographic information systems are computer systems that are used for the creation, storage, analysis, and mapping of digital data. A secondary objective was to develop a robust methodology for the project and share this with other AWOs.

MATERIALS AND METHODS

Study Area

The study analyzed data from the Greater Toronto Area (GTA) in Ontario, Canada. The GTA is the most populated metropolitan area in Canada and includes the city of Toronto and the regional municipalities of Halton, Peel, York, and Durham. As of 2016, the population was 5,928,040 (15). The GTA is comprised of 1,274 census tracts (CTs) of varying sizes, with populations ranging from 10–23,401. According to the 2016

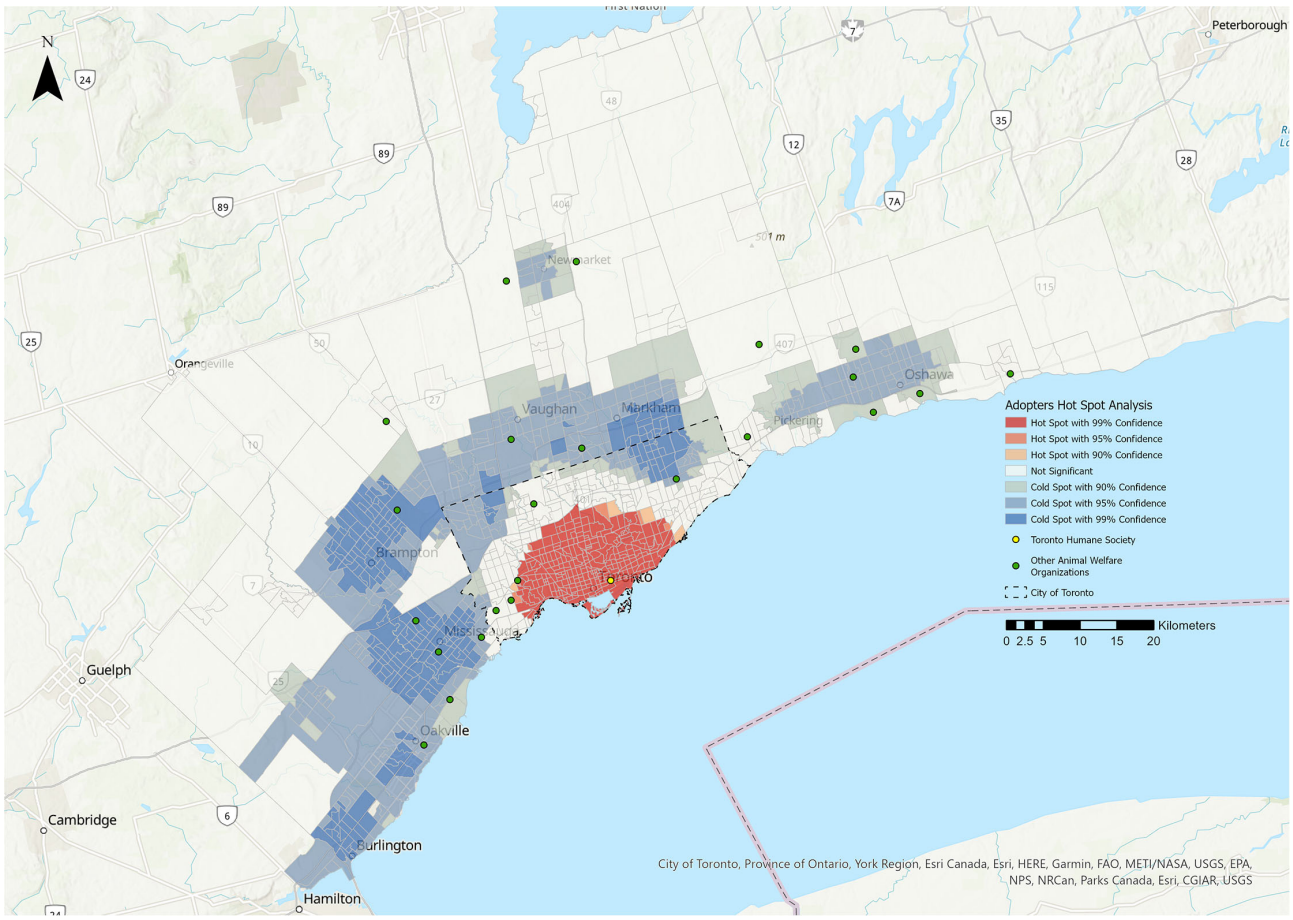


FIGURE 1 | Hot Spot Analysis for the adopters stakeholder group. Shades of blue represent cold spot areas (statistically significant low number of stakeholders), and shades of red represent hot spot areas (statistically significant high number of stakeholders). Toronto Humane Society is represented by the yellow dot, and other animal welfare organizations in the Greater Toronto Area are represented by green dots.

Census of Canada (15), approximately 15% of the population of the GTA are considered low-income, as classified by the "low-income measure after tax" metric. Approximately 51% of the population identify as racialized, and 0.7% identify as Indigenous (15). Toronto Humane Society is centrally located in the city of Toronto and aims to serve the entire GTA, and in some cases, communities beyond the GTA borders. The scope of this research was restricted to THS stakeholders within the GTA.

Data

Stakeholder Data

Data from 2015–2019 were extracted from THS' PetPoint shelter management and Volgistics volunteer management databases, and retrospectively analyzed. The programs included in this study were surrender, stray intake, adoption, foster care, and public veterinary services. Public veterinary services included (but were not limited to): spay-neuter surgery, vaccinations, preventative wellness, dentistry and owner-requested euthanasia. Stakeholders were divided into five groups: adopters, surrenders, public veterinary service (PVS) clients, volunteers, and foster parents.

Prior to data cleaning, stakeholder group sizes were: adopters $n = 16{,}133$, surrenders $n = 18{,}479$, PVS clients $n = 59{,}204$, volunteers $n = 2{,}020$, foster parents $n = 5{,}522$. Instances of a single stakeholder appearing multiple times within the same year in the same group were removed. After removing these duplicates, stakeholder group sizes were: adopters $n = 14{,}464$, surrenders $n = 6{,}647$, PVS clients $n = 33{,}740$, volunteers $n = 1{,}990$, foster parents $n = 2{,}146$. Data cleaning was then performed to exclude stakeholders located outside the GTA, and those who did not provide a complete home address and could not be geocoded. The remaining data was geocoded using the MMQGIS Geocode plugin QGIS, and the resulting points were projected onto the Esri world topographic map (16). The final stakeholder group sizes that

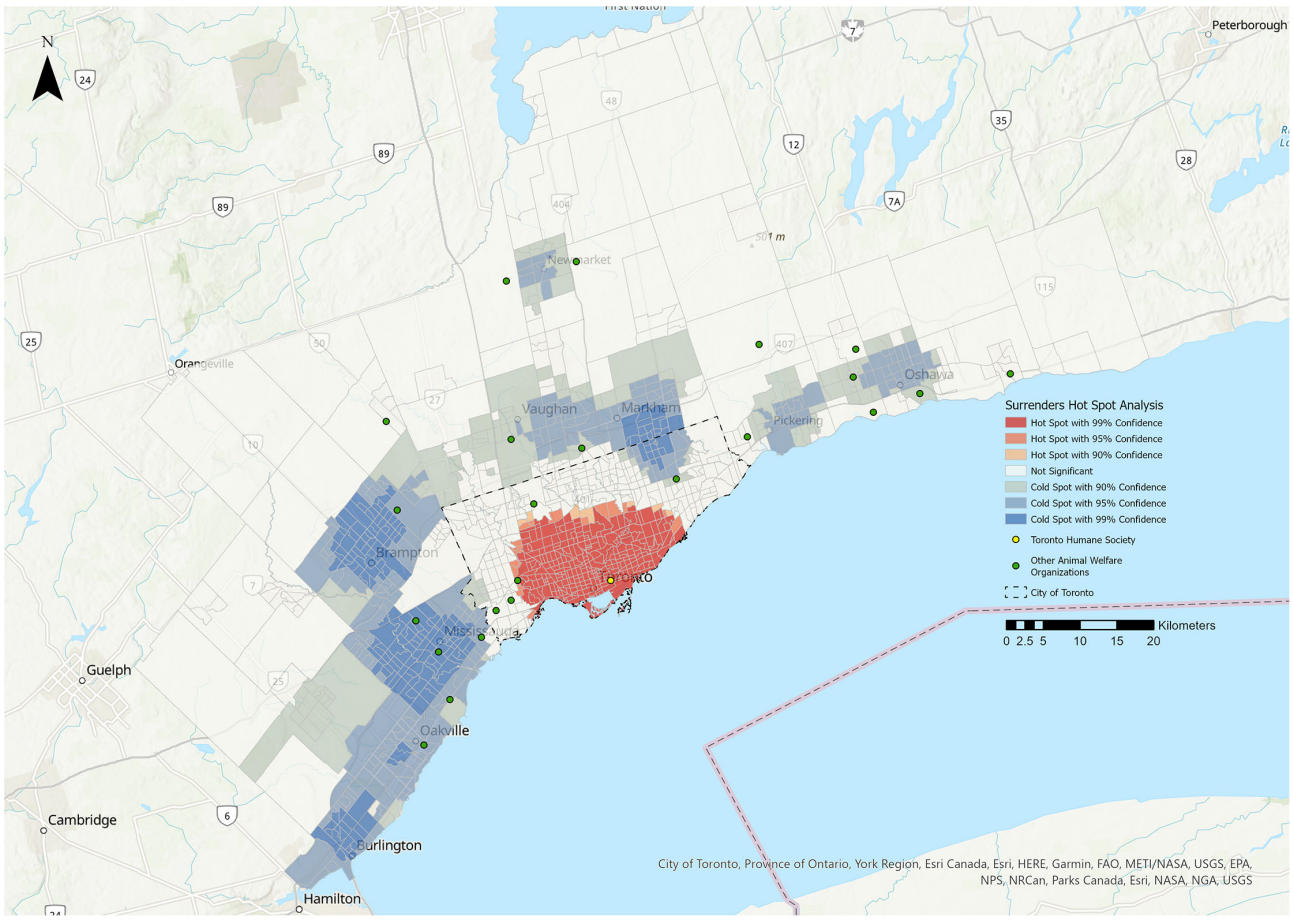


FIGURE 2 | Hot Spot Analysis for the surrenders stakeholder group. Shades of blue represent cold spot areas (statistically significant low number of stakeholders), and shades of red represent hot spot areas (statistically significant high number of stakeholders). Toronto Humane Society is represented by the yellow dot, and other animal welfare organizations in the Greater Toronto Area are represented by green dots.

were successfully geocoded and used in the analysis were: adopters $n = 13,837$, surrenders $n = 5,740$, PVS clients $n = 31,074$, volunteers $n = 1,989$, and foster parents $n = 2,054$.

Ontario Marginalization Index

The study utilized the 2016 Ontario Marginalization Index (ON-Marg), which was developed jointly by Public Health Ontario and the St. Michael's Hospital Center for Urban Health Solutions to measure marginalization in CT areas (17). The Index utilizes a combination of 18 indicators to define four distinct metrics representing marginalization. These are: (1) residential instability, (2) material deprivation, (3) dependency, and (4) ethnic concentration (**Table 1**).

Indigenous Populations

Indigenous indicators are not included in ON-Marg because of undercounting of Indigenous communities in the Canadian Census (19). To compensate for this, we included a normalized Indigenous population metric, namely the number of Indigenous residents per 1,000 total residents in each CT, based on data from the 2016 Census of Canada (15).

Analysis

Spatial Cluster Hot Spot and Cold Spot Analysis

Prior to analysis, a spatial join was performed on the geocoded data for each of the five stakeholder groups, to join them to a map of the CT boundaries. This created a field within the CT attribute table containing a count of the number of stakeholder points falling within each CT area (**Supplementary Figures 1–5**). The count variable for each stakeholder group was then normalized to population size (1,000 * count variable/2016 population), to account for variations in CT population potentially skewing the results (**Supplementary Figures 6–10**). The normalized rates were used throughout the analysis.

Hot spots were defined as statistically significant areas of high stakeholder density surrounded by other areas of high

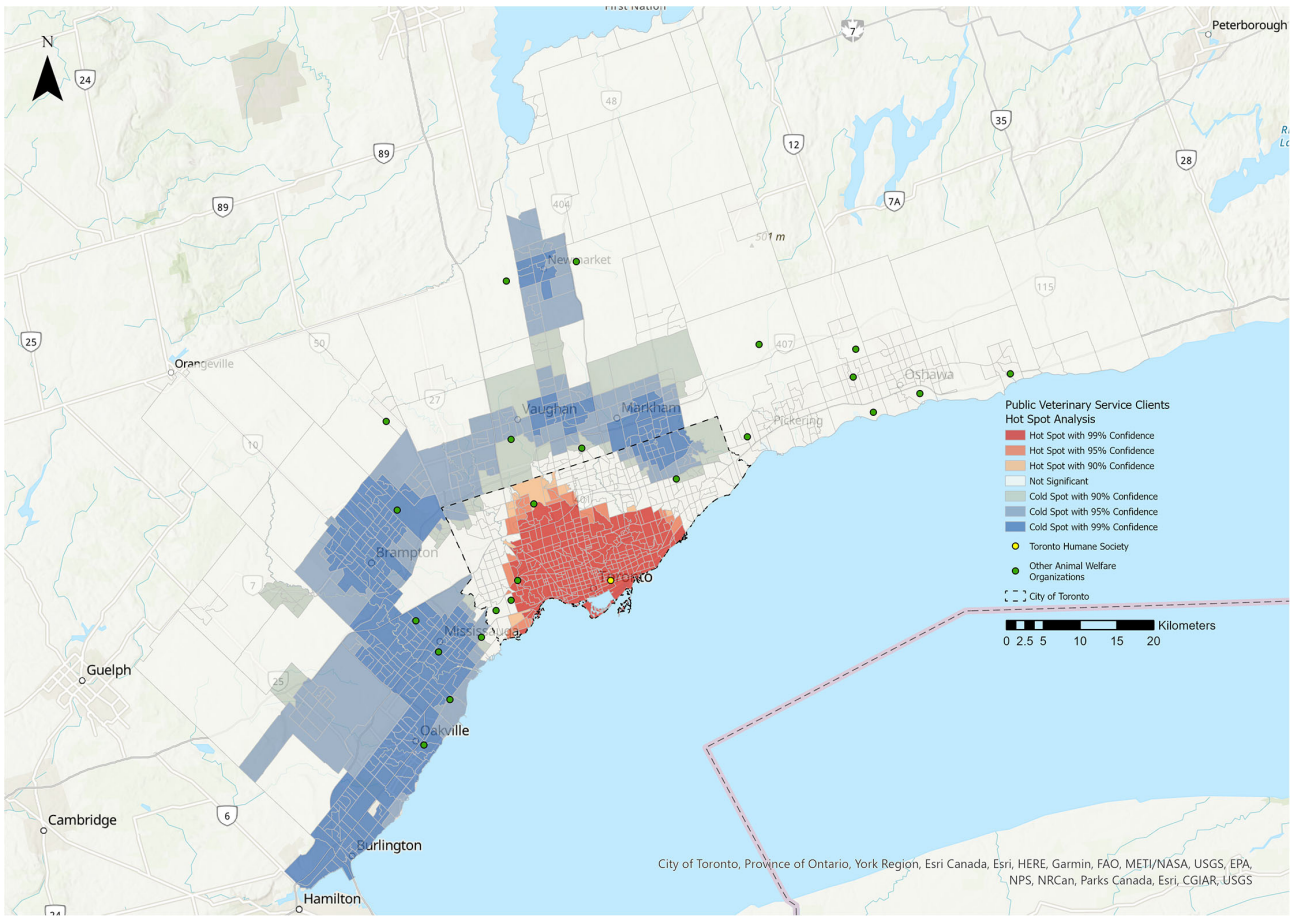


FIGURE 3 | Hot Spot Analysis for the public veterinary service clients stakeholder group. Shades of blue represent cold spot areas (statistically significant low number of stakeholders), and shades of red represent hot spot areas (statistically significant high number of stakeholders). Toronto Humane Society is represented by the yellow dot, and other animal welfare organizations in the Greater Toronto Area are represented by green dots.

stakeholder density. Cold spots were statistically significant areas of low stakeholder density surrounded by other areas of low stakeholder density (20). To locate statistically significant hot spot and cold spot clusters, the Getis-Ord Gi* statistic was calculated using the Optimized Hot Spot Analysis tool in ArcGIS Pro version 2.8 (20–22).

Correlation Analysis

Statistical correlation analysis was conducted to identify statistically significant relationships between the five stakeholder groups (dependent variables) and the four ON-Marg metrics, as well as the additional Indigenous population metric (explanatory variables).

To account for instances of false positives caused by multiple testing and spatial dependency within the data, a false detection rate correction was implemented in both the spatial cluster hot spot and cold spot analysis, and the correlation analysis. The correction estimates the number of expected false positives for a given confidence interval and adjusts the critical p value accordingly, effectively removing the weakest statistically significant results[5].

Spatial correlation was determined using the Local Bivariate Relationship tool in ArcGIS Pro version 2.8 (22), with significance set at $p < 0.05$. The tool classifies the relationship as one of six types defined in **Table 2**. The convex and concave relationships identified by the tool are not necessarily symmetrical curves and may reflect primarily negative or positive associations (**Table 2**). When a statistically significant spatial correlation was detected between a stakeholder group and one of the tested metrics, the result was generated as the percentage of the total number of CTs having a significant relationship, and then broken down to the percentage of CTs having each type of significant relationship. This analysis reflects the association between the dependent and explanatory variable for each CT. This differs from the hot spot and cold spot analysis, which

[5]https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/what-is-a-z-score-what-is-a-p-value.htm#ESRI_SECTION1_2C5DFC8106F84F988982CABAEDBF1440

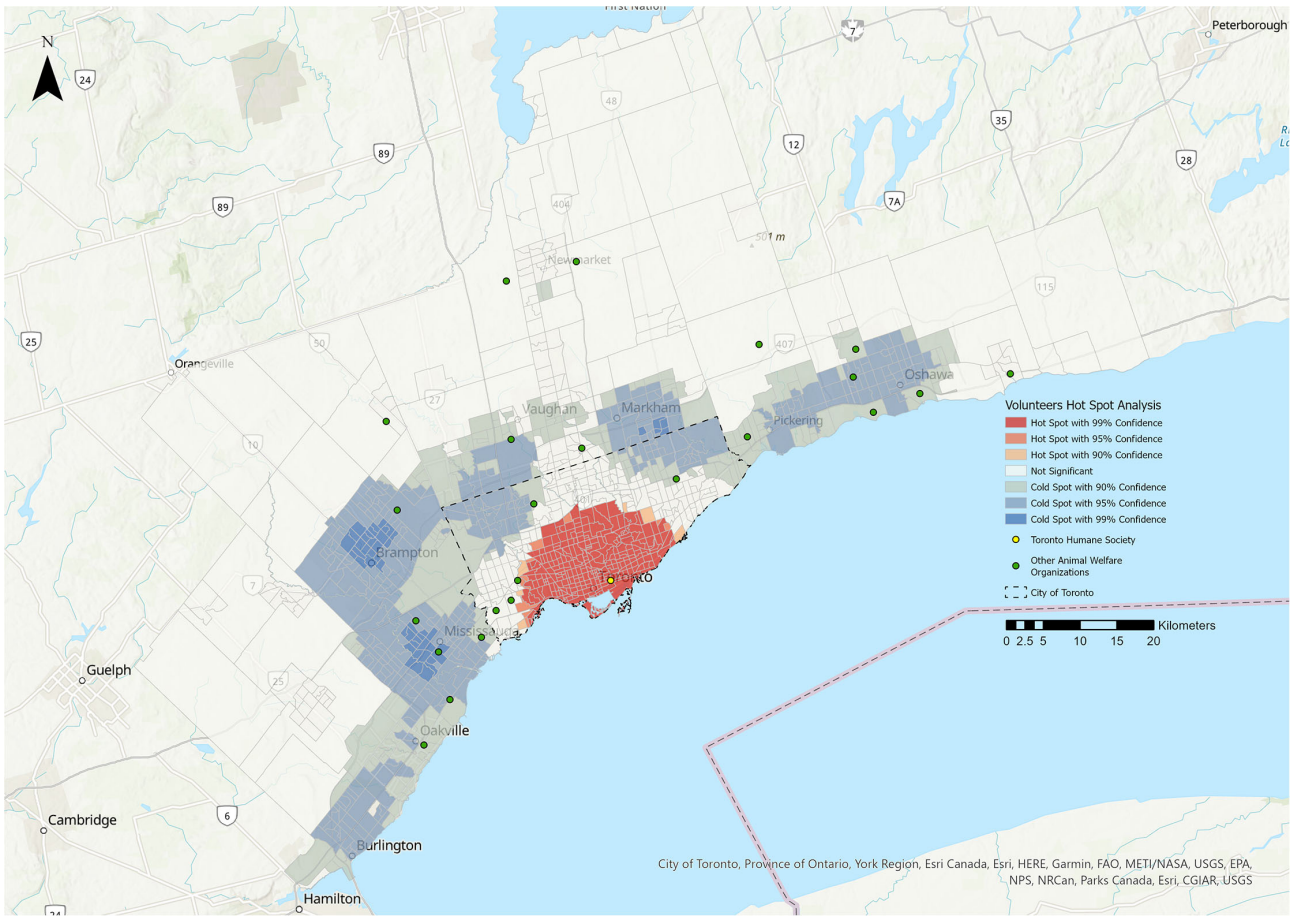


FIGURE 4 | Hot Spot Analysis for the volunteers stakeholder group. Shades of blue represent cold spot areas (statistically significant low number of stakeholders), and shades of red represent hot spot areas (statistically significant high number of stakeholders). Toronto Humane Society is represented by the yellow dot, and other animal welfare organizations in the Greater Toronto Area are represented by green dots.

reflects the number of stakeholders in a CT compared with surrounding CTs. Where a statistically significant relationship was detected between a stakeholder group and one of the tested metrics, these results were quantified as the percentage of the total number of CTs ($n = 1{,}274$) having that type of relationship.

RESULTS

There were 1,274 CTs in the study area. **Figure 1** shows the area included and the location of THS and other GTA AWOs. Stakeholder group sizes were as follows: adopters, $n = 13{,}837$; surrenders, $n = 5{,}740$; PVS clients, $n = 31{,}074$; volunteers, $n = 1{,}989$; and foster parents, $n = 2{,}054$.

Hot Spot Analysis (HSA)

The results of the HSA are shown in **Figures 1**–**5**. All five stakeholder groups formed statistically significant hot spot clusters within the city of Toronto. The adopters, surrenders, volunteers, and foster parents formed hot spot clusters in the central region of Toronto, covering a similar geographic area (**Figures 1**, **2**, **4**, **5**), whereas PVS clients formed hot spots with a larger geographic area reaching further north within Toronto (**Figure 3**).

The cold spots were more varied in their distributions. The adopters group formed cold spot clusters in the north-west and north-east corners of the city of Toronto, as well as in the surrounding cities of Burlington, Oakville, Mississauga, Brampton, Vaughan, Markham, Newmarket, Pickering, and Oshawa (**Figure 1**). Cold spots for the surrenders group were broadly similar in their distribution within the city of Toronto and the surrounding cities, but did not include the cluster in the north-west corner of Toronto that was apparent for adopters, volunteers and foster parents (**Figure 2**). Cold spots for PVS clients were also similar in their distribution in most of the surrounding cities, but clustering to the east, over the cities of Pickering and Oshawa, was absent (**Figure 3**). The volunteers group again formed cold spot clusters similar to those

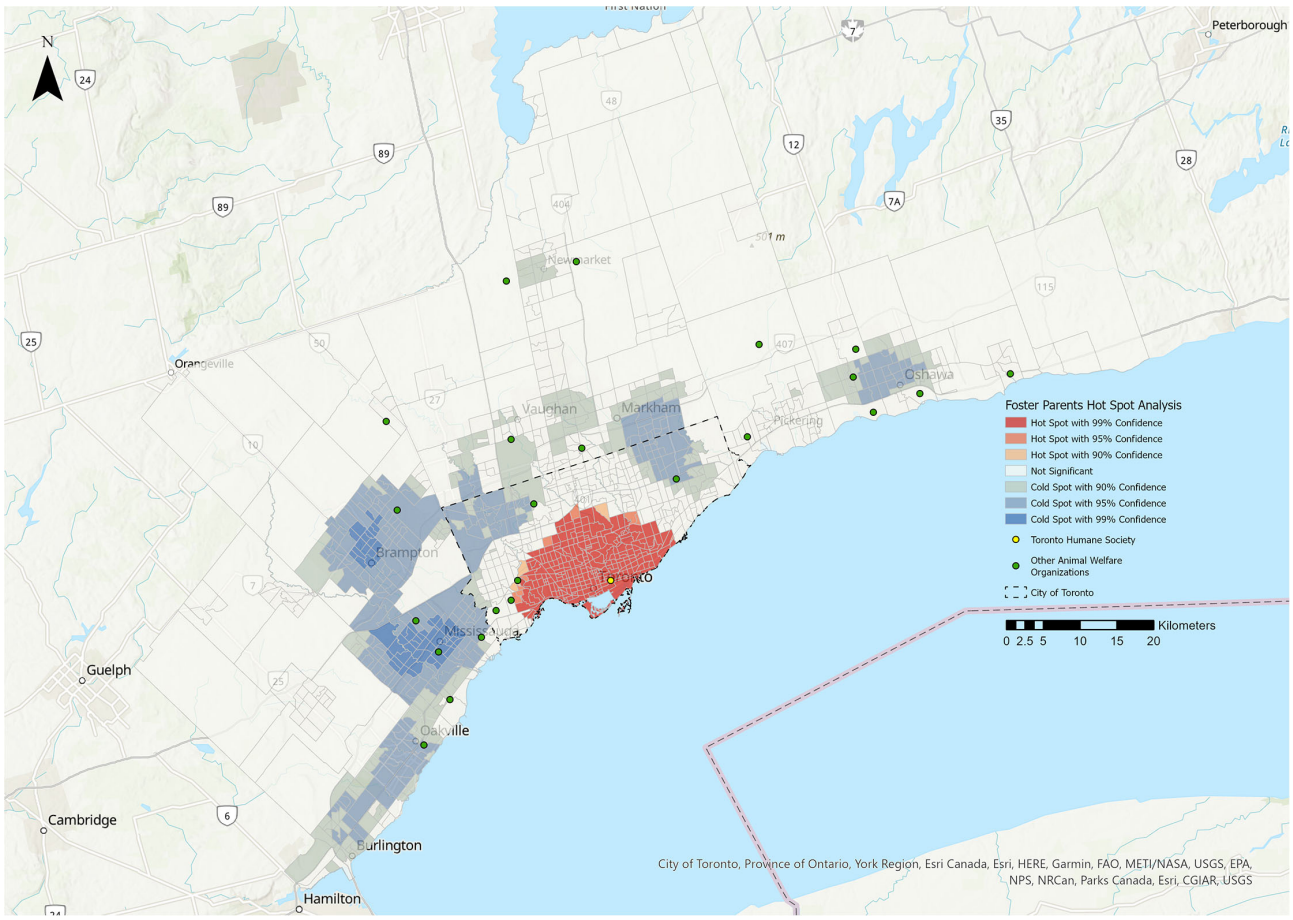


FIGURE 5 | Hot Spot Analysis for the foster parents stakeholder group. Shades of blue represent cold spot areas (statistically significant low number of stakeholders), and shades of red represent hot spot areas (statistically significant high number of stakeholders). Toronto Humane Society is represented by the yellow dot, and other animal welfare organizations in the Greater Toronto Area are represented by green dots.

of the adopters group, with the exception of the area north of Toronto and west of Markham (**Figure 4**). Lastly, cold spot clusters identified in the foster parent group were more sparsely distributed than in other groups, with no clusters between the cities of Oshawa and Markham, or Markham and Brampton (**Figure 5**).

Correlation Analysis

A full breakdown of the correlation classification results can be found in **Table 3**.

Adopters

Statistically significant relationships were identified between the adopters group and all five metrics (**Table 3**, **Figures 6**–**8**). More CTs had a positive linear relationship for the residential instability and the Indigenous metrics (15.38 and 16.37%, respectively) compared with the other relationship types (**Figure 6**, **Table 3**). The most prominent relationship for ethnic concentration was negative linear, representing 14.99% of CTs (**Figure 8**).

Surrenders

Statistically significant correlations were identified for surrenders and the Indigenous metric. These relationships were primarily positive linear (10.18%) (**Figure 9**, **Table 3**). No statistically significant relationships were identified between the surrenders group and the four ON-Marg metrics.

Public Veterinary Service Clients

Statistically significant relationships were identified between the PVS client group and the residential instability, material deprivation, and Indigenous metrics (**Figures 10**, **11**, **Table 3**). The majority of the relationships identified with the residential instability metric were positive linear (39.95% of CTs). For the material deprivation metric, 11.15% of CTs were classified as positive linear relationships and for the Indigenous metric, 28.35% of CTs were positive linear. There were no statistically significant relationships for PVS clients and the dependency or ethnic concentration metrics.

TABLE 3 | Relationships between the stakeholder groups of the Toronto Humane Society, 2016–2019, and the five metrics analyzed.

Stakeholder group (Dependent variable)	Metric (Explanatory variable)	Relationship type (% of total features)				
		PL	NL	CC	CV	UC
Adopters	Residential instability	**15.38%**	0.00%	**2.59%**	**3.85%**	**0.31%**
	Material deprivation	**1.41%**	**4.08%**	0.00%	**0.86%**	**2.28%**
	dependency	**0.39%**	**2.82%**	0.08%	**2.04%**	**0.86%**
	Ethnic concentration	**0.08%**	**14.99%**	**1.65%**	**8.56%**	**4.79%**
	Indigenous	**16.37**	0.00%	**5.17%**	**0.94%**	**0.78%**
	Residential instability	0.00%	0.00%	0.00%	0.00%	0.00%
	Material deprivation	0.00%	0.00%	0.00%	0.00%	0.00%
	dependency	0.00%	0.00%	0.00%	0.00%	0.00%
	Ethnic concentration	0.00%	0.00%	0.00%	0.00%	0.00%
	Indigenous	**10.18%**	0.00%	**0.55%**	**2.58%**	**0.86%**
Public veterinary	Residential instability	**39.95%**	0.00%	**2.90%**	**7.61%**	**2.35%**
Service clients	Material deprivation	**11.15%**	0.00%	**1.18%**	**0.63%**	**1.73%**
	dependency	0.00%	0.00%	0.00%	0.00%	0.00%
	Ethnic concentration	0.00%	0.00%	0.00%	0.00%	0.00%
	Indigenous	**28.35%**	0.00%	**6.19%**	**8.07%**	**3.45%**
Volunteers	Residential instability	0.00%	0.00%	0.00%	0.00%	0.00%
	Material deprivation	0.00%	0.00%	0.00%	0.00%	0.00%
	dependency	0.00%	0.00%	0.00%	0.00%	0.00%
	Ethnic concentration	0.00%	**0.55%**	0.00%	**1.33%**	**0.16%**
	Indigenous	0.00%	0.00%	0.00%	0.00%	0.00%
Foster parents	Residential instability	0.00%	0.00%	0.00%	0.00%	0.00%
	Material deprivation	0.00%	0.00%	0.00%	0.00%	0.00%
	dependency	0.00%	0.00%	0.00%	0.00%	0.00%
	Ethnic concentration	0.00%	0.00%	0.00%	0.00%	0.00%
	Indigenous	0.00%	0.00%	0.00%	0.00%	0.00%

Bold type indicates statistically significant relationships.

Significant percentage of the total number of features (census tracts, n = 1,274) identified as having statistically significant relationships between the stakeholder groups and each of the five metrics. PL, positive linear; NL, negative linear; CC, concave; CV, convex; UC, undefined complex.

Volunteers

The ethnic concentration metric identified a small number of negative linear relationships (0.55% of CTs) within the hot spot in Toronto, and convex relationships (1.33% of CTs) in the cold spots west of Toronto near Mississauga (**Table 3**). No other significant relationships were found.

Foster Parents

No statistically significant relationships were identified between foster parents and the five tested metrics.

DISCUSSION

This analysis was able to identify important relationships between stakeholder groups and socioeconomic metrics. The study fills an important gap in the literature pertaining to stakeholder use of AWO services and contributes to an understanding of Canadian animal welfare equity issues. Some of the relationships identified could be used to inform future welfare efforts by both THS and other local AWOs. Our data suggest that future initiatives could include development of satellite locations or mobile clinics, both to better serve families already using these services at some distance from the facility, and to reach less well-served populations. Education, particularly in schools, could be targeted to communities with lower adoption numbers. Additionally, a full assessment of marketing activities could be completed to ensure stakeholders who need the services most are aware they exist and know how to access them. Marketing strategies and methods may need to change in order to reach those who are not currently being reached.

One of the primary limitations of this study was the confounding factor of distance from THS. This effect can be summarized by Tobler's first law of geography, that "everything is related to everything else, but near things are more related than distant things" (24). This is commonly conceptualized in relation to the friction of distance theory (the idea that moving across space requires the expenditure of energy) (25) and distance decay theory (the idea that interactions between two positions decrease as distance increases) (18). Individuals living further from THS are less likely to utilize its services, particularly if there is another accessible AWO nearby, and therefore may appear to reflect a population under-served by THS that may not truly be under-served. This is supported by the fact that that many of the cold spots identified in this analysis overlap with the location of other AWOs that are geographically closer (**Figure 1**). However, the extent of the hot spots, particularly for the PVS client stakeholder group, suggests that THS is successfully serving a substantial

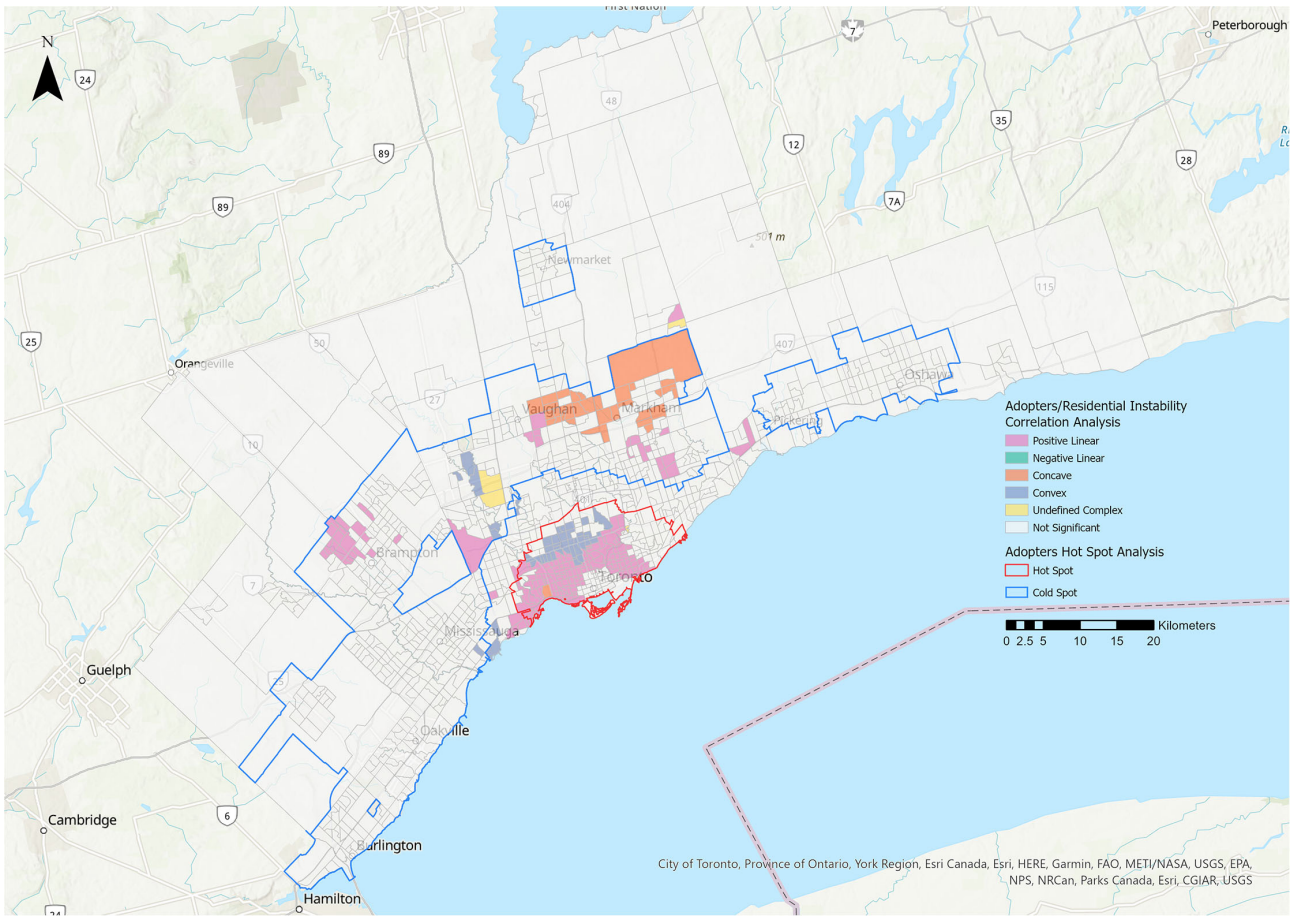


FIGURE 6 | Correlation analysis for the adopters stakeholder group and the residential instability metric of the 2016 Ontario Marginalization Index. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

geographic area, with no under-served areas identified within a 10 km radius of the facility.

Another inherent limitation of this type of spatial analysis is the influence of the modifiable areal unit problem, which is the effect that the boundaries (census tracts) used to aggregate the stakeholder data points can have on the results of the research (26). The results of the analysis may have differed if the data had been aggregated to different spatial boundaries. However, testing was also performed with smaller boundary sizes (dissemination areas) and little variation was noted between the two sets of results.

For certain stakeholder groups, removal of duplicates resulted in a substantial decrease in sample size. This was largely due the removal of instances of a single stakeholder appearing multiple times within the same year - for example, an individual surrendering multiple animals during the same year. Had these duplicates not been removed, stakeholder counts in certain CTs would have been artificially inflated. Further data cleaning, to remove stakeholders outside the GTA and those with incomplete addresses, had a much smaller effect on sample sizes, with 0.1% of the volunteer stakeholder group, 4.3% each of the adopter and foster groups, 7.9% of the PVS group and 13.6% of the surrender group being unavailable for geocoding. This was well within the recommendation of ≥80% "clean" data for GIS datasets in the animal welfare context[6].

This study found that increasing rates of residential instability were associated with higher rates of adopters (**Figure 6**). One possible reason for this is that many THS adopters may be families living in rental homes (a factor included in the metric). While existing U.S. research suggests that certain housing factors such as renting correlate with lower pet ownership rates, this is most frequently due to landlord refusal to allow pets (27). Laws prohibiting Ontario landlords from banning pets (28) could contribute to the relationship identified in our study. In addition,

[6]ASPCA. Targeting Risk: Preparing to Use GIS to Save More Lives. Available online at: https://www.aspcapro.org/sites/default/files/gis_targeting_risk_webinar_slides.pdf

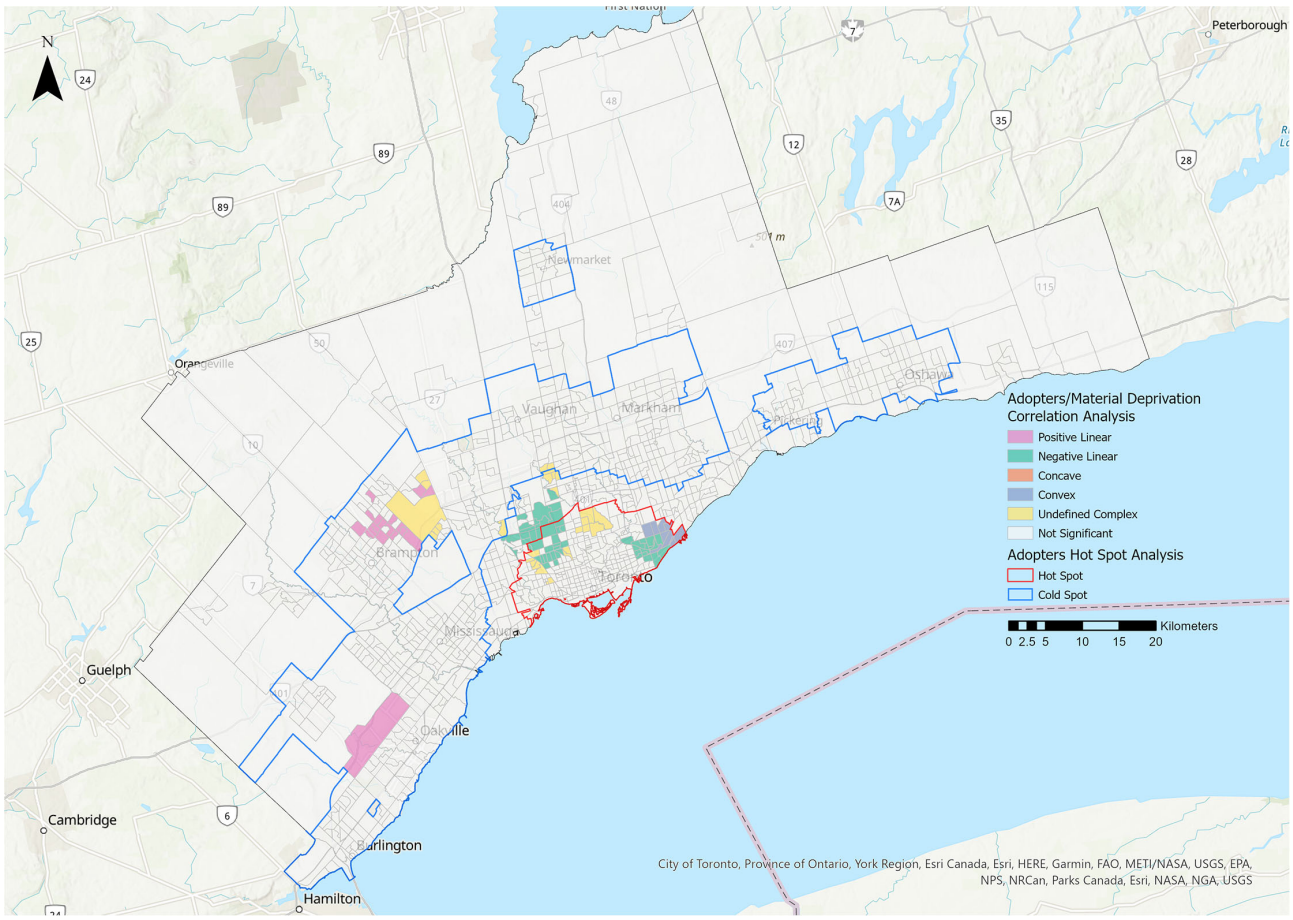


FIGURE 7 | Correlation analysis for the adopters stakeholder group and the material deprivation metric of the 2016 Ontario Marginalization Index. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

the facility's shift to an Adopters Welcome framework[7], some years ago, appears to have successfully decreased barriers to adoption. Further, the residential instability metric considers a greater number of children and total number of individuals living in the home to increase instability. While this may increase the residential instability metric, a greater number of children and total number of individuals living in the home generally correlates with an increase in pet ownership (29).

There was a predominantly negative linear relationship between ethnic concentration and adoption rates in central Toronto (**Table 3**, **Figure 8**). A convex relationship was also quite prominent, suggesting that while adopter rates largely decreased as ethnic concentration increased, in certain areas adopter rates then began to increase as ethnic concentration reached its highest levels. The ethnic concentration metric reflects both the proportion of residents who are recent immigrants and those who identify as part of a racialized community. A high percentage of GTA residents identify as racialized people or immigrants (51.4 and 46.1%, respectively) (15). One possible explanation for the relationship identified in the study may be cultural differences in pet ownership. Among 60 global societies, dogs were recognized as non-working companions or pets in only 22 and cats in 11 (30). Instead, animals have primarily working tasks such as hunting or vermin control (30). Alternative or parallel explanations might be lack of information, implicit bias during the adoption process, language barriers and financial considerations. A clearer understanding of the relevant factors would inform future efforts to address this service gap. Programs aimed at immigrant families could stress the benefits of pet ownership for reduction of stress for children (31), reduced feelings of loneliness and social isolation (32), increased socialization through community engagement (33), and as mental health supports (34).

In 4.08% of CTs, a higher material deprivation score was associated with a decrease in adopter rates (**Figure 7**). This was

[7]Humane Society of the United States. Adopters Welcome: Finding, Engaging and Supporting More Adopters. Available online at: https://humanepro.org/page/adopters-welcome-manual

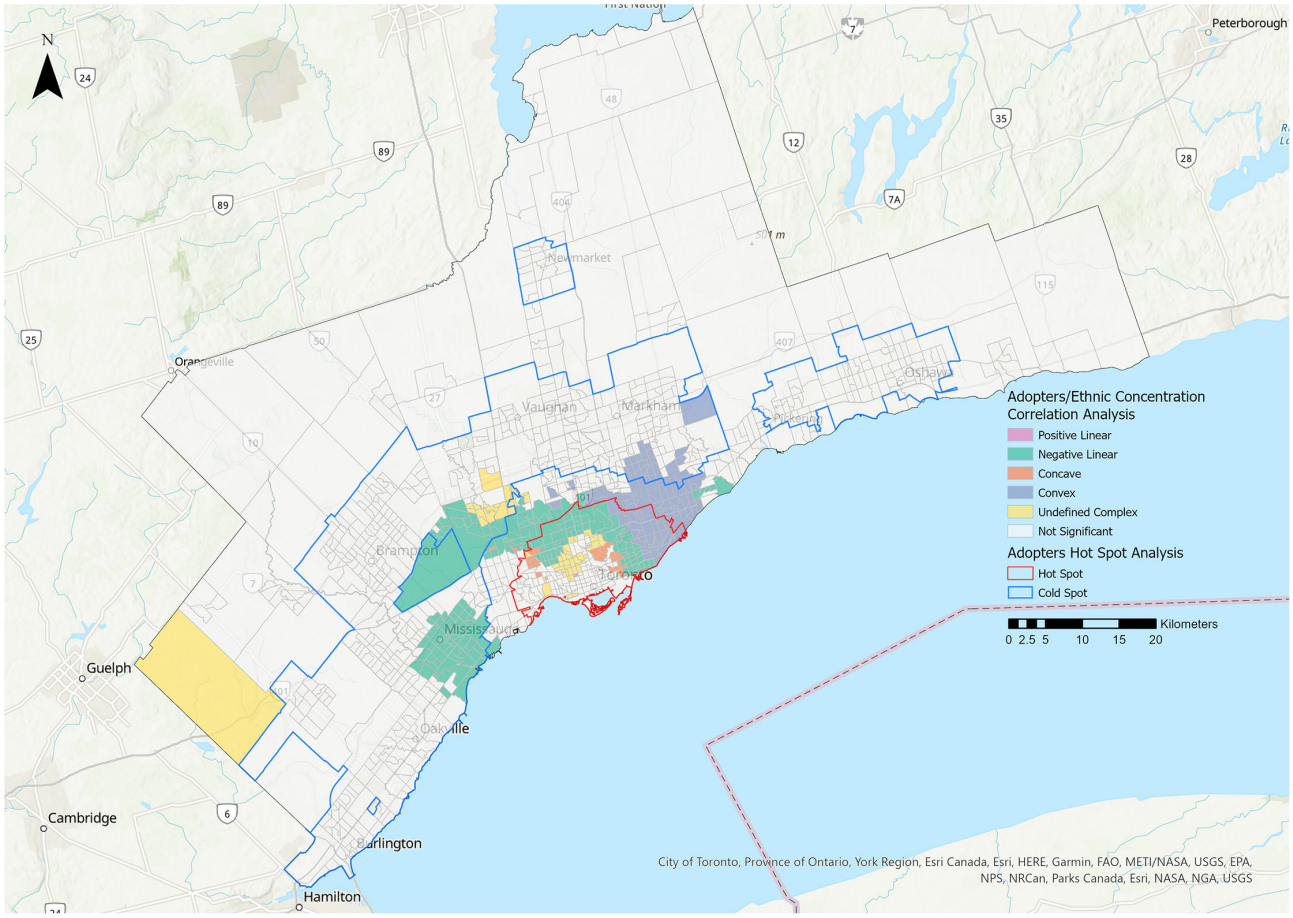


FIGURE 8 | Correlation analysis for the adopters stakeholder group and the ethnic concentration metric of the 2016 Ontario Marginalization Index. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

consistent with previous findings that higher income levels are correlated with higher pet ownership rates (35, 36). Adoption from AWOs may also be affected by factors such as physical and financial access, and perception by stakeholders. In one study, residents earning less than $20,000 per year were significantly more likely than higher income level groups to have acquired their pet from a family member or someone they knew, rather than from an AWO (37).

A legitimate concern for AWOs is the inadvertent transfer of animals from families facing material deprivation, through surrender, to higher income families, through adoption. Our analysis did not find any evidence of this. However, the largely positive linear relationship between surrenders and the proportion of Indigenous residents was noteworthy (**Figure 9**). This may be due to the fact that Indigenous people living in urban areas experience a higher rate of poverty (24%) than non-indigenous residents (13%) (15). Research has shown that, among low-income residents surrendering their pets in the U.S., costs (specifically those associated with veterinary care and food) were the most common reasons for surrendering an animal (38). In a 2017 Statistics Canada survey, 39% of Indigenous residents living in urban areas stated that they could not afford to pay an unexpected cost of $500 or more (39).

There were positive linear relationships between PVS clients and the residential instability, material deprivation and Indigenous metrics, with the largest effect for residential instability (39.95% of CTs) (**Figure 10**). The hot spot for PVS clients also extended further than other hot spots. These findings suggest that THS' public veterinary care programs are successfully reaching many families in need. Census tracts with a higher proportion of Indigenous residents were also associated with an increase in PVS use (**Figure 11**). This relationship may be explained by subsidized preventative wellness and spay/neuter services that are offered to residents with a Certificate of Indigenous Status and suggests that this approach is successful in making veterinary care more accessible to Indigenous individuals living within the GTA.

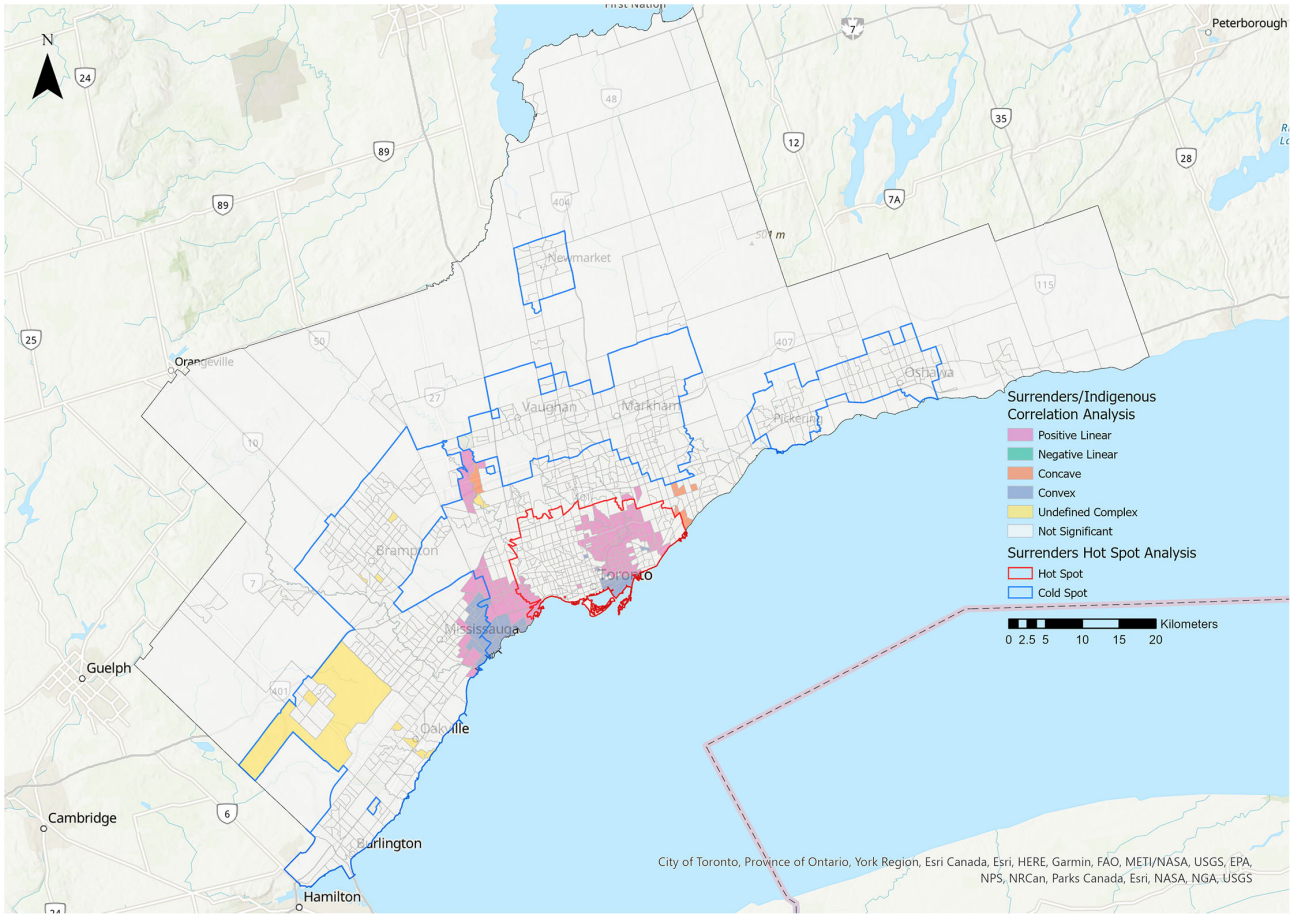


FIGURE 9 | Correlation analysis for the surrenders stakeholder group and the rate of Indigenous residents metric. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

Notably, there were no correlations between PVS clients and ethnic concentration. This could in part be due to the lower rate of adopters associated with the ethnic concentration metric. Our findings were also in agreement with U.S. findings that race and ethnicity were not the primary determinants of veterinary care use in under-served communities (40). The authors hypothesized that structural barriers such as accessibility, transportation, and cost, rather than cultural barriers, could be more important drivers of lower access to veterinary care. However, U.S. surveys have also shown that race and ethnicity do have an effect on national pet ownership levels (41). A greater focus on culturally competent practices, targeted messaging and an understanding of accessibility barriers could allow AWOs to reach a greater proportion of families in need.

Analysis of the volunteers stakeholder group yielded very small negative linear and convex relationships with the ethnic concentration metric (see **Table 3**). The foster parents stakeholder group did not produce any significant relationships with any of the tested metrics. Little data is available regarding the characteristics of animal shelter volunteers or foster parents. A recent study of animal shelter volunteers in Michigan, US, found that most were white (68%), female (83%), had at least some post-secondary education (90%) and were employed full-time or retired (58%) (42). In contrast to the relatively homogenous pattern in that study, our data suggest that THS volunteers and foster parent groups were more representative of the broader community. The volunteers and foster parents stakeholder groups were substantially smaller than the other three groups, and this may also account for the lack of identified relationships. Volunteering for AWOs provides rewarding and meaningful engagement opportunities (42), and recruitment efforts should not be limited by assumptions about which segments of the community might be most interested or available. As most volunteers are recruited directly by the organization or through personal contacts (43), marginalized communities or groups should be actively approached.

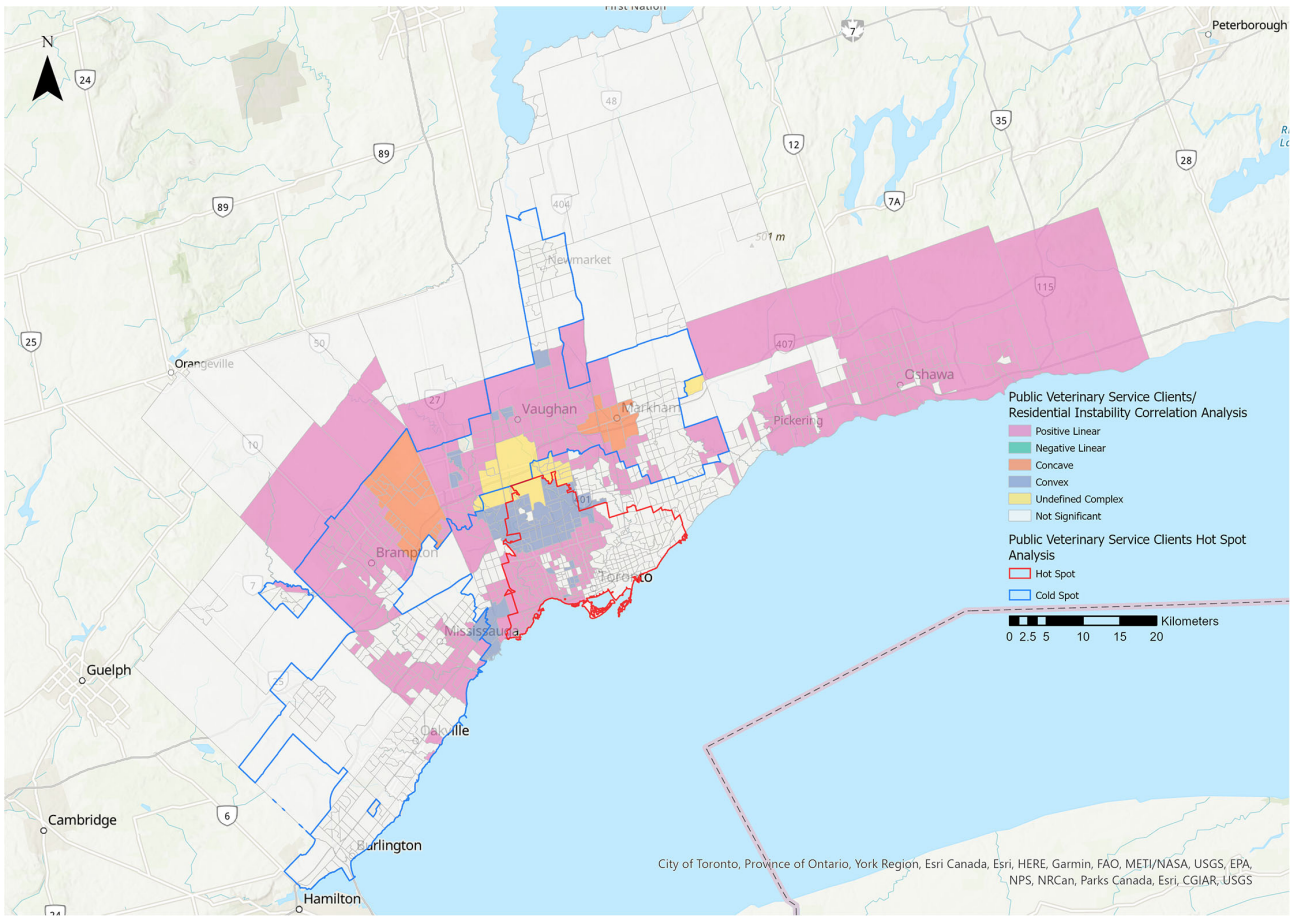


FIGURE 10 | Correlation analysis for the public veterinary service clients stakeholder group and the residential instability metric of the 2016 Ontario Marginalization Index. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

This research into the spatial distribution of THS stakeholder groups identified many areas that are well served, as well as areas that are currently under-served. Correlation analysis identified many statistically significant relationships between the spatial distribution of stakeholder groups and the On-Marg Index and Indigenous metrics, such as a decrease in adopters as the ethnic concentration metric increased, and an increase in surrenders as the Indigenous metric increased. It should be noted that the relationships identified between the stakeholder groups and the five tested socioeconomic metrics do not necessarily indicate a causal relationship. Other confounding factors, such as variations in pet ownership with population density, may also influence stakeholder distributions.

Studies of this nature can allow AWOs to make informed decisions regarding their stakeholders, that take into account factors such as race, ethnicity, and socioeconomic status. Ultimately, this will promote a more equitable and inclusive environment for AWOs to better serve their communities and actively address systemic barriers to access.

Future research could analyze the geographic area closest to THS in more detail, as well as GTA neighborhoods designated as high priority due to socioeconomic factors. Analysis of stakeholder data from multiple AWOs within the GTA would also help gain a better understanding of the spatial distribution of stakeholders in the GTA as a whole. This could identify areas not being adequately served by any AWO.

Given its relative simplicity, the spatial analysis performed in this study could be replicated by geospatial data analysts from other AWOs hoping to evaluate the reach and inclusiveness of their services. Organizations increasingly collect large amounts of electronic data, which lends itself to novel forms of analysis. Animal welfare organizations should consider adding data analytics skills to their staff or volunteer bases. This would allow organizations to better understand metrics that currently are not commonly utilized in this sector.

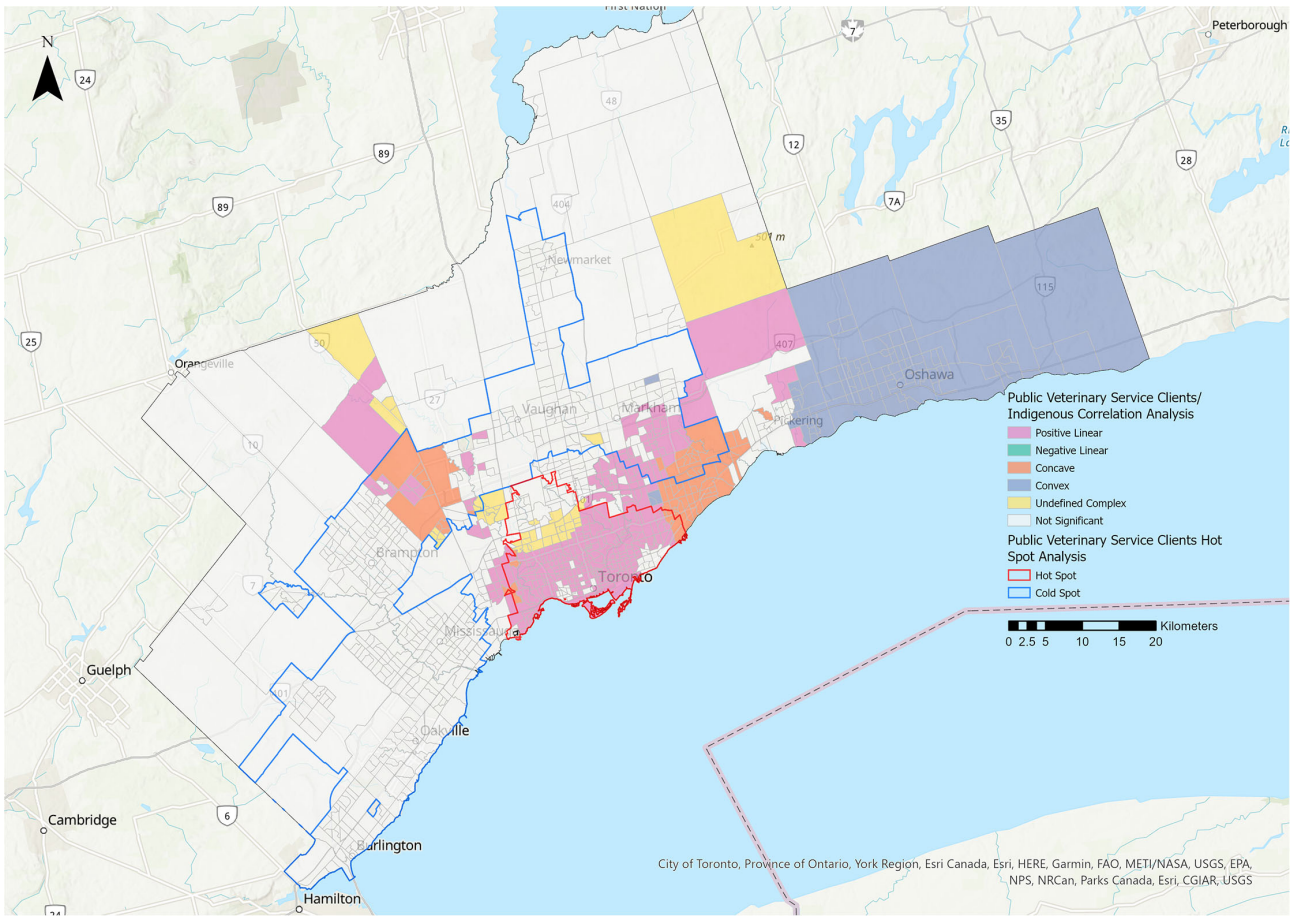


FIGURE 11 | Correlation analysis for the public veterinary service clients stakeholder group and the Indigenous residents metric. Pink represents positive linear relationships, green represents negative linear relationships, orange represents concave relationships, blue represents convex relationships, and yellow represents undefined complex relationships.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the raw dataset contains identifying information for animals and stakeholders. Requests to access the datasets should be directed to tbuckingham@torontohumanesociety.com.

AUTHOR CONTRIBUTIONS

All authors have made a substantial, direct, and intellectual contribution to the work and approved the final version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2021.785071/full#supplementary-material

Supplementary Figure 1 | Map showing the number of stakeholders per census tract for the adopters stakeholder group.

Supplementary Figure 2 | Map showing the number of stakeholders per census tract for the surrenders stakeholder group.

Supplementary Figure 3 | Map showing the number of stakeholders per census tract for the public veterinary service clients stakeholder group.

Supplementary Figure 4 | Map showing the number of stakeholders per census tract for the volunteers stakeholder group.

Supplementary Figure 5 | Map showing the number of stakeholders per census tract for the foster parents stakeholder group.

Supplementary Figure 6 | Map showing the normalized (number of stakeholders per 1,000 people residing in each census tract) data for the adopters stakeholder group.

Supplementary Figure 7 | Map showing the normalized (number of stakeholders per 1,000 people residing in each census tract) data for the surrenders stakeholder group.

Supplementary Figure 8 | Map showing the normalized (number of stakeholders per 1,000 people residing in each census tract) data for the public veterinary service clients stakeholder group.

Supplementary Figure 9 | Map showing the normalized (number of stakeholders per 1,000 people residing in each census tract) data for the volunteers stakeholder group.

Supplementary Figure 10 | Map showing the normalized (number of stakeholders per 1,000 people residing in each census tract) data for the foster parents stakeholder group.

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"State of the Mewnion": Practices of Feral Cat Care and Advocacy Organizations in the United States

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Over the last several decades, feral cats have moved from the fringes to the mainstream in animal welfare and sheltering. Although many best practice guidelines have been published by national non-profits and veterinary bodies, little is known about how groups "in the trenches" actually operate. Our study sought to address that gap through an online survey of feral cat care and advocacy organizations based in the United States. Advertised as "The State of the Mewnion," its topics included a range of issues spanning non-profit administration, public health, caretaking and trapping, adoptions of friendly kittens and cats, veterinary medical procedures and policies, data collection and program efficacy metrics, research engagement and interest, and relationships with wildlife advocates and animal control agencies. Respondents from 567 organizations participated, making this the largest and most comprehensive study on this topic to date. Respondents came primarily from grassroots organizations. A majority reported no paid employees (74.6%), served 499 or fewer feral cats per year (75.0%), engaged between 1 and 9 active volunteers (54.9%), and did not operate a brick and mortar facility (63.7%). Some of our findings demonstrate a shared community of practice, including the common use of a minimum weight of 2.0 pounds for spay/neuter eligibility, left side ear tip removals to indicate sterilization, recovery holding times after surgery commonly reported as 1 night for male cats and 1 or 2 nights for females, requiring or recommending to adopters of socialized kittens/cats that they be kept indoor-only, and less than a quarter still engaging in routine testing of cats for FIV and FeLV. Our survey also reveals areas for improvement, such as most organizations lacking a declared goal with a measurable value and a time frame, only sometimes scanning cats for microchips, and about a third not using a standardized injection site for vaccines. This study paints the clearest picture yet available of what constitutes the standard practices of organizations serving feral and community cats in the United States.

Keywords: free-roaming cat, feral cat, community cat, spay/neuter, trap neuter return, shelter neuter return, return to field, TNR

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INTRODUCTION

Animal shelters across the United States have adopted many intake diversion strategies to decrease the number of relinquished animals, maintain the human-animal bond at all socioeconomic levels, improve life-saving metrics, decrease euthanasia, and to meet community goals. There is a growing body of evidence that feral and community cat advocacy, long term colony management, and trap neuter return (TNR) and shelter-based return-to-field (RTF) programs are effective in keeping cats out of shelter systems, thus reducing feline euthanasia and improving the quality of life for both individual cats and colonies. As an example, a shelter in Albuquerque, New Mexico, started a combined TNR and RTF program that served a total of 11,746 cats over 3 years. During that time, the Albuquerque Animal Welfare Department saw an 84.1% decrease in feline euthanasia and a 37.6% decrease in feline intake (1). Similarly, when a shelter in Jefferson County, Kentucky initiated a RTF program in addition to an existing TNR program, feline euthanasia at the Louisville Metro Animal Services dropped by 94.1% over 8 years (2). This suggests that feral and stray cats may have represented the majority of feline euthanasia performed in these facilities prior to implementing these strategies. A greater understanding of the practices of organizations serving feral cats will help the animal welfare sector standardize and professionalize the care they provide to feral cats. This should lead to further real-world successes and progression of the field.

In addition to concerns around improving animal welfare, there are important One Health aspects of the phenomenon of people interacting with feral cat populations. Cats pose a risk to humans by serving as reservoirs for zoonotic diseases that could be transmitted to individuals who handle or shelter them, as well as act as agents of injury, from minor scratches to bites and more serious infections. Conversely, because of their ongoing exposure to local environments, cats can also serve as valuable sentinels for hazards in the environment that could harm humans. For example, when a large episode of mercury poisoning occurred in communities living near Minamata Bay in Japan in the 1950s, local cats were the first ones to show symptoms because they had greater exposure to contaminated fish and accumulated a toxic level of mercury faster than humans (3). Similarly, cats are studied as sentinels for lead (4), flame retardants (5), chlorinated pollutants (6), and infections such as avian influenza (7). A feral cat presenting as having been poisoned may indicate a risk to people in the area who could also make contact with the substance.

While there has been a growing emphasis in the past decade for animal shelters and rescues to engage in better statistics tracking (8–11), in part at the behest of major funders, these efforts are less well developed among organizations that are not focused on adoptions. Traditionally, groups engaged in TNR programs track the number of surgeries performed, caretaker reports of cats known to frequent certain colonies, and publicly-available data on animal shelter intake and euthanasia. Other types of data and metrics that could be useful for program planning, refinement, and impact assessment, such as the sterilization percentage and density of feral cat populations, tend to be collected and reported much less often.

Quantifying the growth and the impact of the feral cat welfare field without more and standardized data collection practices is a challenge. No previously-published research has sought to study its full extent in the United States, despite some formal documentation of projects dating to the early 1990s (12, 13). In total, 1 metric for charting the popularity of this movement is the financial support it has garnered from the public and grantmaking institutions. This however is complicated by the fact that most organizations that undertake feral cat work also engage in other animal welfare activities. Alley Cat Allies is an exception in that it focuses only on feral cat issues at a national level. In examining their total revenue as reported across the 19 available years of tax returns cataloged online by ProPublica (14), and adjusting these amounts for inflation to August 2021 (15), there has been a clear upward trend. From taking in approximately $3,079,005 USD in fiscal year 2001 (adjusted from $1,988,764 USD) to approximately $11,609,361 USD in fiscal year 2019 (adjusted from $10,905,204 USD), Alley Cat Allies has experienced sizable and steady growth within this century, suggesting that concern and interest in feral cat welfare may be on the rise.

While retrospectively analyzing historical trends isn't always possible, there is always a need for more endeavors aimed at cataloging the field and following its continued refinement moving forward. To address the lack of comprehensive, national scale information about what constitutes a typical community of practice, we conducted an online survey of feral cat care and advocacy organizations based in the United States.

MATERIALS AND METHODS

Advertised as "The State of the Mewnion," our online survey ran from January to March 2018 using the SurveyMonkey.com platform. We cast an inclusive net, asking for participation from organizations of all sizes that self-identified as involved in any aspect of feral cat care and advocacy, without restricting respondents to entities that only worked with such cats. The language we used for participants was "feral and community cats," but we did not further define those terms. We allowed respondents to use their own judgement of what constitutes a feral or community cat, which may vary slightly among participants. A file containing questions and answer choice options appears in this article's (**Supplementary Materials**). All questions after the organization demographics section were optional. Most consisted of a set of multiple choice answers, sometimes with the ability to select more than 1 option, and some with the ability to enter a write-in response. Questionnaire topics included non-profit administration and policy, public health, cat caretaking and trapping, adoptions of friendly kittens and cats, veterinary medical procedures and policies, data collection and program efficacy metrics, research engagement and interest, and relationships with wildlife advocates and animal control agencies. Our survey and study protocol were reviewed by the University of Washington's Human Subjects Division as STUDY00004003.

We promoted the survey in Facebook Groups dedicated to feral and community cats, cat rescue, or TNR, invited participation from feline, shelter medicine, and feral cat student clubs at veterinary schools, emailed cat-focused organizations listed on Petfinder's rescue database and the Humane Society of the United States' list of community cat organizations, contacted groups found by searching Google for terms such as "feral cats," "stray cats," and "TNR," and used our personal contact lists. During this process, we also noticed individuals who were not part of the study team sharing the survey on Facebook, increasing our reach organically within these niche communities through social media-based snowball sampling (16). While we attempted to remove duplicate email addresses and avoid reaching out to any group multiple times, it is unknown how many of our contact attempts could have been duplicates or made to an organization which has ceased to operate or did not work with feral cats. Determining a response rate would not be possible.

In addition to gathering descriptive data with the intention of repeating our survey to track sector-wide trends over time, we also sought to explore whether there were organization demographic factors influencing their adherence to popular best practice guidelines produced by major animal welfare and veterinary entities. In the survey, we asked respondents to select which guidelines they used so that we could compare the advice from the 5 most popular answers cited across all organizations. This allowed us to quantitatively define what constitutes popular guidelines rather than using our own judgement, and to test how well respondents are incorporating the advice within. We assumed the recommendations in these guidelines would form a community of practice standard for feral cats, although not necessarily an objectively "correct" standard for all contexts. For example, in private veterinary offices, routine radio-frequency identification microchipping is arguably a best practice. However, in the context of seeking to provide high volume care focused on population reduction and achieving the best outcomes for the greatest number of unowned cats, microchipping is not a priority.

We solicited write-in answers for some items, which we then categorized into groups for reporting results. In total, 1 author tallied responses to the questions asking organizations to list their news/informational resources and TNR/medical best practice resources. For other write-in questions, 2 or 3 authors discussed and reached agreement about how they should be categorized.

To test for associations between best practice adherence and demographics of respondent organizations, we used generalized linear models (GLMs) modeled under a binomial distribution. For our response variables, a respondent's best practice adherence was defined as the number of answers aligned with best practice recommendations (from 0–12) out of a total number completed by the respondent (from 0–12). For our predictor variables, we looked at the following organization-level demographic factors: the Census Region of the United States where an organization is based, the geographic scope covered by the organization, if the organization served urban, suburban, and/or rural areas, the approximate proportion of animals served that were feral cats, whether the organization had its own 501(c)3 United States federal non-profit charity status, whether the organization had a brick-and-mortar facility, the approximate number of feral cats that a respondent served per year, the number of paid employees, and the number of active volunteers. We began with a GLM containing all 11 organization demographic predictors and used the step() function found in R for automated bi-directional model selection based on their Akaike information criterion (AIC). We used the default cut-off criteria for model selection with the step() function, $k = 2$ or approximately $p = 0.157$.

We performed statistical analysis and created graphics using R (17) with R Studio (18) and the packages plyr (19), plotrix (20), dplyr (21), ggplot2 (22), tidyverse (23), maps (24), alberusa (25), ggthemes (26), and pathwork (27).

RESULTS

Demographics and Basics

XOur survey received responses from 567 organizations. Our data represented every state except for Alaska, Vermont, and Wyoming, with the populous states of California, Florida, Texas, and New York drawing commensurately high levels of participation (see **Figure 1**). We used the phrasing "feral/community cats" in our survey questions, but report simply "feral cats" here for brevity.

Respondents came primarily from grassroots organizations, as shown from answers to the required demographic questions ($n = 567$). A majority employed no paid employees (74.6%), reported serving 499 or fewer feral cats per year (75.0%), had between 1 and 9 active volunteers (54.9%), and did not operate a brick and mortar facility (63.7%), although 73.7% did have their own 501(c) federally-recognized non-profit status. In terms of the geographic scope of their activities, 12.0% operated at the level of a neighborhood or development, 72.7% at the level of a city or town, 10.0% statewide, 4.9% multi-state, and 0.4% at a national level. Regarding human density, 68.1% served urban areas, 77.2% served suburban areas, and 70.7% served rural areas (not mutually exclusive). Most of these organizations were not feral cat exclusive, with 44.4% of respondents estimating that three-quarters or more of animals they serve were feral cats, 16.6% estimating between 1 half and three-quarters feral cats, 20.6% reporting one-quarter to 1 half feral cats, and 18.3% reporting 1 quarter or fewer feral cats. In total, 4 respondent groups (0.7%) identified as being projects/clubs operated by veterinary students.

Respondent organizations filled a wide variety of roles across a spectrum from hands-on to policy work ($n = 567$). Among the most popularly-reported primary functions, of which an organization could choose multiple, 53.6% were engaged with the direct feeding and colony care for feral cats, 38.6% socialized/fostered kittens from feral cats for adoption, 31.7% offered low-cost sterilization/vaccination/basic medical care for feral cats, 28.2% offered free sterilization/vaccination/basic medical care for feral cats, and 30.2% coordinated volunteers who are trapping feral cats for TNR. Less common primary functions included 11.6% of organizations reporting that they campaigned for law and policy changes around feral cats, 8.5% operated their own clinic focused on feral cat care, 6.5% engaged in organization-level training and mentorship to other feral cat groups, 4.6% provided disaster relief for feral cats as needed,

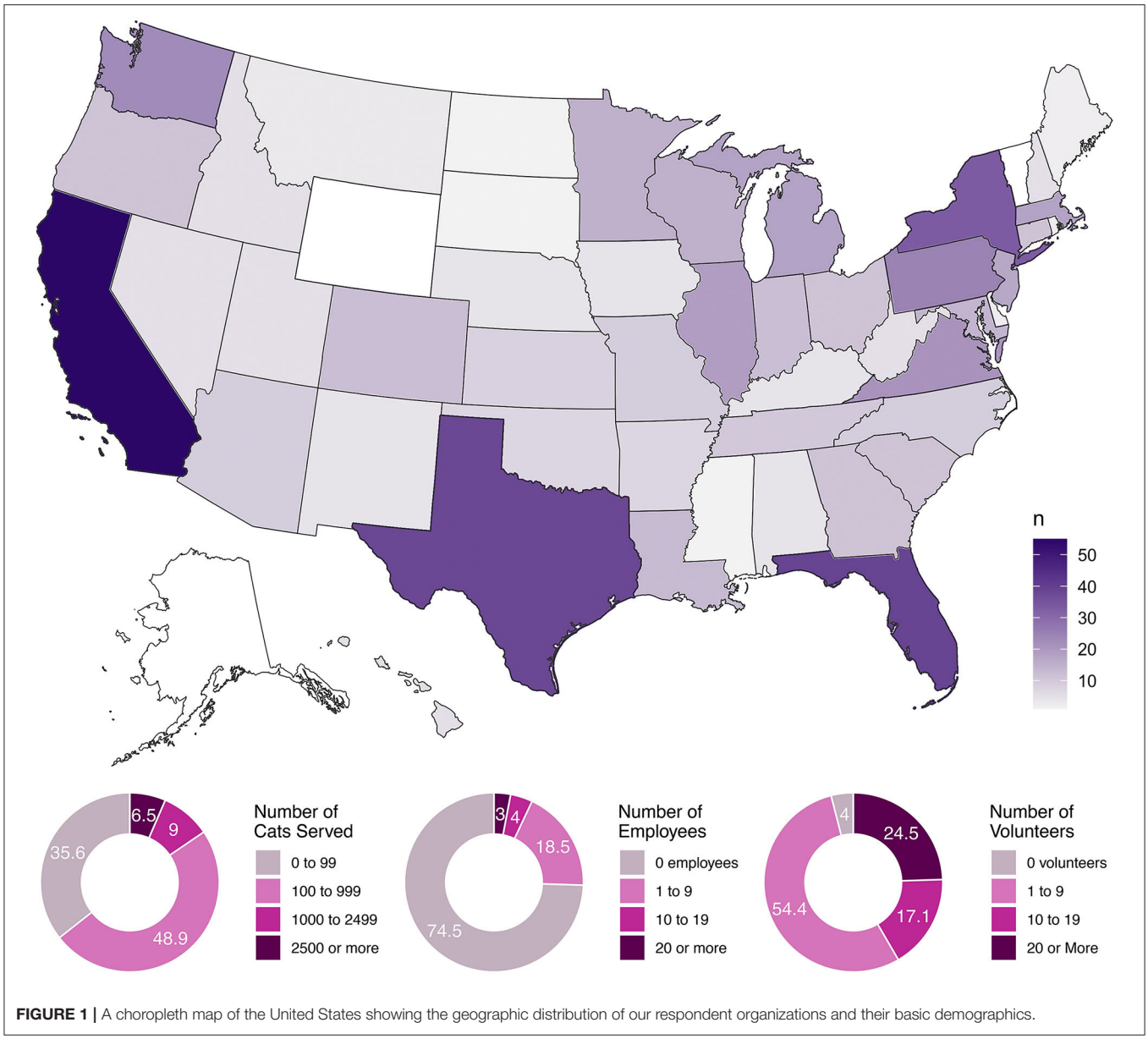

FIGURE 1 | A choropleth map of the United States showing the geographic distribution of our respondent organizations and their basic demographics.

and 2.6% provided grants and funding organizations doing feral cat work.

When asked if TNR is explicitly allowed or endorsed by local laws and animal control ordinances where they operate, 46.5% of respondents answered yes, 17.8% answered no, 9.9% were unsure, and 25.9% reported that it varies based on the areas in which they work ($n = 566$). For organizations operating where TNR is not explicitly legal, we asked whether there are local laws that could be used, or are actively enforced, to prohibit or limit feral cat care, feeding, or TNR. Of the laws reported to be actively enforced, in descending order or popularity, respondents noted mandatory stray holding periods (171), animal control of nuisance animals (116), pet limits (103), pet licensing laws (73), laws defining outdoor cat feeders as the cat's owner (63), abandonment laws (57), laws against feeding (43), mandatory spay/neuter requirements (33), leash laws which include cats (26), microchipping requirements (20), colony registration requirements (16), and laws restricting veterinarians' abilities to provide free/low-cost services (7). Despite these potential challenges, only a minority of organizations had consulted with an attorney regarding legal problems that could arise from their work. Just 8.2% of respondents were working with an attorney on an ongoing basis, 24.5% having done so in the past, 6.1% were unsure, and 61.1% had not ($n = 558$).

When describing the relationship between feral cat advocates and animal control authorities in their area, 3.9% felt that public/overt conflict was occurring, 11.0% reported some tension between groups, 16.9% neutral or no interactions, 17.4% some efforts being made toward bridge-building, 32.9% active collaboration and working toward shared goals, 15.6% that

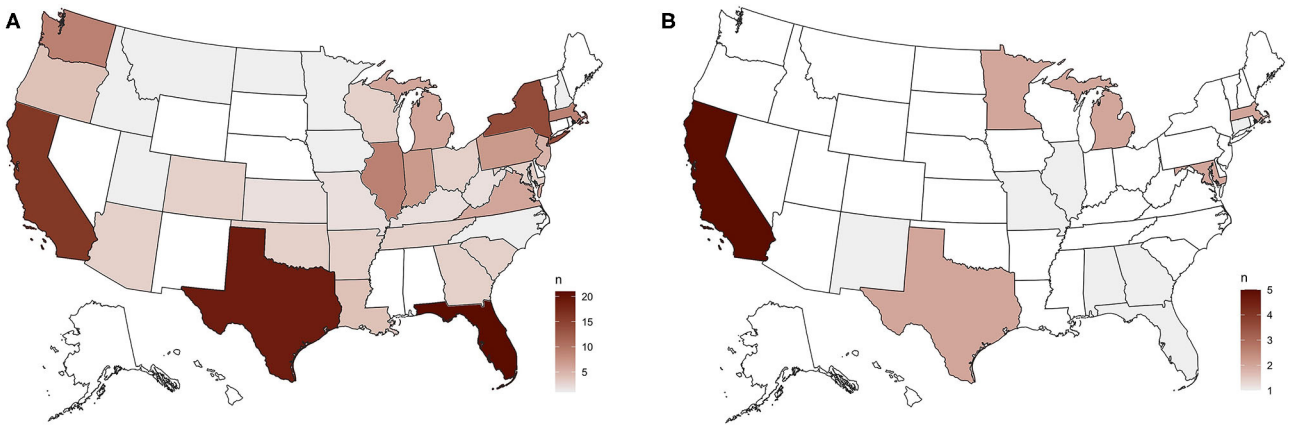

FIGURE 2 | (A) Organizations reporting that feral cat advocates and animal control authorities involved in active collaboration were distributed similarly to our overall sample. **(B)** Organizations reporting public/overt conflict between feral cat advocates and animal control authorities, with the greatest number from California.

they serve many locations and each was different, and 2.3% of respondent groups were themselves the animal control authorities for their area ($n = 563$) (see **Figure 2**).

In cases where feral cats were only one part of their work, we asked organizations to select reasons they didn't serve more feral cats. The most commonly-selected options were that they would do more with feral cats if they had specific grants/funding (330), they are a comprehensive animal program that fulfilled many roles (197), they didn't have the proper facilities or equipment (182), there was an alternative for feral cat care in their area (53), their staff didn't have the proper training (31), concern about possible injuries to staff and volunteers (15), and that the organization had a policy that prevents (more) care of feral cats (7). Out of the write-in answers to this question, other common themes emerged, with explanations grouped into respondents expressing a need for volunteers (74), a need for personnel/staff (32), a need for spay/neuter services (26), being a small or rural group (24), a need for trappers and places to trap (23), a need for transportation (8), a need for foster homes (8), and limits of partner organizations (8).

In asking respondents a write-in question about which resources (books, websites, blogs, Facebook groups, etc.) they regularly use and trust for updates, information, and news about feral cat issues, the most commonly-cited sources were Alley Cat Allies (223), Best Friends Animal Society (56), Neighborhood Cats (46), the Humane Society of the United States (44), the American Society for the Prevention of Cruelty to Animals (33), Community Cats Podcast (21), Maddies Fund (17), Peter Wolf or his Vox Felina blog (10), and the Million Cat Challenge (9). About a third (37.1%) of organization reported having a locally-focused online discussion group or email list where feral cat advocates can ask questions, share resources, seek assistance, and support 1 another ($n = 566$).

We asked organizations whether they currently had at least 1 declared goal that includes both a measurable value and a timeframe such as "reduce the outdoor cat population of our town 25% by 2025" or "provide 1,000 free spay/neuter surgeries every year." About 1 third (32.1%) reported that they do, while 67.9% did not ($n = 563$).

Environmental, Human, and Public Health

When asked if they were seeing health issues in feral cats suspected of being caused by exposures to toxins or environmental contaminants, 13.8% respondents reported yes, 59.0% of reported no, and 27.2% reported that it was unknown ($n = 544$). In categorizing write-in explanations, the common trends for those reporting a concern were chemical or toxic exposures (51), infectious diseases (10), climate and weather related issues (5), reproductive issues and birth defects (4), suspected cancers and carcinogens (4), and firearms (3).

Some respondents suspected observing health issues in feral cats caused by environmental exposures, with the intentional poisoning of cats as the most commonly-mentioned problem. Write-in suspected toxicants and sources of concern included antifreeze, rodenticides, agricultural chemicals, and drinking polluted water. Illnesses mentioned by respondents as presumed to be associated with environmental exposures included infectious disease, cancers, birth defects, eye problems, kidney disease, skin issues, and plasma cell pododermatitis ("pillow pad"), some of which may be linked to environmental factors in cats (28–31). Other responses included cats as victims of hazards in their environment including firearms, flooding, mold, and hurricanes.

The physical and mental health of human participants is another component of feral cat projects. We inquired if organizations maintained insurance for staff and volunteers to cover medical care for injuries sustained during work with feral cats, and only 33.6% responded yes ($n = 542$). When asked if they have a formal process for staff or volunteers who receive bites or other injuries from feral cats, 40.0% groups responded in the affirmative ($n = 543$). We also asked if they provided staff and/or volunteers with mental health care resources, such as information on compassion fatigue, support groups for animal welfare workers, suicide and crisis hotlines, or referrals to mental health providers, and 12.9% reported that they do ($n = 543$).

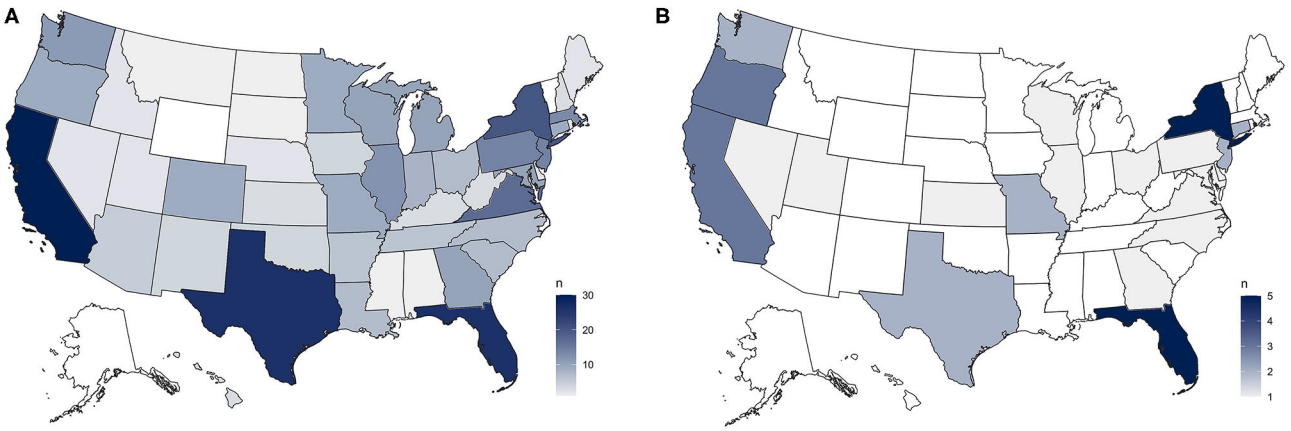

FIGURE 3 | (A) In asking organizations how they decided where to trap cats for sterilization, our most common answer was via requests from colony caretakers, which followed a distribution similar to our overall sample. **(B)** Our least common trapping motivation, areas where cats were suspected to pose a risk to birds, was selected the most by organizations from New York and Florida.

Caretaking, Trapping, and Release

Caretaking of feral cats can be done with varying levels of formality and record-keeping. When asked whether colonies or colony caretakers in their service area required by law to be registered in some way, most organizations reported that they are not (76.9%), some were unsure (14.0%), and some reported yes (9.2%) ($n = 523$). Regardless of whether registration is required by law, we asked organizations approximately what proportion of colonies or colony caretakers in their service area did they estimate were actually registered. The vast majority estimated one-quarter or less (86.9%), with 6.7% estimating one-quarter to half, 1.7% estimating half to three-quarters, and 4.8% estimating three-quarters or more ($n = 480$). For those organizations that do register colonies or caretakers, a majority reported that they don't know where that information was stored (57.4%). Of those aware of where the information was stored, 28.8% reported it was with a private non-profit or individual, 6.9% with a government office, and 6.9% stored with both government and private entities ($n = 378$). We asked organizations to select their reasons if they do not always register colonies or caretakers. The most commonly-chosen options, of which they could select multiple, were that they lacked the time or personnel to maintain a registry (157), didn't see a reason to register colonies/caretakers (145), lacked the tools or technical resources to maintain a registry (87), some caretakers had refused (81), they believed caretakers might be resistant (78), feeding/TNR is illegal in their area (52), they were intending on implementing a registry (or better registry) soon (26), and they were advised by an attorney to not document colonies/caretakers (11). Out of write-in answers to this question, we grouped explanations into respondents expressing that they do not register colonies or caretakers because the group has their own records (35), registration is not required (32), fear of how the data could be used (29), noting that there was no way to register (9), and that another entity has a registry (6).

For groups trapping feral cats for sterilization, we asked how they decided where to trap, rating a list of options as higher priority, lower priority, or not a factor. The most commonly-selected high priority reasons were requests from colony caretakers (371), trapping in 1 area or colony until all cats were caught and sterilized (364), complaints from the public about the number of cats in a location (335), trapping for TNR and relocation to protect cats at risk of harm (264), providing TNR services to low-income neighborhoods (238), concentrating efforts in smaller areas to get high sterilization coverage of some areas (188), locations from which many cats were entering the shelter/animal control system (188), locations that were safe for trappers to work (174), places located conveniently for trappers (such as near their homes) (151), based on funding/grants that specified where they provide services (136), evenly distributing efforts to provide some sterilizations to as many caretakers as possible (102), and areas where cats were suspected to pose a risk to birds and wildlife (40) (see **Figure 3**).

Finding homes for kittens was a primary (38.6%) or secondary function of many groups (42.2%) ($n = 567$). For kittens (born to feral cats) under 2 months of age, we asked organizations how commonly they remove them from the outdoors for fostering, socialization, and adoption. Almost half (48.4%) reported that they always do, 28.0% usually, 15.9% sometimes, 5.9% rarely, and 1.8% never ($n = 510$). For kittens (born to feral cats) between 2 and 3 months of age, we see an overall response that shifted away from removal from the outdoors, with 23.5% selecting always, 12.4 % usually, 31.0% sometimes, 29.8% rarely, and 3.3% never ($n = 510$). For organizations that facilitated adoptions of socialized feral cats (as pets, not working/barn cats), we asked if their adoption information had a position on whether these cats should be kept as indoor-only animals. Just over half (52.7%) required that adopted cats/kittens be indoor-only, 28.5% recommended that adopted cats/kittens be indoor-only, 1.2% recommended that adopted cats/kittens be allowed both indoors and outdoors, 9.8% had no position on where adopters keep their cats/kittens, and 7.7% chose "Other" ($n = 491$).

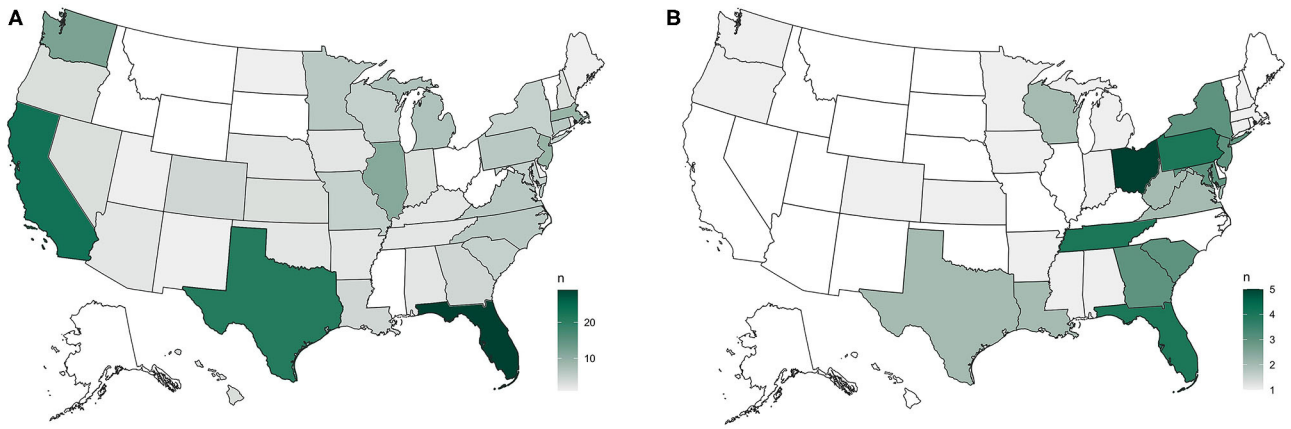

FIGURE 4 | (A) Just over half of our respondents reported always scanning cats for identification microchips during their TNR process, with a distribution similar to our sample as a whole. **(B)** There was a regional trend among organizations that reported never scanning cats for microchips, revealing this practice is largely an East Coast phenomenon.

After being trapped and sterilized, organizations tended to hold cats for different lengths of time based on sex. After a routine neuter with no complications, 6.7% released males on the same day as surgery, 73.9% held males overnight before release, 9.2% held males for 2 nights before release, 2.9% held males for 3 nights before release, and 7.3% selected "Other" ($n = 510$). After a routine spay with no complications, 2.7% released females on the same day as surgery, 47.9% held females overnight before release, 24.1% held females for 2 nights before release, 13.0% held females for 3 nights before release, and 12.3% selected "Other" ($n = 514$).

We asked organizations if they routinely recommended or used any supplements or alternative medicine products with feral cats, and if so, to select which type(s). Some organizations answered "no" to this question but selected 1 or more types. By re-coding some "no" responses so that organizations reporting use of specific modalities were tallied as a "yes," 57.0% of respondents did not routinely recommend or use alternative medicine, whereas 43.0% did ($n = 567$). Commonly-reported were probiotics such as FortiFlora (used by 17.1% of respondents), Feliway pheromone spray (14.5%), Rescue Remedy flower essence (9.2%), homeopathic products (6.7%), herbal products (4.2%), and glucosamine (3.2%).

Clinical and Medical Issues

Most of our respondent organizations were small projects, and as such, would likely not have a staff veterinarian. For organizations that trapped cats but did not operate a clinic, we asked approximately how far animals must be transported to reach their nearest provider of sterilization services for feral cats. About half (54.5%) were able to reach such a provider in under 30 min by car, 38.9% required 30–60 min, 4.7% required 60–90 min, and 1% apiece required 90–120 min and 2–4 h by car ($n = 404$). Regardless of whether or not they operated their own clinic, we also asked approximately how far away was the next-nearest provider of sterilization services for feral cats. These driving distances did not change greatly, as 46.4% were able to reach a second option in under 30 min, 41.5% required 30–60 min, 7.8% required 60–90 min, 2.8% required 90–120 min, and 1.5% required 2–4 h by car ($n = 463$).

Costs, as well as transportation time, is another issue for accessing veterinary care. For organizations that provided or facilitated sterilization and veterinary services, we asked whether their fees were different for cats reported as owned vs. cats reported as being feral cats, with 56.4% reporting yes and 43.6% reporting no ($n = 328$). For organizations that provided free or discounted services to low-income caretakers and trappers, we asked if they had a stated cut-off for what qualifies as "low-income". Over half (64.1%) did not, 11.6% did state a cut-off, and 24.3% decided on a case-by-case basis ($n = 251$). For those that did use a cut-off, we asked if they required documentation of low-income status, such as a pay stub, tax return, or qualification for federal assistance programs like Medicare. The vast majority (84.6%) did not ask for such documentation, although 15.4% did ($n = 311$).

Among organizations that had a required fee or suggested donation for feral cats, we asked the amount for 6 common types of basic services. (Some respondents entered $0.00 in response; we dropped zeros from calculations since this question was about fees.) The mean fee or suggested donations for a routine female spay was $44.58 (SD $22.63, range $10.00–120.00), routine male neuter $37.72 (SD $18.89, range $10.00–115.00), routine female spay plus rabies vaccine $48.06 (SD $24.54, range $5.00–130.00), routine male neuter plus rabies vaccine $42.24 (SD $20.60, range $5.00–130.00), routine female spay plus rabies and FVRCP vaccines $53.83 (SD $29.24, range $5.00–195.00), routine male neuter plus rabies and FVRCP vaccines $48.73 (SD $25.38, range $5.00–158.00).

Regarding identification microchips, 52.6% of respondents reported that they always scan feral cats for microchips during their TNR process, with 34.6% reporting that they sometimes do, and 12.8% never scanning for microchips ($n = 439$) (see **Figure 4**). For organizations that microchip feral cats, the information was registered with different entities. The most

commonly-selected answer options indicated that the chips were registered with a standard pet microchip company's database (114), registered with a rescue group (73), registered with local animal control (29), and 28 respondents noted that chip numbers were just for the caretaker's records.

To build a picture of what comprises typical veterinary care offered to feral cats besides just sterilization surgery, we asked organizations which services were part of their process and to categorize them as routine (done to every animal), done at the discretion of a veterinarian or vet tech, provided if requested by a caretaker, or not offered. Described here as a count, the percentage rating that service as routine, and number of respondents answering about that service, services most commonly considered routine included rabies vaccination (383, 89.5%, $n = 428$), FVRCP vaccination (245, 59.0%, $n = 415$), flea/ectoparasite treatment (215, 50.5%, $n = 426$), meloxicam or other injectable pain relief (185, 44.7%, $n = 414$), and de-worming/endoparasite treatment (171, 40.8%, $n = 419$). Services less commonly considered routine included FeLV testing (95, 23.2%, $n = 412$), FIV testing (89, 21.9%, $n = 407$), microchipping (77, 19.1%, $n = 403$), and fluids (46, 11.3%, $n = 407$).

While only a minority of organizations routinely test for feline immunodeficiency virus (FIV) and feline leukemia virus (FeLV), about half of respondents reported offering testing at caretaker request or perform testing at the discretion or a veterinarian or technician. Our survey explored how groups act upon test results. If a feral cat has a positive FeLV test, the most common recommendation options for the cat were retesting at a later date (91), retesting on serum (72), euthanasia if the cat is symptomatic (48), transferred to a rescue/shelter (28), returning to site after sterilization (25), and euthanasia regardless of symptoms (22). Of the write-in answers, we grouped new response types into 4 categories: organizations tried to adopt/foster the cat (16), transfer/relocate the cat (16), isolate the cat (5), or monitor the cat (2). If a feral cat has a positive FIV test, the most common recommendation options for the cat were returning to site after sterilization (95), euthanasia if the cat is symptomatic (68), transferred to a rescue/shelter (41), euthanasia regardless of symptoms (37), retesting at a later date (31), or retesting on serum (7). Of the write-in answers, we grouped new response types into 4 categories: organizations tried to adopt/foster the cat (21), monitor the cat (6), transfer/relocate the cat (5), or isolate the cat (3).

For vaccinations, two-thirds of organizations reported using a standard vaccine injection site. Most commonly, 42.0% gave rabies in the right rear leg and FVRCP in the right front leg, 17.6% gave rabies in the right rear leg, 7.4% used some other standard location, and 33.1% had no standard location for vaccines ($n = 393$). In asking organizations how often they re-trap cats in managed/cared-for colonies for rabies re-vaccination, 1.6% reported doing so always, 4.9% usually, 17.8% sometimes, 25.0% rarely, and 50.7% never ($n = 428$).

Feral cats receive some type of permanent marking to indicate them as sterilized after a spay/neuter surgery. We asked organizations to rate 4 methods as being performed always, on request, or never, and the options aren't mutually exclusive. The most common answers were always using ear tipping (removal of the tip of the ear under anesthesia) (408 respondents), always placing a tattoo in ventral midline abdominal region (152), always using ear notching (removal of a notch from ear) (25), and always placing an ear tattoo (15). There were also write-in answers revealed that 2 organizations reported the use of microchipping and 3 reported tattooing females. Of organizations using ear tipping or notching on of feral cats, 64.8% did so on the left side, 16.4% on either side, 12.7% on the right side, 5.2% did the right side for females and left for males, and 0.9% did the right side for males and left for females ($n = 440$).

For kitten spay/neuter, 58.1% use a minimum weight, 3.5% use a minimum age, and 38.3% require kittens to meet both a set age and weight ($n = 454$). Among organizations that use only a weight, the most common answers were 2.0 pounds (182 respondents), 3.0 pounds (45), 2.5 pounds (15), and 4.0 pounds (10). Only 14 organizations reported a weight less than 2.0 pounds, with 1.6 pounds being the lowest reported minimum weight. Among organizations using only an age, the most common answers were 8 weeks or 2 months (35 respondents), 12 weeks or 3 months (18), 16 weeks or 4 months (12). In total, 3 organizations reported a minimum of 5 weeks as the lowest age limit. Finally, among organizations using both a weight and age, the most common answers were 2 pounds and 2 months (75 respondents), 3 pounds and 3 months (32), and 2 pounds and 3 months (11). The lowest minimum reported for this option was 2 organizations using 2.2 pounds and 2 months.

In describing typical recovery care offered to feral cats after surgery, we found that standard processes after routine surgery often include a small amount of food provided after patient is sternal and alert (209), heat support (147), checking a patient's respiratory rate (130), checking a patient's heart rate (119), checking a patient's mucous membranes/capillary refill (107), checking a patient's temperature (95), corn syrup or dextrose applied along the gumline/mouth (50), administration of subcutaneous fluids (46), and administration of subcutaneous fluids in females only (25). Slightly more organizations reported a single-stage recovery process where a cat is immediately placed in its carrier/trap after surgery (145) than reported a two-stage recovery process where a cat is first attended to outside of a carrier/trap, then placed into a carrier/trap as the cat regains consciousness (131).

When asked whether perioperative antibiotics were part of a routine spay/neuter procedures, a majority of organizations reported that they are not (71.7%), but a sizable minority selected yes (28.3%) ($n = 381$). When using antibiotics for any condition, we asked which types of antibiotics organizations used, with the option to select multiple. Veterinary-formulated/marketed antibiotics were most commonly-reported (379), followed by fish/aquarium-formulated/marketed (51), human-formulated/marketed (46), and antibiotics available in feed stores for farm animals (33).

For organizations that are private non-profits, we asked if they currently received assistance (financial or supplies) from government public health or animal control programs. A large majority reported no (88.0%), with 9.9% reporting yes and 2.1% unsure ($n = 434$). Among organizations answering yes, we inquired about the form of that assistance, allowing for multiple

answers. The most common answers included grants and general financial help (27), animal control contracts (9), spay/neuter services (7), rabies vaccines for cats (7), FVRCP vaccines (5), humane traps and animal capture supplies (3), drugs or surgical supplies and equipment (3), and vouchers/reimbursements (3).

Humane live outcomes aren't always possible. We asked organizations to select conditions for which humane euthanasia would be recommended in feral cats. The most common conditions chosen were signs of chronic illness (177), masses suspected of being neoplastic (172), a single FeLV positive test if cat is symptomatic (135), severe respiratory disease (106), a single FeLV and FIV positive test if cat is symptomatic (103), a single FeLV and FIV positive test if cat is symptomatic (103), multiple FeLV positive tests if cat is symptomatic (99), feline stomatitis or severe dental disease (93), a single FIV positive test if cat is symptomatic (85), loss of vision (81), a single FeLV positive test regardless of symptoms (80), multiple FIV positive tests if cat is symptomatic (53), a single FeLV and FIV positive test regardless of symptoms (45), loss of limb (44), multiple FeLV positive tests regardless of symptoms (39), feline plasma cell pododermatitis (37), a single FIV positive test regardless of symptoms (32), cannot return to previous location (26), heart murmur or arrhythmia (16), and multiple FIV positive tests regardless of symptoms (15). For write-in answers to this question, 99 organizations explained criteria related to a cat's quality of life or suffering, and 12 cited issues with trauma, pain, or injury.

Data and Research

Regarding why organizations collect data about feral cats, the most popular answer options selected were applying for new grants and funding (248), internal activity reporting (190), periodically analyzing progress and impact (171), reports to current funders (150), modifying or expanding future trapping efforts (144), public presentations and documents (118), challenging claims made by those who oppose TNR (117), creating maps, graphs, and diagrams (107), campaigns aimed at changing laws (92), collecting data without using it (37), and some write-in answers. By combining categories to better summarize data use trends, the most common uses for data collected by feral cat groups were administrative and fundraising (611), activism, education, and outreach (329), monitoring population impact (320), creating maps, graphs, and diagrams (107), collecting data without using it (37), and medical reasons (6).

We asked respondents which methods they currently used to determine whether their program was effective at saving the lives of cats and/or reducing outdoor cat populations. The most popular answer options selected were feedback from trappers/colony caretakers based on their judgement of cat numbers (268), tracking shelter cat intake (177), tracking shelter kitten intake (155), tracking shelter cat euthanasia (126), monitoring target cat populations at regular intervals to obtain a count or estimate of abundance or density (96), monitoring target cat populations at regular intervals to obtain an estimate of proportion of kittens (79), tracking cat nuisance calls made to animal control (72), monitoring target cat populations at regular intervals to obtain an estimate of sterilization rate (69), and some write-in answers. By combining categories to better summarize types of program efficacy metrics, most were indirect (541) and anecdotal (289), although some were analytical (245).

One means of assessing program impact is tracking the approximate number of cats on the landscape. Our survey asked organizations if they had ever attempted to estimate the number of outdoor cats in a given area, and the most popular response was no (240). In asking what method had been used by those who had attempted to estimate cat numbers, the most popular was asking colony caretakers to count or estimate their cats (174). The most common write-in answer for estimating cat populations referenced using a human-to-cat population ratio (15), a rough guesswork method wherein one divides the human population by some number to get a general idea of how many cats might live in one's service area.

We asked organizations if they had ever reached out to an academic or researcher for assistance with collecting data, analyzing data, or planning any aspect of their program. A vast majority had not (90.2%), and some were unsure (5.6%) or reported yes (4.2%) ($n = 449$). By grouping the write-in answers for those who had sought help, the 2 most common type of entities contacted were veterinarians and academics (6) and cat welfare organizations (5), and the only motivating needs mentioned by more than 1 group were planning their spay/neuter programs (2) and quantifying cats (2). Inversely, we also asked if a group had ever been contacted by an academic or researcher who wanted to work with them or collect data about their organization. While a majority still reported no (82.2%), more contact had been initiated in this direction, with 8.4% unsure and 9.4% reporting yes ($n = 466$). In asking those who reported yes to explain who had contacted them and why, the most common write-in explanations were cat welfare organizations (13), students (9), and academics (7). The write-in reasons for the contact included someone seeking statistics and data (7), interest in animal welfare and behavior (7), bird and wildlife issues (5), disease and medical issues (5), and seeking biological samples (4).

Our survey asked whether respondents would utilize expert assistance in designing and interpreting their data collection if it were available, 14.7% replied no, 29.9% were unsure, 50.9% were interested but only if such assistance is provided without cost, and 4.5% were interested and willing to pay a reasonable fee ($n = 462$).

We proposed 3 areas in which research occurs around feral cats and asked organizations to rate each topic as something they would definitely, possibly, unsure, unlikely, or not be collaborate with researchers to study. Both of the cat-focused options received high support, with 51.6% definitely interested in research aimed at improving the welfare of feral cats ($n = 467$), and 46.5% definitely interested in research aimed at improving the health/welfare of owned cats ($n = 467$). However, for research not geared toward helping cats, support waned. Here, 24.7% were definitely interested in research aimed at studying public health issues ($n = 466$), and 21.5% definitely interested in research aimed at studying cat impacts on birds and wildlife ($n = 466$).

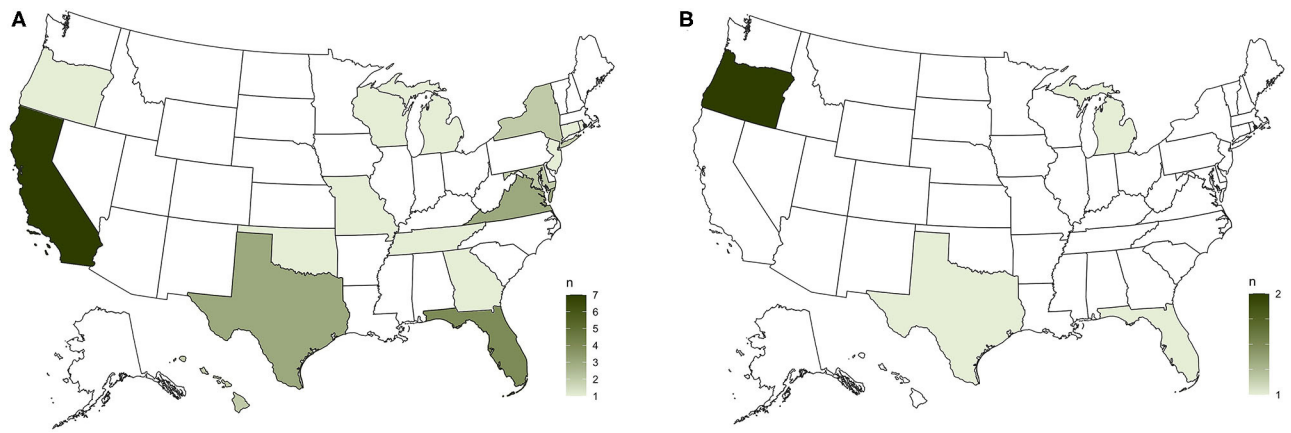

FIGURE 5 | (A) Similarly to our question about animal control authorities, public/overt conflict between feral cat advocates and wildlife and bird people was most reported from California. **(B)** Conversely, Oregon was the only state with more than one organization reporting feral cat advocates as engaged in active collaboration and working toward shared goals with wildlife and bird people.

Bird and Wildlife Issues

We asked if organizations had an official position (such as a statement on their website) about the impact of outdoor cats on birds and wildlife, and if so, which out of 3 options was closest to that position. Most (83.5%) respondents indicated no official position or statement, 8.5% had the position that cats rarely or never have a serious impact on birds or other wildlife, 5.6% had a position that cats may have a serious impact on birds or other wildlife in some places but little or no serious impact in other places, and 2.4% had a position that cats often have a serious impact on birds and/or other wildlife ($n = 449$). We further inquired if organizations had an official position (such as a statement on their website) about how TNR programs change the impact of outdoor cats on birds and wildlife, and if so, which of 4 options was closest to that position. Similarly to above, 75.7% had no official position or statement. Of the rest, 19.9% had a position that TNR programs generally reduce these impacts, 3.1% had a position that TNR programs have impacts that vary from place to place, 5 groups (1.1%) had a position that TNR programs generally do not change these impacts, and a single group (0.2%) had a position that TNR programs generally increase these impacts ($n = 453$).

When asked to describe the current relationship between feral cat people and wildlife/bird people in their area, nearly half (42.9%) reported neutral or no interactions, 7.2% reported public/overt conflict, 35.2% reported some tension between groups, 4.8% reported some efforts being made toward bridge-building, 1.1% reported active collaboration and working toward shared goals, and 8.9% reported that they serve many locations and each is different ($n = 457$) (see **Figure 5**). Finally, to learn more about how positive collaborations occurred, and if it seemed directed formally by organizations or personally by individuals, we asked how that process started. The most commonly-selected answer options were that individuals involved in feral cat issues reached out to individuals they know who were involved in wildlife/bird issues (33), feral cat organizations formally reached out to wildlife/bird organizations (15), working together grew out of tension or public conflict (15), individuals involved in wildlife/bird issues reached out to individuals they know who are involved in feral cat issues (5), and wildlife/bird organizations formally reached out to feral cat organizations (1).

Best Practice Adherence

By requesting organizations list which guidelines they used in shaping their TNR and medical practices, we identified the 5 most popular resources for investigating best practice adherence (not mutually exclusive): 237 respondents indicated that they used the Guide to Trap-Neuter-Return (TNR) and Colony Care (32), 149 used the Best Friends Community Cat Programs Handbook (online) (33), 148 used the Neighborhood Cats TNR Handbook (34), 137 used Alley Cat Allies Veterinary Resource Center (online) (35) and 90 used the Association of Shelter Veterinarians Guidelines for Spay-Neuter Programs (36). Twelve of our survey questions had an answer or answers supported by a majority or plurality of these guidelines which had a recommendation on the issue. See **Table 1** for a summary.

We compared models using stepwise backwards model selection by AIC (see **Table 2**). The best model included whether the organization served urban and suburban areas, whether the organization had a brick-and-mortar facility, whether the organization had its own 501(c)3 federal non-profit status, the US Census Region where an organization is based, and the approximate proportion of animals served annually that were feral cats. Of the answer options for these variables, only 2 were statistically significant using an alpha of 0.05: serving suburban areas and having 501(c)3 status were both predictive of higher best practice scores (term-wise *t*-test *p*-values 0.0243 and 0.0213, respectively) (see **Table 3**) for ANOVA results.

DISCUSSION

Overview

To the best of our knowledge, this is the largest and most comprehensive study of its type, revealing the most complete available picture of what constitutes the standard practices,

TABLE 1 | Twelve questions used in the creation of our best practice adherence model.

Question	Popular advice aligns with survey answer option(s)
Has your organization consulted with an attorney regarding legal problems that could arise from your work?	Yes, in the past; Yes, on an ongoing basis
Are feral cats scanned for microchips during your TNR process?	Always
For kitten spay/neuter, what is the minimum weight and/or age to determine if kittens can have surgery?	2.0 pounds; 8 weeks/2 months
How does your organization mark feral cats as sterilized? *Ear notches*	Never
How does your organization mark feral cats as sterilized? *Ear tips*	Always
What clinical services do you provide to feral cats? *De-worming/endoparasite treatment*	Discretion of vet/tech; Caretaker request
What clinical services do you provide to feral cats? *Flea/ectoparasite treatment*	Discretion of vet/tech; Caretaker request
What clinical services do you provide to feral cats? *Microchipping*	Discretion of vet/tech; Caretaker request
What clinical services do you provide to feral cats? *Rabies vaccination*	Routine
What clinical services do you provide to feral cats? *FeLV testing*	Not offered
What clinical services do you provide to feral cats? *FIV testing*	Not offered
What clinical services do you provide to feral cats? *Meloxicam or other injectable pain relief*	Routine

TABLE 2 | A comparison of model terms and their test statistics.

	Df	Deviance	AIC	ΔAIC	LRT	Pr(>Chi)
<none>		669.41	1884.3			
–serve urban	1	671.59	1884.5	0.2	2.175	0.140309
–brick and mortar	2	673.62	1884.5	0.2	4.201	0.122410
+ proportion feral	3	664.53	1885.4	1.1	4.882	0.180649
+ serve rural	1	669.13	1886.0	1.7	0.287	0.592200
−501c3	2	676.19	1887.1	2.8	6.778	0.033744
–serve suburban	1	674.48	1887.3	3.0	5.068	0.024366
+ active volunteers	5	663.05	1887.9	3.6	6.367	0.272096
+ geographical scope	4	665.07	1887.9	3.6	4.349	0.360794
+ number of paid_employees	4	665.55	1888.4	4.1	3.861	0.425090
–census_region	3	681.77	1890.6	6.3	12.360	0.006246
–number of ferals served	8	714.44	1913.3	29.0	45.021	3.646e-7

TABLE 3 | ANOVA results for terms within the best model.

Terms	Df	Deviance	Residual Df	Residual Deviance	Pr(>Chi)
census region	3	10.345	561	777.97	0.015848
Serve urban	1	20.690	560	757.28	5.401e-6
Serve suburban	1	11.322	559	745.96	0.000766
501c3	2	20.007	557	725.96	4.523e-5
Brick and mortar	2	11.519	555	714.44	0.003152
Number of ferals served	8	45.021	547	669.41	3.646e-7

opinions, assumptions, and attitudes of organizations serving feral and community cats in the United States. Our large volume of responses from across the country show that a majority of respondent organizations generally appear to face the same challenges, make similar decisions, rank comparable priorities, and offer the same types of care to the feral cats they serve.

There are also minority practices that may be of interest to the animal welfare community. As described in more detail below, we suggest that these findings may in some cases be as notable as majority responses, either in cases where improvement and modernization is warranted or where a small number of groups are leading the way in staking out better solutions.

The following are findings that may be especially interesting or relevant to readers.

Environmental, Human, and Public Health

Although suspected environmental exposure observations are potentially subjective and largely unconfirmed by a veterinarian or diagnostic testing, they could point to areas where more research is needed. While the survey did not specifically explore whether individuals noting these events then notified public health or other health professionals, the findings indicate that there could be benefit from greater communication between the feral cat welfare community and local public health resources in order to better identify and reduce environmental health risks to both cats and people. This is of additional environmental justice importance considering that half of surveyed organizations report prioritizing trapping cats in low-income areas.

While rabies vaccination is the most common veterinary service apart from sterilization offered by our respondent organizations, it is still not considered routine by all, possibly as a cost-cutting measure. Only a handful reported receiving assistance from government entities in the form of rabies vaccines. Public health and rabies control programs should supply funding for rabies vaccines to feral cat organizations,

which benefits the entire community by reducing the number of potential rabies carriers.

Caretaking, Trapping, and Release

In deciding where to trap cats, a majority of respondents prioritized factors such as intensive and colony-level trapping to get high sterilization coverage, data-driven area selection based on where cats have been entering the shelter system, as well as providing coverage to low-income neighborhoods which tend to lack access to affordable veterinary services. However, there were also 102 organizations that prioritized an even distribution of sterilization services. This latter focus, while perhaps seeming the most fair at face value, is discouraged by experts as a being an inefficient use of time compared to mass trappings (34). Population modeling research has shown that low intensity sterilization is less effective at both reducing preventable cat deaths and decreasing cat population sizes than high intensity sterilization efforts (37).

Clinical and Medical Issues

Although the prevalence of FIV FeLV has been extensively studied (38), the dispensation of affected feral cats varies and remains largely up to the individual or organization caring for a given animal. While a majority of our respondents reported not routinely testing for these retroviruses, 21.9 and 23.2% did test all cats for FIV and FeLV, respectively. Routine testing of feral cats in TNR programs is not in alignment with advice from professional bodies (39) or advocates (40) on the grounds that doing so is an inefficient use of limited financial resources that could be better spent on sterilization efforts. This recommendation takes resources and capacities for care into account (41), but its adoption is likely dependent on many factors including individual experiences, level of education, cultural acceptance within their communities and access to financial resources. Further, the decision to euthanize should be based on severity of symptoms and quality of life issues, not solely on FIV or FeLV status.

The main purpose of identification microchipping is to reunite lost animals with their owners. Since some cats trapped and presumed to be feral are actually lost pets, the scanning of all cats should be routine in every TNR program. However, only 52.7% of respondents reported always scanning cats for microchips, which highlights the issue of lost reunification opportunities.

A minority of respondents reported using antibiotics not marketed or approved for use in cats, such as aquarium, feed store, or human formulations. This is concerning, as it could be contributing to antibiotic resistance in those communities. It reveals a need for greater access to affordable veterinary care and oversight outside of sterilization and vaccination services, including cases that may warrant antibiotic use.

Data and Research

For groups that collect data, the most commonly reported motivation for data collection is to meet administrative needs and/or to support fundraising efforts. Only a minority of respondents collected data to assess population level impacts or reported making attempts to engage in more active forms for data exploration, such as mapping or charting.

Most respondents attempt to determine program effectiveness, but a large majority of these do so anecdotally or by relying on indirect measures, such as shelter euthanasia. Less than one-quarter attempt to determine impacts more analytically.

Very few groups have attempted to engage assistance from entities that could provide technical assistance in data collection or analysis, but somewhat more have been contacted by such entities. Slightly over half of respondents would be willing in principle to accept this assistance, but only under certain circumstances. These include the absence of any additional cost, and a perceived motivation by the technical partner for improving cat welfare. Willingness to collaborate with a technical partner fall if the goal of the collaboration involves quantifying cat impacts on wildlife or public health.

Collectively, these responses indicate a TNR constituency that is utilizing data for program support in only a very limited fashion, we infer largely to meet the requirements of funders or to help secure additional funding. Collaborations to improve the use of data in TNR programs are of interest to many TNR practitioners, but willingness to incur costs to secure these services is very limited. There also appears to be substantial discomfort with the idea of investigating wildlife or public health issues during the course of collecting data in conjunction with TNR programs. This suggests a need for continuing outreach and education to make the field more comfortable with the idea of data driven cat population management, and the development of support services to facilitate the use of these tools and integrate them incrementally into routine TNR practice.

Challenges and Caveats

As with all voluntary response surveys, our respondents might not be entirely representative of our target population. Further, by conducting our survey online through social media, animal welfare websites, and email contact lists, we were unable to make contact with organizations who are not connected to such resources. This could lead to an under-sampling of the most isolated organizations.

Despite our survey being conducted transparently by people with long-term involvement in animal welfare, One Health, and spay/neuter work, there were some accusations that we were "bird people" infiltrating cat welfare Facebook Groups with the intention of spying on cat advocates and harming cats. This may have reduced participation.

Our other key challenge regards whether respondents had the knowledge to answer certain questions. As most organizations reported that they did not operate their own clinics and are presumably reliant on 1 or more third party veterinarians, accurately reporting their veterinary decision-making criteria to us was likely to be difficult. This problem is highlighted by findings such as the 44 organizations which clicked the option indicating that they routinely amputate tails as part of their TNR process. We included rare procedure items in our list to learn whether they were offered to feral cats at all, and we were not expecting so many people to rate it as "routine" rather than "not offered" or "performed at the discretion of

a veterinarian." Despite our explanation that routine means "done to every animal," we posit these implausible answers about rare procedures may have been interpreted as routinely done to every animal presenting with a need. Further, 28.3% of our respondents reported that they use perioperative antibiotics for routine spay/neuter. If over 1 quarter of feral cat organizations are giving antibiotics to all sterilization patients, this would be a concerning finding. However, since this question used a medical term ("perioperative") and may have been subject to the same misunderstanding as other questions which contained the word "routine," we believe this figure skews high. Some of the issues covered in our study would require the collection of medical records to investigate more thoroughly and accurately. The more technical a question, the more we urge caution about some of our results as there is likely a margin of misunderstanding by survey respondents.

This issue arose not only with medical topics, but also with our question on methods of cat population estimation. To the best of our knowledge at the time of this survey, only the Feral Cat Coalition of Oregon was engaged in scientific cat population monitoring through their collaboration with Portland Audubon (42). Yet, 19 organizations clicked a box indicating that they were using mark-recapture population estimation, and 17 indicated they were using transect counts to determine the efficacy of their work. While such findings would be excellent news, we believe it highly unlikely that so many organizations would be conducting rigorous cat population data collection and research programs without those efforts being publicized within the animal welfare community or known privately by the study authors.

We believe that the confusion apparent in some of our questions indicates simple misunderstandings on the part of respondents, rather than a malicious attempt to deceive. Moving forward, our responsibility as researchers is to put more thought into ensuring that the next iteration of this survey will focus on questions that can be understood and answered by anyone at an organization, not just someone with a strong veterinary and scientific background.

CONCLUSIONS

The focus of the present study was not to make recommendations for ideal policies on the matters covered in our survey. There are many veterinary bodies and major animal welfare organizations that publish recommendations for feral cat care and high volume spay/neuter, and we hope these entities can use our results to improve or add emphasis in their materials as they evolve. As we discovered in identifying our set of the most agreed-upon topics to investigate best practice adherence, there were only a dozen issues covered by our survey where the most popular how-to guides were largely in agreement. This demonstrates an area where upper-level interorganizational collaboration and cooperation could result in a more standardized community of practice in the feral cat world.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Washington Human Subjects Division. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SA co-designed the study, developed the questionnaire, solicited participation for the survey, performed the statistical analysis, created figures, and wrote the manuscript. JMB co-designed the study, developed the questionnaire, and contributed to the manuscript. JDB and PR assisted in developing the questionnaire and contributed to the manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2021.791134/full#supplementary-material

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Corrigendum: "State of the Mewnion": Practices of Feral Cat Care and Advocacy Organizations in the United States

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In the original article, the **Abstract** contained a results error. It should state "1 or 2 nights for females." The corrected paragraph appears below.

Over the last several decades, feral cats have moved from the fringes to the mainstream in animal welfare and sheltering. Although many best practice guidelines have been published by national non-profits and veterinary bodies, little is known about how groups "in the trenches" actually operate. Our study sought to address that gap through an online survey of feral cat care and advocacy organizations based in the United States. Advertised as "The State of the Mewnion," its topics included a range of issues spanning non-profit administration, public health, caretaking and trapping, adoptions of friendly kittens and cats, veterinary medical procedures and policies, data collection and program efficacy metrics, research engagement and interest, and relationships with wildlife advocates and animal control agencies. Respondents from 567 organizations participated, making this the largest and most comprehensive study on this topic to date. Respondents came primarily from grassroots organizations. A majority reported no paid employees (74.6%), served 499 or fewer feral cats per year (75.0%), engaged between 1 and 9 active volunteers (54.9%), and did not operate a brick and mortar facility (63.7%). Some of our findings demonstrate a shared community of practice, including the common use of a minimum weight of 2.0 pounds for spay/neuter eligibility, left side ear tip removals to indicate sterilization, recovery holding times after surgery commonly reported as 1 night for male cats and 1 or 2 nights for females, requiring or recommending to adopters of socialized kittens/cats that they be kept indoor-only, and less than a quarter still engaging in routine testing of cats for FIV and FeLV. Our survey also reveals areas for improvement, such as most organizations lacking a declared goal with a measurable value and a time frame, only sometimes scanning cats for microchips, and about a third not using a standardized injection site for vaccines. This study paints the clearest picture yet available of what constitutes the standard practices of organizations serving feral and community cats in the United States.

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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Decolonizing Animal Welfare Through a Social Justice Framework

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Keywords: social justice, human-animal bond (HAB), animal welfare, disability justice, environmentalism, gender and sexuality diversity, racial equity

INTRODUCTION

A shift in animal welfare approaches has centered more attention on the human-animal bond (HAB) between diverse people and other animals (1). Scientific curiosity into the significance of these bonds is led by prestigious academic research institutions and organizations like the Human-Animal Bond Research Institute (HABRI). Although interdisciplinary study into the phenomena has become prevalent, animal bond disparities between historically excluded populations persist. Companions and Animals for Reform and Equity (CARE) argue for social scientists and animal welfare researchers to probe further into the human-animal relationship critically through race, ethnicity, class, sex, and gender frameworks to reimagine a welcoming and inclusive sector for marginalized communities.

Historically, police brutality within communities of color has been broadly documented. George Floyd's death in May 2020 served as a catalyst that ignited a global call and response for racial equity and justice. Likewise, animal welfare in the United States has responded with countless diversity, equity, and inclusion centered discussions and initiatives. Earlier in 2020 CARE, the country's first Black-led animal welfare organization was founded to prioritize inclusion as a key tool in lifesaving and human and animal well-being. Community participatory research and personal storytelling are key to examining the impact of disparities in animal welfare. Two challenges persist: Black, Indigenous, and other people of color (BIPOC) remain noticeably absent, while perceptions of tokenism, colorism, and texturism slant the national dialogue toward white fragility as opposed to BIPOC-centered solutions to increase inclusion within the sector. Nevertheless, these conversations continue as an essential discourse to healing the national racial divide across all sectors, including animal welfare.

CARE focuses on comprehensive human and animal well-being through the pursuit of community wisdom that will drive lifesaving activities in marginalized communities. Doing so requires adopting transformative justice principles into a human and animal well-being framework. As a result, community engagement strategies and programs will result impacted by more welcoming, culturally competent, and responsive spaces for BIPOC communities in animal welfare. Animal welfare must expand the narrow notion of well-being to include critical justice issues like gender and sexual diversity, racial equity, economic and housing security, disability rights, and environmentalism.

DISABILITY JUSTICE

Disability justice may appear to be a notable outlier in much of justice advocacy and studies. In accessibility can easily be described as one of the most impactful barriers to disability justice. Divesting from that requires intellectually and physically disabled populations to be visible

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and centered in the movement toward inclusive social justice. Scholar advocates like Radical Disabled Women of Color United (2) urge for a critical intersectional disability studies approach that prioritizes the meeting of race, gender, class, and disabilities. Disabled lived experiences with systems of oppression essentially provide increased validity to justice advocacy frameworks across interdisciplinary and cross-sector approaches.

Animal welfare to outwardly appears to be in agreement that the utilization of service animals is necessary. Despite this, the fight for emotional support service animals to be legitimized continues for people living with a disability and requiring this form of support. Current federal legislation does not define emotional support service animal training as work or a task for the animal ignoring the direct feedback from disabled communities (3). Legislation supporting communities with visual impairments and their service animals reveals bias and lack of disabled community involvement in policy creation. This is merely one example of the lack of commitment to cross-disability solidarity at the intersection of disability justice and animal well-being (4).

Ableism is as normative to our society as colonial whiteness. Reimagining disability justice for animal and human well-being challenges advocates like CARE to create a culture of access in the outputs to the community. Disability justice advocacy is most simply placing value on the advancement of equitable access practices despite the lack of societal buy-in from individuals, institutions, and government.

ENVIRONMENTAL JUSTICE

Climate experts like Dr. Ayana Johnson (5) acknowledge that the environmental justice movement improves by being interconnected to race and class liberation work. This requires environmental justice support and solutions to be centered around minoritized communities in order to be sustainable models. If we think of environmental racism as an extension of harmful state sanctioned practices then we can more effectively theorize it as a form of state violence. The largely white western environmental movement has not prioritized racially diverse communities. BIPOC populations are disproportionately exposed to environmental racism like proximity to highways landfills, chemical facilities, or toxic waste. The associated health risks like cancer or asthma impact the humans and other animals in those communities. Animal advocates must consider combining efforts with related human service organizations to improve services to all.

Environmental Scholar, Dr. Pellow (6) continues on environmental justice with critical environmental justice studies, which seek to expand the field of environmental justice to move beyond its conceptual, theoretical, and methodological limitations. Their approach draws from numerous fields of scholarship to produce more robust arguments resulting from the examination of the persistent occurrence of environmental injustices that impact humans and non-humans. Notably, the approach offers animal welfare an opportunity to reimagine old paradigms through intersectional theory to define new strategies for BIPOC community engagement and coalition-building. The promise of critical environmental justice studies lies in its capacity to explain the sources and consequences of our socio-ecological crises and develop more generative analyses of how social change efforts within and across species may meet those challenges more fully.

Issues of environmental racism like communities of color and their animals' discorporate exposure to health risks, food deserts, and proximity to toxic facilities or environmental hazards can all be more easily understood using environmental justice frameworks to reimagine deliberate support. It is not the intent of the authors to appear anthropocentric in presented views of human-animal relationships. Instead, the desire is to improve what Critical Animal Studies hopes to do by centering the needs and lived experiences of historically oppressed humans who have companion animals for the purpose of keeping those relationships sufficiently supported.

GENDER AND SEXUAL DIVERSITY JUSTICE

Although animal welfare has embraced research that examines the human-animal bond (1), the sector has only scratched the surface to use the knowledge to address disparities and inequities experienced by LGBTQ+ communities. Further extension into sexualized communities is likely to elucidate even more fertile research and program designs that cater to their unique challenges. In order to engage such challenges, animal welfare researchers must embrace immersive critical research rigor practice that fearlessly intersects animal welfare with race, sexuality, and gender. Walsh (7) underscores how transgender, non-binary, and older sexual minorities who experience social stigma value the nonjudgmental acceptance of companion pets (8). Additional research from the National Health, Aging and Sexuality Study (NHAS) demonstrates that sexual and gender minorities in midlife and later life are at elevated risk for disability, poor physical health, and depression (9). Nevertheless, uncharted opportunities remain elusive to designing innovative, solution-oriented community-based programs to address isolation among aging sexual minorities.

RACIAL JUSTICE

Critical race scholars suggest that harm reduction and equitable societal progression surrounding race cannot exist without acknowledgment of racialized lived experiences (10). Racial justice studies promote frameworks that value understanding the differences in institutional, structural, interpersonal, and internalized racism to effectively reimagine equity efforts for non-white populations' quality of life (11). It is vital to humanize these experiences in racial justice work across sectors by recognizing racial trauma's impact on the individual and their community. A race-based traumatic impact can present itself as increased aggression, vigilance/suspicion, sensitivity to threats, psychological/physiological symptoms, alcohol/drug usage, or a narrowing sense of time (11). Harper (10) does clarify that

critical race theory does not need to work alone in reimagining equitable approaches. Therefore, there is a healthy argument for the intersectional relationship race and other systems of oppressions mentioned in this article have on building equitable frameworks of justice-based support for humans and their animals. The racially diverse individuals and families served by animal welfare require sensitivity and trust-building components that honor their lived experiences. Additional modifications to practices are required for racially diverse individuals who also experience intersections of poverty or economic hardships and gender differences.

The CARE/Harvard Project Implicit study (12) identified significant negative attitudes toward racially diverse, specifically Black, and poor, animal owners within the animal welfare sector. In addition, the study collected demographic data that supports the casual narrative that animal welfare is predominantly white-run and operated. This disparate representation in the field dictates the types of services and approaches prioritized that lack centrality in equity or justice to establish animal welfare as welcoming to BIPOC communities. The study also revealed significant differences in attitudes and perceptions toward various racial groups that suggest a racial hierarchy. Although non-white communities in animal welfare are all subjected to harmful practices there are differences in treatment between people of color by white authority and leadership in animal welfare. Likewise, Crenshaw (13) argues that the surface level grouping of white and non-white can be harmful due to the very different racialized lived experiences. Reimagining and co-creating racial justice for human and animal well-being requires divesting from the current monolithic perspective that prevails. Animal welfare has an opportunity to evolve by acknowledging the intersectional realities of BIPOC lived experiences and to support comprehensive human and animal well-being ethically and respectfully.

DISCUSSION

Little research is available to provide an explanation as to why animal welfare scholars, advocates, practitioners, and grant makers maintain such minuscule data specific to Black, Indigenous, and other people of color. The University of Michigan Health recently published a survey study to better understand the needs for companion animal care for individuals requiring hospitalization. Despite the study's ability to generate discussion on access to emergency boarding and companion animal fostering there appears to be a lack of prioritization for racial diversity by the researchers. Polick et al. (14) report "Race/ethnicity was initially categorical but, due to the low frequency of responses in seven non-white categories, this item was dichotomized." This is harmful to racially diverse communities that own companion animals for a few reasons. The researchers bulk all BIPOC individuals into one as a convenience that inherently tells the animal welfare sector that experiences are either white or non-white. This is seen as an erasure of complex racial experiences because all non-white experiences are not the same. Additionally, the authors state 62% of the sample pool used identified as white. When animal welfare references published articles like the mentioned study to support programing they are prioritizing white experiences and needs to inform their work. Monolithic approaches to reporting racial diversity, lack of clear race or ethnic breakdowns, and significantly small sample pools of people of color contribute to harm in our field yet continue to occur.

A query that explores the historical impact of the concept of race neutrality within animal welfare would be worthy of examination. Floyd's death elucidated the need for more scholarly research and grassroots data collection within the academy, national animal welfare organizations, veterinary practices and animal grant makers. Additional research that provides an extensive analysis of the human-animal bond between intersectional communities would benefit community-based programmatic design and outreach.

Once this research is inevitably pursued, researchers should practice due diligence to ethically implement research methodologies that partner with marginalized communities as participants as opposed to subjects. Participatory action research methodologies are available that follow a social justice framework that mitigates the historically harmful, and sometimes violent nature, in which knowledge has been unethically extracted from marginalized communities (15).

We argue animal welfare must build authentic relationships with intersectional BIPOC communities to holistically address the challenges that impact these communities and their pets. In essence, this work requires the disruption of the status quo within animal welfare to benefit pets within marginalized communities.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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The Evolving Role of Triage and Appointment-Based Admission to Improve Service, Care and Outcomes in Animal Shelters

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The historical norm for many animal shelters has been to admit animals on an unscheduled basis, without prior assessment of animal or client need or regard to the shelter's ability to deliver humane care or ensure appropriate outcomes. This approach allows little opportunity to provide finders or owners with alternatives to keep pets safe in their homes or community rather than being impounded. In addition to needlessly impounding animals and separating pets from families, unmanaged/unscheduled admission frequently results in animal influx exceeding shelter capacity, leading to crowding, stress, disease, and euthanasia of animals, as well as poor customer experience, compromised staffing efficiency and decreased organizational effectiveness. Many of these harmful consequences disproportionately impact vulnerable community members and their pets. Triage and appointment-based services have been well developed in healthcare and other service sectors allowing organizations to prioritize the most urgent cases, align services with organizational resources and provide situation-specific solutions that may include virtual support or referral as appropriate. This article discusses the trend in animal sheltering toward triage and appointment-based services that parallels the use of these practices in human healthcare. Reported positive results of this approach are detailed including improved staff morale, reduced disease rates and substantially reduced euthanasia. These positive outcomes support the endorsement of triage and appointment-based services by multiple North American animal welfare professional and academic organizations, recognizing that it better realizes the goals of shelters to serve the common good of animals and people in the most humane, equitable and effective possible way.

Keywords: animal shelter, managed access, community oriented, coordinated care, appointment, triage system, stray dog and cat, animal relinquishment

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INTRODUCTION

"Triage" is a well-developed strategy in human general practice medicine and refers to the provision of care based on exigency and available resources. Triage allows the medical practice to prioritize those who are most in need of immediate care, and who benefit most from clinic services (1). In order to make this determination, the following factors are considered:

- Why the patient has sought help from their general practitioner
- What kind of help the patient needs (which may be different than the reason help was sought)
- How quickly the patient needs help
- Who the best person is to help this patient

The answers to these 4 questions allow a determination of where and when a patient should be accommodated. Urgent cases can be routed directly to immediate care, non-emergencies can be scheduled for a time when the practice is able to accommodate the patient's needs, and some cases can be identified that can be handled more conveniently and efficiently through remote services, for example through a telehealth visit or call with an advice nurse (2). This in turn has resulted in decreased workload for primary care physicians while increasing speed of access to information for patients (3).

Although it may not always provide instant gratification, the benefits of triage can be readily appreciated by users of health care services. Few general practices—human or veterinary—would be able to safely accommodate all patients seeking care on a walk-in basis. We appreciate the ability to be seen on an appointment basis to avoid long waits, and hope that the health systems we participate in are not so overwhelmed that they are unable to accommodate emergencies. We recognize that remote care can be a safe and convenient option while also lowering costs and risks within healthcare systems.

TRIAGE IN ANIMAL SHELTERS

In spite of its apparent benefits in other sectors, triage systems have not historically been well developed in North American animal shelters. Instead, the norm has been *ad hoc*, unscheduled admission of any animal presented during open hours (and sometimes even after hours via "drop boxes") regardless of shelter capacity or animal needs. In fact many publicly funded shelters report being explicitly prohibited from managing the flow of animals into the shelter. Yet animal shelters share the challenges faced by human and veterinary general practice in terms of the number and variety of animals presented for care, from urgent (e.g., injured and dangerous animals) to more chronic (e.g., free roaming neighborhood cats). Without a triage system in place, shelters tend to fill with less critical cases, leaving resources stretched thin when emergencies do occur. Crowding in shelters leads to increased disease and behavioral disorders, compounding the strain on limited resources.

Perhaps most importantly, in the absence of thoughtful triage animals are impounded that could have been served more humanely, effectively and equitably by remaining in the community. For instance, research has documented that most stray dogs are found close to their homes and that dogs and cats are >11 and >40 times, respectively, more likely to be found by searching the neighborhood of origin or returning home on their own than through a call or visit to a shelter (4, 5). By transporting found animals to a shelter without first making efforts to locate the owner, well-intended finders often unwittingly reduce the likelihood of the pet ever being reunited with its family. This is especially likely where language, transportation or other barriers prevent some community members from readily accessing the shelter, perhaps one reason why those making under $30,000 USD annually were less than half as likely to find a lost pet than those making over $50,000 (4).

Shelter admission may likewise not be the best option for pets whose owners are considering relinquishment; for underage kittens found outside; for healthy community cats, or for other common categories of animals presented to shelters. For instance, it may be possible to provide support to keep pets safely with their families or help owners rehome their own animal without the stress and risk of surrendering to a shelter, while underage kittens may be safer remaining with their mother until they are old enough for adoption. Such ideal solutions may not always be possible, but cannot even be considered without a process in place to evaluate the animal and owner or finder's situation and offer alternatives to admission if appropriate.

Trends Toward Triage

In recent years there has been an increasing appreciation for the value of triage in animal shelters to provide situation-specific solutions. Programs utilizing triage have been known by various terms, including Community-oriented Sheltering, Managed Admissions/Intake, Coordinated Entry and Appointment-based Services. In the last decade such programs have been implemented by a number of shelters and incorporated into national initiatives. Managed Admissions (with provision of Alternatives to Intake) was among the key initiatives of the Million Cat Challenge, a successful campaign to save over a million cats from euthanasia in North American animal shelters over a 5-year period from 2014 to 2019 (6). Managed Admissions was also identified as a component of the Capacity for Care management model, which has been linked to reduced disease, lower costs and reduced euthanasia rates (7).

The operational changes necessitated by the COVID-19 pandemic accelerated the adoption of triage systems by North American animal shelters (8). Many shelters implemented appointment-based services out of necessity to regulate customer flow and keep public and staff safe. An unexpected result was the greater opportunity to provide a thoughtful assessment of animal needs, offer alternatives to impoundment and ensure operation within shelter capacity. The benefits were evident in reduced euthanasia (9, 10) and improved animal care in the shelter, leading to the retention of this practice in some cases even as pandemic restrictions eased. For instance, the Managed Intake program implemented in 2020 by the Los Angeles County Department of Animal Care and Control, one of the largest shelter systems in the U.S., earned awards in 2021 from the National Association of Counties and from the Quality and Productivity Commission, and received the endorsement of national organizations including the American Society for Prevention of Cruelty to Animals, Best Friends Animal Society, and the National Association for Animal Care and Control (11).

Evolution of the Shelter Triage Model

Building on the success of appointment-based services, the "Human Animal Support Services" (HASS) animal sheltering

model emerged in 2020 with a focus on providing safety net services to keep animals in homes, not kennels (12). Key strategies of the HASS model include community-based interventions that bypass shelter intake, such as returning lost pets to their homes in the field, increasing the scope of animals placed in to foster care, and overcoming barriers to keeping pets in their original homes (13). Some shelters have chosen to rebrand themselves as "Pet Resource Centers" to reinforce the idea that impoundment is not a one-size-fits-all solution.

Similar to the human medicine model, triage in a shelter context means that each time an animal is presented for possible intake, consideration is given to:

- The goals of the owner/finder/concerned bystander
- The needs of the animal
- The exigency of the situation
- The best possible solution given capacity and resources in the shelter and community

This assessment may take place over the phone, via a web-form, or in some cases even by simply using flow charts and criteria provided on a website. The resulting response may range from a recommendation for immediate intake (for instance, of an injured or dangerous animal), intake by appointment for non-urgent cases (e.g., healthy kittens old enough for adoption), or guidance to help manage the situation without shelter admission (e.g., resources to reunite found pets with their owners or strategies for co-existence and spay/neuter support for healthy community cats).

As more shelters replace *ad hoc*/unmanaged intake with appointment-based triage systems, the advantages of the latter have become increasingly apparent (8, 11). In addition to keeping more animals safe in the communities where they live, shelter workflow becomes more predictable, allowing more effective and efficient staffing. With fewer animals in the building, disease rates and associated medical costs tend to decrease (7, 14). Prioritizing the most vulnerable animals allows greater investment in each one. This may in part explain why, when COVID-19 related changes to U.S. shelters operations in 2020 resulted in a 22% decrease in intake, shelter euthanasia dropped in U.S. shelters by 49% (176,000 pets)—fewer animals in the system allowed a larger percentage to get the care needed to leave the shelter alive (9).

Reduced euthanasia and the ability to provide better care for animals in turn often results in greatly improved staff morale (14). This is significant as workplace stress is commonly identified amongst animal shelter workers and may contribute to a variety of mental health issues and even elevated risk for suicide (15–17). Inadequate staffing, the inability to provide an appropriate level of care and a lack of control over the work environment have been linked to an increased risk of moral distress and burnout in animal and human healthcare settings (18–20). Euthanasia of animals is often a specific and potent additional stressor for shelter staff (20). Conversely, appointment-based triage offers greater opportunities for control and predictability of the work environment, and allows more opportunities for appropriate care to be provided either within the shelter or via community-based solutions. This may explain why some shelter staff reported paradoxically high levels of work satisfaction even in the very challenging early days of the COVID-19 pandemic.

Lower intake, reduced euthanasia, decreased disease rates and higher staff moral have the potential to trigger a virtuous cycle, freeing resources for greater investment in safety net services that improve community health and decrease the overall need for animal impoundment, as exemplified in this quote from one director of a public shelter from a survey of California shelter leaders regarding the impact of changes made in response COVID-19:

"When the pandemic hit and we were able to use that to put in place more stringent managed intake policies, we were able to see a true difference in our ability to meet the 5 Freedoms, truly care for the animals, reduce LOS (length of stay), and also reduce our Net County Cost. The decrease in cost allowed us the ability to push through our plan to place a clinic building on the shelter property, which will open up so many opportunities to serve the public without increasing intake." (California shelter survey performed by UC Davis Koret Shelter Medicine Program, April 2021).

DISCUSSION

The COVID-19 pandemic revealed the hidden costs of "business as usual" in many sectors of society. In animal shelters we now recognize the costs of unmanaged intake as the flip side of the benefits of appointment-based triage: animals needlessly impounded; fewer pets reunited with their families; increased crowding, stress, disease and death of shelter animals; higher expenses and lower staff morale. Even more troubling, the burden of these negative consequences falls disproportionately on marginalized community members and their pets (21). The status quo system has resulted in animals from less affluent and more vulnerable communities being admitted to shelters at a higher rate, and leaving shelters alive at a lower rate in comparison to more affluent areas (22–25). This disparity has been linked to a variety of socioeconomic factors including poverty, housing insecurity, and ethnocultural factors (24, 26, 27). When intake is unplanned and chaotic, there is limited opportunity to understand and remediate a problematic situation, e.g., by offering short term care for pets of people experiencing a housing crisis, help with medical, food or other urgent care needs, spay/neuter services or other support to reduce intake and stabilize the valued connection between people and pets (28).

There is no reason to continue to tolerate such harms and inequities in association with animal shelters. Whether funded by public dollars or private donors, these organizations are intended to serve the common good of animals and people, keeping communities safe and supporting the connection between pets and families. Shelter staff and volunteers deserve the opportunity to provide humane care for animals and responsive customer service without struggling under an unmanageable burden or working within a chronically overwhelmed system. These ends can best be served by replacing *ad hoc*, unscheduled intake with

a thoughtful, appointment-based system that allows situational assessment and response for all non-emergency requests. The decision of whether and when to admit an animal can then be made based on the capacity of the shelter and the needs of the animal and people involved, and guidance provided for finders, owners and concerned bystanders when shelter admission of an animal is not recommended.

CONCLUSION

The COVID-19 pandemic created a systemic disruption that, while undeniably tragic, revealed opportunities to replace long-established norms with more humane, equitable and effective alternatives (2). The *ad hoc*, unscheduled intake model of sheltering so prevalent in North America arose over a century ago, undoubtedly with good intentions to optimize animal care and customer service; however, the experiences of many shelters during the pandemic built on existing research to prove the advantages of a more thoughtful, scheduled approach. The success of triage and appointment-based care in human healthcare provides a roadmap for shelters to similarly match the type and timing of the response with the needs of those seeking care, the exigency of the situation and the capacity of the organization. In so doing, shelters lay the foundation for more equitable, humane and sustainable systems that will better serve animals and communities in the years to come.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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REVIEW
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Rethinking the Animal Shelter's Role in Free-Roaming Cat Management

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Substantial societal investment is made in the management of free-roaming cats by various methods, with goals of such programs commonly including wildlife conservation, public health protection, nuisance abatement, and/or promotion of cat health and welfare. While there has been a degree of controversy over some of the tactics employed, there is widespread agreement that any method must be scientifically based and sufficiently focused, intensive and sustained in order to succeed. The vast majority of free-roaming cat management in communities takes place through local animal shelters. Throughout the 20th century and into the 21st, this consisted primarily of *ad hoc* admission of cats captured by members of the public, with euthanasia being the most common outcome. In North America alone, hundreds of millions of cats have been impounded and euthanized and billions of dollars invested in such programs. Given the reliance on this model to achieve important societal goals, it is surprising that there has been an almost complete lack of published research evaluating its success. Wildlife conservation and public health protection will be better served when debate about the merits and pitfalls of methods such as Trap-Neuter-Return is grounded in the context of realistically achievable alternatives. Where no perfect answer exists, an understanding of the potential strengths and shortcomings of each available strategy will support the greatest possible mitigation of harm—the best, if still imperfect, solution. Animal shelter function will also benefit by discontinuing investment in methods that are ineffective as well as potentially ethically problematic. This will allow the redirection of resources to more promising strategies for management of cats as well as investment in other important animal shelter functions. To this end, this article reviews evidence regarding the potential effectiveness of the three possible shelter-based strategies for free-roaming cat management: the traditional approach of *ad hoc* removal by admission to the shelter; admission to the shelter followed by sterilization and return to the location found; and leaving cats in place with or without referral to mitigation strategies or services provided by other agencies.

Keywords: feral cats, community cats, Trap-Neuter-Return, lethal management, cat population control, animal shelter, wildlife

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INTRODUCTION

Significant investment is made in active management of cats in many parts of the world, with common (and sometimes purportedly conflicting) goals including reduction of cat populations and associated harmful impacts on wildlife; mitigation of nuisance complaints and public health concerns; and promotion of cat health and welfare. This paper will review traditional and emerging strategies to achieve these commonly held goals, with an emphasis on those available to shelter-based control programs which represent one of the most common contexts through which cat management efforts are funded and delivered.

Definitions and distinctions amongst cats have been made based on socialization level toward people (e.g., "feral" or unsocialized vs. friendly), ownership status (e.g., owned/pet vs. semi-owned or un-owned), confinement (indoors, outdoors at times, or free-roaming), level of care (subsidized or self-sufficient), or location found (urban, suburban, or natural habitats). Assessment of the category(s) to which a free-roaming cat belongs often cannot be determined on casual inspection, cats may move between categories over time, and broadly applied interventions will inevitably impact cats in multiple categories. Therefore, this review will focus on the potential for cat management practices to achieve common societal goals with respect to any cat found outside without evidence of ownership, for which the umbrella term "free-roaming cats" will be used.

Background

In recent decades, there has been extensive research and public debate on the role of lethal and non-lethal methods of free-roaming cat management (1, 2). A point of agreement among advocates of either approach is that cat management strategies should be subject to scientific scrutiny, driven by data, and reviewed for impact with reference to the specific environment in which they are applied and the outcomes they are intended to achieve (1, 3). In this context it is appropriate to evaluate all cat control methods that might be applied on a broad scale by the same standards, including cost, effectiveness, and practicality on a large scale.

Trap-Neuter-Return

Trap-Neuter-Return (TNR) in particular has been the subject of extensive scientific and public debate (2, 4, 5). TNR programs have most commonly relied on community volunteers to trap cats for sterilization (often with vaccination for infectious diseases and ear tipping to identify cats as sterilized) and return to the location found. Trapping is usually on an *ad hoc* basis based on volunteer capacity and driven by local concern or annoyance regarding individual cats or larger groups and is often associated with adoption of some cats, especially socialized kittens. Demonstrated benefits of TNR include improvement to cat health and welfare and reduction of nuisance complaints (6–8). Success has also been reported in reducing or eliminating cat populations in focal areas (9, 10). Volunteer engagement means that TNR programs are often carried out at minimal or no public cost (11, 12). However, population models differ on their predictions of what proportion of cats must be sterilized to meaningfully reduce or eliminate cat populations on a broad scale (2, 13–17).

Non-shelter-based Alternatives to Trap-Neuter-Return

Alternatives to TNR include lethal and non-lethal cat control methods implemented by federal or local wildlife management programs. Like TNR, some of these interventions have been well-documented and studied, with varying results. Successful campaigns are expensive and labor intensive, with costs to eradicate cats from islands ranging from $400 to $431,000 USD per km^2 (18). At the lowest end of that range, a campaign to eliminate 40 cats from Faure Island (58 km^2 area primarily using aerial distribution of poison bait) took just 3 weeks and cost $26,000 (19). At the higher end of the range, eradication of 761 cats from Macquarie Island (128 km^2 area primarily using cage traps and shooting of cats) took 22 years and cost ∼$2.5 M (20). Recently, the proposed eradication of the estimated 1,629 feral cats from Australia's 4,405 km^2 Kangaroo Island, which is inhabited by ∼4,400 people, via a culling campaign including poisoning, trapping, and shooting was projected to cost $15 million over a 10-year period (21). The largest documented primarily non-lethal cat removal campaign took 3 years and $2.9 M to eliminate 66 cats from San Nicolas Island (57 km^2 area primarily using padded leg-hold traps) (22). Where complete eradication and exclusion of new immigration is not possible, significant ongoing investment is required on top of initial costs (23).

Shelter-Based Methods of Free-Roaming Cat Management

The methods and cost of such intensive campaigns preclude their use on a large scale in areas inhabited by people and pets (24). In the absence of large-scale government-sponsored alternatives, this leaves the vast majority of cat management on a community level to take place through programs operated by local animal shelters, including publicly and privately funded organizations. Billions of dollars are invested annually and millions of cats pass through shelters each year (25). In spite of this significant investment and the implied or stated reliance on these programs as the primary alternative to TNR, curiously little scientific scrutiny has been applied to the potential for traditional or emerging sheltering methods to decrease cat number or mitigate the impacts of cats on wildlife or public health.

This is an important oversight. TNR has been criticized because it may fail to reach the necessary scale or be sustained with sufficient intensity to meaningfully reduce cat populations. However, the same can be said of shelter-based control programs. Animal shelters are not generally staffed or funded at the level of documented successful cat control campaigns. Even the lowest cost documented for such campaigns, at $26,000 USD for 40 cats ($650/cat) (19), would be substantially out of reach for community animal control programs.

The methods as well as the cost of meaningful eradication campaigns are a limiting factor for shelter-based control. Use of poison, shooting, or other broadly applied lethal methods is

not an option in most populated regions. This leaves community control efforts mainly reliant on live capture (either trapping or confinement by some other means), a process that requires the location and habits of cats to be known with some precision. Traps set by shelter personnel can be interfered with or destroyed unless continually monitored. As a result, the vast majority of shelter-based control involves cats that are brought into shelters on an *ad hoc* basis by individual members of the public, unrelated to targeting of particular cats or locations with respect to wildlife protection.

Thus, traditional shelter-based control shares some of the same potential weaknesses raised by critics of TNR as a means to meaningfully reduce cat populations. However, advocates for traditional shelter methods might argue that cat management programs in populated regions have additional goals. For instance, TNR programs have been touted as a means of improving cat welfare, decreasing disease transmission, and reducing nuisance complaints. These objectives are shared by most shelters, along with a priority placed on reuniting lost animals with their owners and finding new homes for pets in need (24, 26).

The extent to which traditional shelter-based control programs attain commonly held goals will benefit from the same critical examination applied to TNR and other methods. Discontinuing ineffective strategies will allow greater investment in more impactful approaches. At the same time, addressing problems for which animal shelter programs have been a perceived palliative—such as conservation of birds and wildlife—would benefit from a recognition of the true potential and limitations of the shelter-based tactics on which advocates have historically relied. These methods can be broadly divided into three categories: removal (whether for adoption, relocation, or euthanasia); sterilization and return to the location of origin; or leaving cats in place with or without referral to additional resources. In one form or another, these three categories encompass all possible responses to cats in the community.

Free-Roaming Cat Dynamics and Public Perception

Strategies for cat management in populated areas must account for the number and dynamics of free-roaming cats as well as the nature of public perception and preferences with regard to these animals. Although estimates for cat population size vary widely, the numbers are unarguably substantial: 30–80 million unowned and 70–100 million owned cats in the United States; and 10 million owned and 1.4–4.2 million unowned cats in Canada (25, 27). Between 25–85% of owned cats are kept indoors in the United States and Canada (25, 28) and >80% are sterilized (29), suggesting that while management strategies must account for both groups, unowned cats likely contribute the most to cat population replenishment and account for the majority of concerns. Unowned cats will also generally be found at higher density in modified environments where shelter-based programs tend to predominate, vs. natural habitats in which other methods may be deployed (30).

Importantly, although public and published debate has tended to center on cat "colonies" (cats living in large aggregates around a food source), such groups account for <5% of unowned cats (31–35). Scattered individual cats accessing multiple food sources are difficult to detect compared to the more visible and troublesome groups. Identification and management of dispersed cats in urban and suburban areas relies almost exclusively on the voluntary actions of community members who are in a position to notice one or a few free-roaming cats in their immediate neighborhood and raise concerns or complaints.

Reliance on public participation for management of most cats means that attitudes toward cat control must underpin any successful strategy. Multiple surveys have documented a majority of community support for TNR in the US and Canada (36, 37).

There is less data on support for management of stray cats through shelters detached from the question of euthanasia. A California survey found that 76% of respondents favored spay/neuter and return as a management strategy, while 73% also supported impoundment of stray cats and dogs (31). Although this survey did not distinguish between preferences for impoundment of cats vs. dogs, it suggests that at least under some circumstances a majority of the public are supportive of options for shelter admission as well as TNR for community animal management.

However, where shelter admission is explicitly linked to euthanasia, support falls off substantially. For instance, in a survey in the US, >80% of survey respondents reported that they would leave a cat where it is if the alternative was that the cat would be killed (38). A survey in Guelph, Ontario found that respondents believed that euthanasia at shelters was the least effective method for managing free-roaming cats, ranking only above "do nothing." Qualitative follow-up uncovered moral discomfort even where euthanasia was considered a theoretically effective option (39). In contrast, accessible spay/neuter, cat owner education, and TNR were deemed effective by more than three-quarters of respondents.

Taken together, these data indicate that many community members simply will not cooperate with shelter programs or access shelter resources if they believe the result will be probable death of a cat. Some people will continue to tolerate nuisance behaviors that could be at least partially mitigated through sterilization of the cats and education of known caregivers. Pet cats may be abandoned or added to colonies if their owners can no longer keep them but fear bringing them to a shelter. In the worst case, cats will continue to breed unchecked, and a handful of cats that might have been manageable will grow into a colony creating significant public health and wildlife risks.

Harm Reduction Opportunities Aligned With Public Preference

The problem of free-roaming cat management may benefit from the "harm reduction" approach, which has been impactful in the public health sector (40). Harm reduction methods recognize that while elimination of an undesired behavior (such as intravenous drug use or teen sexual activity) may be ideal, it is not always achievable (41). Paradoxically, interventions

that acknowledge that the behavior will sometimes occur but that aim to reduce the associated risk (such as clean needle exchange programs for IV drug users or access to birth control for teenagers) have been found to be more effective at reducing negative consequences than strictly abstinence-oriented approaches. Similarly, while there have been calls to eliminate cats on the North American continent "by any means necessary" (5), practical considerations limit the possibility that such an outcome can be achieved. Shelters practicing lethal methods create significant barriers to engagement, education, and risk mitigation, paradoxically increasing the harmful impacts they aimed to prevent. Conversely, non-lethal programs may open up opportunities to significantly mitigate risks to cats and reduce their impact on the environment. Consideration of such opportunities is an important element of evaluating the three possible shelter-based approaches provided here (removal, return, and remaining in place) (2, 12).

REMOVAL FROM THE ENVIRONMENT AS A SHELTER-BASED CONTROL STRATEGY

Removal refers to any action that results in a cat being taken from the environment where it was living and not returned. In most non-shelter management contexts this has generally meant that cats were killed, but there have been some cases of removal for relocation (22). From an ecosystem perspective, the impact of removal will be the same regardless of whether cats are killed, relocated or adopted.

Historically, shelter-based management of cats relied almost exclusively on removal, and this remains a common practice. Impounded cats may be reclaimed by their owners, adopted, relocated, or euthanized, but are not returned to the location found.

There has been a tendency to assume that removal to animal shelters is a more effective method for management of free-roaming cats compared to TNR. This likely reflects the intuitive belief that removing a cat leads to the presence of one less cat in the environment, while sterilizing and returning a cat clearly does not reduce the population by one. However, this simplistic view fails to take into account what happens when density is reduced and immigration or breeding by remaining individuals is not prevented.

In order to avoid rapid repopulation, it has been well-documented in many species that removal must reach a critical threshold. For instance, removal of over 50% of coyotes over a 2-year period resulted in drastic initial population reductions (42). However, the population rebounded to pre-removal levels within 8 months as a result of increased litter size and survival. This tendency of populations to rebound to the carrying capacity of the environment may be the basis for the old saying "Kill a coyote and two will come to its funeral."

When thus placed in the contexts of coyotes (or other highly adaptable species with whom we share urban and suburban environments, such as rabbits or racoons), the limitations of removal may seem obvious. One can easily imagine that if there are 10 coyotes living in a field and 1 or 2 are removed—whether killed or relocated—without any other modification to reduce available food or habitat, the remaining animals will quickly repopulate to the carrying capacity of the area.

Perhaps because of the emotionality of the debate about TNR and long-standing acceptance of shelter-removal in North America, the same scenario does not seem so readily appreciated when it comes to cats. It may also be that because cats are considered a domesticated species, there is a tendency to assume that different biological factors will govern their management. However, not surprisingly given their prolific and adaptable nature, the same population dynamics observed in other litter-bearing mammals have been documented in this species. For instance, when 44% of cats on a semi-isolated peninsula were removed through an intensive month-long trapping effort, the number of cats returned to pre-removal levels within 3 months (43).

On a larger scale, the critical threshold for cat population control through removal has been estimated at 50% or more in multiple modeling studies (13, 14, 16, 17). While lower than the estimates of 57% to >90% for TNR to reach a threshold of control (13, 14, 17, 44, 45), this level is still substantially out of reach for shelter-based removal programs. For instance, even at the low end of the estimated range of unowned cat populations in the US, 50% removal would require admission of 15 million cats to shelters (over 13 million more than the ∼1.34 million free-roaming/stray cats estimated to enter shelters in 2019) (46).

The gap between the number of cats currently removed and the number required to reach the critical threshold becomes even more striking when considered on a rolling vs. annual basis. Although shelter intake does show seasonality in association with a rise in summertime kitten births, admission of breeding-age animals is distributed throughout the year vs. intensively as generally modeled or applied in focused control efforts. A total of 1.34 million cats admitted annually averages to 3,659 per day, or 1 in ∼8,200 cats at the low end of the estimated unowned cat population range. There is simply no plausible biological basis to support the idea that untargeted removal of fewer than 1 in 8,000 animals on a day to day basis is effective for control.

Negative Consequences of Failed Removal Efforts

Importantly, removal short of eradication may not only fail to decrease the population, it can magnify the concerns associated with each individual. The increased breeding, birthing, and translocation of animals documented in response to lower population density has the potential to increase disease transmission opportunities and risk. Animals migrating from one location to another may introduce novel pathogens to the resident populations, including zoonotic infections. Young animals are more susceptible to contracting and shedding a number of pathogens of concern for public and/or wildlife health, such as roundworm, hookworm, and toxoplasmosis.

A juvenile-shifted age structure may also have welfare implications for the animals themselves (47). In litter bearing species, young animals suffer substantially higher rates of mortality compared to adults. For instance, the mortality rate for

kittens born to free-roaming cats is as high as 75% (48), while the mortality rate for free-roaming adult cats has been estimated to be as low as 10% (49). Thus, although preserving the welfare of cats is an important goal for most shelters, by triggering an increased birth rate in response to lower density, untargeted removal may lead to a paradoxical increase in the number of kittens suffering and dying (16).

In addition to shifting the age structure toward younger animals, greater environmental harm and risk may also result from a paradoxical increase in overall population size in response to removal. For instance, researchers evaluated the impact of removing up to 30% of cats from target areas (50). This study was intentionally designed to replicate what could be realistically achieved in open cat populations vs. the highly localized contexts in which successful eradication has been documented. Contrary to expectation that substantial removal would decrease population size, the number of cats present in the culling sites *increased* by 75% to over 200%. The authors speculated that this resulted from immigration of new individuals in response to removal of the most dominant adults. When culling was discontinued, cat numbers fell and stabilized at pre-culling levels. This led the authors to conclude: "*This study provides evidence that ad hoc culling of feral cats may be not only ineffective, but has the potential to increase the impact of feral cats in open populations*." This is an important and striking finding. Although in this case the cats were culled, removal to shelters also results in decreased density at the source and similarly takes place in open populations in which new immigration cannot be prevented. This suggests that the practice of *ad hoc* admission to shelters may not only be ineffective, but may actually increase harm to the wild populations it has aimed to protect.

Opportunity Costs of Failed Removal Efforts

A final risk of untargeted removal is the potential opportunity cost of reliance on an ineffective method to solve genuine problems. In addition to diverting resources, this may reduce incentives to identify and implement more effective solutions. Again, the management of other prolific and adaptable species provides informative parallels. For instance, the harm of reliance on ineffective methods has been hypothesized in the context of managing coyotes through removal/lethal control by federal wildlife personnel:

> "*As long as private livestock producers can externalize the costs of predator losses via government-subsidized predator control, they will have little incentive for responsible animal husbandry techniques, i.e., reduce stocking levels, clear carcasses and after-births quickly, confine herds at night or during calving/lambing, install fencing…or numerous other non-lethal preventive methods to avoid depredation.*" (51)

This theoretical scenario played out in Marin County, CA, when lethal management of coyotes was banned in the region. Producers responded by installing electric fencing and reduced livestock losses by 60–70% (52). These interventions were available previously but were not utilized to the fullest extent until the false promise of lethal control was eliminated.

Similarly, there are a number of mitigation strategies for cat-related concerns, from resolving nuisance situations to protecting wildlife and reducing public health risks. Releasing reliance on ineffective removal programs may free up resources to invest in emerging shelter-based programs as well as non-shelter-based solutions that better address these issues.

The limitations and potential harms of untargeted shelter-removal have led to a growing number of recommendations against this practice (26, 53) as reflected in the 2021 position statement from the National Animal Care and Control Association.

> "*It is the position of NACA that indiscriminate pick up or admission of healthy, free-roaming cats, regardless of temperament, for any purpose other than TNR/SNR, fails to serve commonly held goals of community animal management and protection programs and, as such, is a misuse of time and public funds and should be avoided.*" (54)

Appropriate Use of Removal by Shelters

In spite of its limitations for cat management on a large scale, there are appropriate uses for shelter removal (impoundment) of healthy cats in specific circumstances. As with TNR or other methods, *sufficiently targeted and sustained* removal has the potential to decrease or even eliminate focal groups of cats where a critical need is identified, such as in vital habitat or severe nuisance situations (16, 17). Achieving the necessary level of intensity and public support generally requires a multi-faceted approach by which friendly cats are adopted out, healthy but unsocial cats are relocated, and seriously ill or suffering cats are treated or humanely euthanized. Focused and sustained follow-up is required to ensure that populations do not rebound and should be included in the planning for any intervention effort targeting a group of cats.

Impoundment of individual cats may also be indicated under specific circumstances. This would generally include sick and injured cats and those at exigent risk due to immediate environmental factors (e.g., trapped on a median strip of a busy road, living in a building scheduled to be demolished). Impoundment would also be an appropriate response for a cat known to have been abandoned, for instance when a neighbor is aware that an owner has moved away and intentionally left the cat behind. It may also be appropriate for cats that are not sick or injured but are not thriving where they are (e.g., poor body condition, matted fur). In addition, where possible kittens should be adopted into pet homes whether through a shelter or by community volunteers.

STERILIZATION AND RETURN AS A SHELTER-BASED CONTROL STRATEGY

In recent years, an increasing number of shelters have added shelter-based sterilization and return to their methods of free-roaming cat management. This has emerged as the first wide-scale alternative to shelter-based removal programs that

predominated in North American shelters for more than a century. Sometimes referred to as Shelter-Neuter-Return (SNR), Return-to-Field (RTF), Return-to-Home (RTH) or the umbrella term "Community Cat Programs" (CCP), this approach is similar to traditional TNR in that cats in good health are sterilized, vaccinated against infectious diseases, ear-tipped, and returned to the location found (either by the finder, shelter staff, or volunteers). However, it should be noted that shelters may provide veterinary care and other services in support of community/volunteer TNR programs.

The primary differentiation of shelter-based return from TNR is the origin of the cats. In TNR programs, cats are typically trapped and transported to veterinary providers by community cat caregivers or volunteers associated with community TNR groups with the specific intent of returning the cats to their original location following sterilization. In shelter-based return programs, cats are trapped and transported to the shelter by individuals or animal control officers seeking help from the shelter for welfare, nuisance, or environmental concerns. Thus, shelter-based return has the potential to reach a wider swath of free-roaming cats than those that come to the attention of advocates in the community, notably the majority of free-roaming cats that live outside of highly visible groups clustered around a food source.

Although originally conceived as an alternative to euthanasia for cats that could not be adopted from shelters, additional benefits of shelter-based return programs have come to light, leading to their expansion to include friendly as well as feral free-roaming healthy cats. Importantly, when returned to the location of origin, cats in good body condition are likely to continue accessing whatever food source was available previously, rendering that food unavailable to other intact cats in the area and preventing the increased breeding and immigration that occurs in response to removal.

A reduction in kitten births and/or decreased translocation of individuals could explain the decrease of 29–38% in cat and kitten intake and 20–29% decrease in the number of cats picked up dead on the road reported in conjunction with shelter-based return programs (55, 56). While many factors can lead to changes in shelter intake to shelters, the decrease in these communities contrasted with steady or increasing cat intake in the years prior to the program in spite of removal by impoundment of thousands of cats annually.

Harm Reduction Opportunities in Conjunction With Shelter-Based Sterilization and Return

Sterilizing and returning cats offers an avenue for engagement with the majority of residents who believe shelters should play a role in stray animal management but are opposed to euthanasia. By engaging this substantial sector of the community, harm reduction opportunities are created that may not have been accessible to either traditional shelter-based removal or traditional TNR programs.

The presence of a cat in good body condition is a de facto indicator that a food source is present in the area where the cat was found. Even where no visible group of cats is present, it is likely that other cats are also accessing a freely available food source. Shelter-based removal generally affords no opportunity or motivation to identify this source, locate other intact cats in the area, educate caregivers, or take other mitigating actions. Shelter-based return, by contrast, affords multiple such opportunities.

Even when the motivation of the cat trapper is resolution of a nuisance issue vs. concern for cats or the environment, these individuals can be an important part of developing long-term solutions. Previously, shelters recognized many trappers who were "frequent flyers," repeatedly bringing in cats over a period of months or years. Trapping a cat provided short-term relief, leaving little incentive to address the root cause. Predictably, however, another cat would show up soon after one was removed. This is the basis for the common recommendation against trapping and relocating nuisance wildlife such as racoons or squirrels: without addressing the instigating conditions, more will eventually appear.

By contrast, when trappers are advised that cats will be returned, they can be engaged in identifying longer-term solutions. In some cases, this will involve the trapper themselves modifying their environment in some way, such as placing a lid on an uncovered trash can or bringing a bowl of dog food in from the porch. This has the benefit of reducing environmental carrying capacity (and also reducing food sources for other potentially problematic wildlife species) as well as helping to resolve complaints.

There is also a direct benefit of sterilization in reducing roaming and nuisance behaviors along with improving cat health (57). Trappers are familiar with their own neighborhood and can often identify one or more additional cats that can be targeted for follow-up TNR. In this way, engagement with complainants can help to micro-target sterilization efforts and identify those cats living outside of highly visible groups.

Return of cats can also lead directly to opportunities for education of caregivers and further mitigation. At the time of return, the cat itself may lead shelter staff to a food source and additional cats, including cats unknown to the original trapper that may be an ongoing source of kittens. Additionally, many such programs include hyper-local outreach coordinated with cat return, e.g., by placing flyers in multiple languages on nearby doors or even placing breakaway collars on the cats with information about the program. Offering low-cost spay/neuter for additional cats in the neighborhood can open the door to education on responsible feeding practices, management of cat waste and other mitigation strategies.

The practical value of engaging with caregivers and concerned community members should not be underestimated. Feeding of cats is a common behavior: between 7% and 26% of survey respondents in various studies in the US reported feeding cats they do not own, with the average number of cats fed ranging from 2.6 to 4 (31–34). Feeding of just a few cats is virtually impossible to regulate as it can take place quickly, anonymously, and on private property. Yet providing excessive food will tend to increase breeding and immigration as surely as will reducing

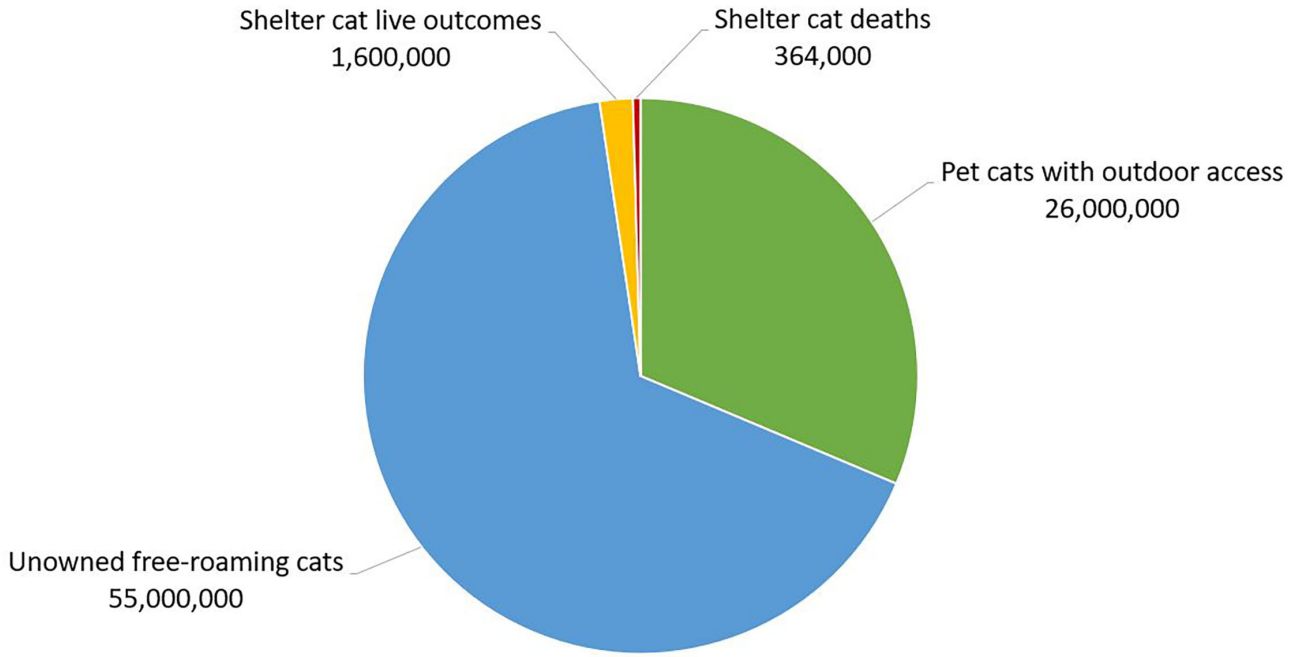

FIGURE 1 | Estimate of the number of cats in the United States with outdoor access and the number and outcome of cats taken in by animal shelters. Approximately 33% of an estimated 79 million owned pet cats are allowed outdoors at least some of the time (58). The number of unowned free-roaming cats has been estimated at 30-80 million, so a mid-point of 55 million was used (19). In this example, almost one-third of outdoor cats are owned pets, two-thirds are un-owned free-roaming cats, and <3% are managed by animal shelters (12).

cat density. This can be mitigated by guiding caregivers to feed only as much as the cat(s) will eat in 30 min or less; feeding on an elevated surface to limit access by other animals; keeping the feeding area clean and in one spot; and feeding at a consistent time of day to enable identification of which cats are present, note any newcomers, and take needed action (e.g., trap and sterilize).

LEAVING CATS IN PLACE WITH OR WITHOUT REFERRAL TO ADDITIONAL RESOURCES

Given the reality that fewer than 1 in 8,000 free-roaming cats are admitted to North American shelters on a daily basis, remaining in place is the status quo for the vast majority as shown in **Figure 1**. Additionally, for some shelters, sterilization-return is not an option due to lack of veterinary services, financial limitations, or legal barriers. For these shelters, leaving in place is the only alternative to removal. Even for shelters with ample resources, there may be instances where shelter admission is not the most effective or humane way to address a concerning situation. There is an increasing recognition that community-based care and services are often more equitable and humane as well as preferable to the costs and risks associated with shelter impoundment (59).

With these considerations in mind, the option of leaving cats where they are may benefit from more intentional use as a management strategy rather than simply being the default option most of the time. By recognizing that most cats will remain in the community, shelters can be more strategic about which cats are admitted while also investing resources in stabilizing populations and reducing harms associated with cats who remain outside the shelter's walls.

Harm Reduction Opportunities in Conjunction With Leaving Cats in Place

Leaving cats in place need not be a passive practice. Although shelter-based sterilization and return is a powerful means to open doors for communication, even a call about a cat can become an opportunity for engagement. As with other species with which we share urban or suburban environments, support and education can be provided to mitigate nuisances and reduce risks associated with cats. Strategies for coexistence include reducing attractants such as food sources, using chemical or motion activated repellants, and modifying habitat to exclude or discourage entry. These strategies are commonly recommended in the context of urban wildlife not out of any particular advocacy for racoons, skunks, squirrels or other species sometimes looked upon as pests, but rather out of simple recognition of the futility or potential harm of removal or relocation.

In the case of cats, coexistence strategies can be combined with education of cat caregivers to feed appropriately, manage waste, and most importantly, to access available services to get cats sterilized. Even where the shelter is not able to offer sterilization services directly, they may be able to provide vouchers, loan traps or even assist with transport to a local clinic.

Additional Considerations for Leaving Cats in Place/Diversion Directly to Sterilization Services

Shelter Operations Impact

Shelters have a number of critical roles to play in communities, including admitting and caring for sick and injured animals, protecting animal victims of cruelty and neglect, and rehoming pets whose owners can no longer care for them. In many communities, shelters are also on the front lines of response to disasters and other emergencies, supporting pet owners by providing safe harbor for animals in danger or distress. Protection of public health and safety is another essential shelter function, including response to dangerous animals and mitigation of zoonotic disease threats. In addition to these important reactive functions, shelters ideally serve communities best when they are able to support community members and prevent problems from developing in the first place.

When shelter resources are not overstretched by unregulated intake of healthy free-roaming cats and resultant crowding within the facility, they are better able to perform these critical functions. This was seen in many regions as intake dropped dramatically during the first year of the COVID-19 pandemic (60). Shelters that previously may have euthanized even mildly ill or injured animals found themselves with the resources to care for these most vulnerable pets. They were also able to provide safe temporary housing for animals in need, whether due to natural disaster, because the owner was sick with COVID-19, or another exigent need.

Effect on Adoptions and Rehoming Success

When shelters are not overcrowded, they are better able to provide a safety net for owned pets, reducing the number abandoned or relinquished to shelters. Even when animals do need to be admitted, the chances for adoption will be greatly increased with less crowding and competition. Fewer cats in the building means staff and volunteers can provide a higher level of care, enrichment, and treatment for each individual, reducing the number of pets that end up euthanized. This in turn is likely to improve public confidence and further reduce new abandonment of cats to the outdoors by owners who otherwise would have been reluctant to entrust their pet to a shelter's care.

Lost Pet Reunification

Reuniting lost pets with their owners is a central goal of most shelters. Contrary to the historic assumption that this goal was well-served by bringing cats to a shelter facility, leaving healthy cats in place (or returning them to the location found) may be a far better means to achieve this end. Multiple studies have now documented that cats are 10–50 times more likely to be reunited with their owners by returning home on their own or being found in the neighborhood of origin than through a call or visit to a shelter (61–63). This reality is reflected in the fact that only $\sim$ 2% of cats admitted to US shelters are reunited with their owners (64).

The low rate of owner reunification for shelter cats likely reflects common behavior patterns of both cats and owners. Allowing cats outdoor access is still a common practice in many communities, and a search for a missing cat may not be initiated until well past even the longest stray holding period in a shelter would have expired. At the same time, lost cat behavior differs from dogs. Often a "lost" cat is missing because it got trapped somewhere, was frightened and went into hiding, or perhaps most commonly, was simply enjoying a meal at another neighbor's house when a well-intended "Good Samaritan" intervened and brought the cat to a shelter. Thus, a cat may not appear in a shelter until days or even weeks after it went missing, again resulting in a mismatch between the timing of when cats are lost, when owners look for them, and when cats are in shelters.

Impoundment of free-roaming cats may disproportionately impact lower-income families, as barriers of transportation, language, cost, or simple lack of awareness of the cultural practice of impounding cats may deter pet owners from seeking their lost cat at a shelter. This may account, at least in part, for the fact that people earning <$30,000 per year were only 1/10th as likely to find a lost cat as those earning >$50,000 (63).

A more equitable, as well as more effective, approach may be to help finders reunite most lost cats with their owners without impoundment at a shelter. This could include posting photos on the shelter's lost and found website, offering services to scan found cats for microchips, and encouraging finders to post on local social media, talk to neighbors, post signs locally, and even consider placing a paper "is this your cat" collar on the cat. Advising finders not to feed cats that show up in their yards in good body condition may also encourage cats to simply go back home. Exceptions to this policy should be made whenever cats are sick, injured, in poor body condition or otherwise failing to thrive, or after efforts to reunite the cat in the neighborhood of origin have failed to identify an owner or caretaker.

Ecosystem Impact

Perhaps the most sweeping, though counterintuitive, benefit of leaving cats in place is simply the inverse of removal. As described above, untargeted removal of cats or other litter-bearing mammals leads to a destabilization of age and dominance structures, resulting in a paradoxical increase in numbers as well as potential harms. Impounding, caring for, and potentially euthanizing healthy free-roaming cats also diverts resources which could be better invested proactively.

By replacing *ad hoc* admission with solutions to sustainably reduce free-roaming cat populations to the extent possible, leveraging spay/neuter, and minimizing additional costs of impoundment by diverting most healthy adult free-roaming cats to community-based services, the overall number as well as the harmful impact and risks experienced by individual cats can be more effectively reduced.

SELECTING THE APPROPRIATE SHELTER-BASED STRATEGY

Each of the three strategies available to community animal shelters for free-roaming cat management—removal, sterilization and return, or leaving cats in place—is appropriately used under certain conditions. In non-emergency situations (e.g., the cat is not sick, injured, causing or experiencing immediate danger), an assessment should be performed of

the individual cats' circumstances and the environment in which it was found. Most healthy free-roaming cats should be referred to community resources or admitted for sterilization and return. Exceptions should be made where evidence exists of abandonment or other change in circumstances resulting in increased risk, such as where an owner is known to have left the area recently. Cats should also generally be removed rather than returned where a significant concern exists, such as presence within a critical habitat for prey species. For example, in Alachua County Florida, animal shelter and conservation managers collaborated to develop a policy to protect both wildlife and cats. The policy supports a relocation program for cats on properties specifically managed for conservation and a plan for collaborative assessment and mitigation of conservation threats on properties that are not formally defined as conservation areas. If removal is pursued in the latter case, it should be coupled with resources to meaningfully abate the issue including sufficiently intensive and sustained removal efforts and prevention of new immigration or abandonment.

In order to perform the necessary individualized assessment to tailor an appropriate response, an increasing number of shelters are replacing *ad hoc* admission with a more thoughtful approach, sometimes termed "Managed Admissions" or "Coordinated Care" (65–69). In this individualized case management approach, contact via phone or web form is made before the animal is transported to the shelter, and a situational assessment is performed to determine the most appropriate course of action. Similar to calling an "advice nurse" prior to scheduling a doctor visit, this provides an opportunity to gather information, identify whether shelter admission is the best solution, and provide alternatives where indicated.

CONCLUSION

No realistically available intervention is sufficient to completely eliminate free-roaming cats from the landscape. Traditional *ad hoc* admission to shelters is not a panacea that eliminates the concerns generated by free-roaming cats. Placing it as such in contrast to TNR has needlessly pitted the interests of cats, cat lovers, and shelter staff against the interests of wildlife advocates and public health officials. Success in solving the complex issues associated with free-roaming cats will be best served by moving beyond this false dichotomy to an evidence-based assessment of all possible approaches to management of this prolific and adaptable species.

In many communities, animal shelters will continue to play a central role in response to free-roaming cats and the concerns they generate. This role will be carried out most effectively when all sheltering agencies, public and private, are able to tailor their responses to the needs of each situation encountered: for each individual cat, is it better to be admitted to a shelter, to be altered and returned, or to remain in place with referral to resources for coexistence? We owe it to ourselves to ask this question without prejudice or pre-conceived notions, for each and every cat that might come through a shelter's doors. The result will be solutions that balance the needs of wildlife, public health, pets, and community members to the greatest possible extent and make the most effective use of all available resources.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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CONCEPTUAL ANALYSIS
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Critical Problems for Research in Animal Sheltering, a Conceptual Analysis

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Animal shelter research has seen significant increases in participation over the past several decades from academic organizations, private organizations, public entities, and even corporations that aims to improve shelter programs, processes, operations, and outcomes for the various stakeholders/participants involved in a shelter system (animals, humans, the community, wildlife, and the environment). These efforts are scattered through a huge variety of different research areas that are challenging to define and scope for organizations seeking to start new lines of research inquiry. This work aims to enumerate some of the most critical outstanding problems for research in animal sheltering in a conceptual framework that is intended to help direct research conversations toward the research topics of highest impact (with the highest quality outcomes possible). To this end, we define seven (7) key areas for research: animal behavior, adoptions and special needs populations, medical conditions, disease transmission, community, ecology, and wellness (one health), operations, and public-private-academic-corporate collaboration. Within each of these areas, we review specific problems and highlight examples of successes in each area in the past several decades. We close with a discussion of some of the topics that were not detailed in this manuscript but, nonetheless, deserve some mention. Through this enumeration, we hope to spur conversation around innovative methodologies, technologies, and concepts in both research and practice in animal sheltering.

Keywords: animal shelters, animal welfare, research problems, animal behavior, shelter adoption, disease transmission, one health

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INTRODUCTION

Animal Sheltering in Western society, in some form, has existed since the mid-1800's (with the creation of both the Royal Society for the Prevention of Cruelty to Animals and the American Society for the Prevention of Cruelty to Animals in 1824 and 1866, respectively) and has been a constantly evolving field to both the benefit (1, 2) and detriment (3, 4), of its stakeholders: animals, pet owners, communities, and the organizations that tie these groups together. In the past several decades, a cultural shift has been occurring in which animal welfare (5, 6) has received more attention, resources, and scrutiny than in the decades before. Success in sheltering is commonly measured by the Live Release Rate (hereafter LRR) that is obtained by dividing the total number of live animal outcomes (such as adoptions and transfers) by the total number of live animal intakes (7). Many cities have been able to increase their LRR and those of surrounding counties above 90

and even 95% (8), yet shelters still struggle with having adequate resources (9) and rural shelters may be more likely to struggle (10). The number of conceptual problems in sheltering is enormous, and as awareness of the needs of shelters continues to rise, more and more groups—academic, corporate, non-profit, and private—are looking for ways to contribute to the wider movement of animal welfare using their unique skills and talents. One difficulty for these potential partners is in understanding what the needs of shelters are and what high-value unsolved problems exist in the field.

Some of these are knowledge problems, others, implementation problems, and even more, systemic, cultural, and societal problems. Almost all require some manner of research to elucidate best practices and truths and differentiate them from traditions and myths. To aid interested parties in contributing to these areas of animal sheltering, we seek to enumerate and explain many of the critical problems for research in animal sheltering so that those organizations and interested parties might find a place to contribute. The key areas for future research were developed through a combination of both empirical and a priori traditions. The empirical approach used included input from animal sheltering professionals, including the responses of over 10 working groups representing more than 300 shelter professionals associated with Human Animal Support Services project to the question of what research needs were to advance animal sheltering. A priori observation and reflection of the researchers and reviews of the existing literature also helped to inform a lengthy list of research needs. These research needs were then thematically grouped in to the 7 key areas. Each of the areas was then evaluated on two factors: the degree of potential impact to animal sheltering and the difficulty in studying the problem.

Table 1 presents the 7 key areas identified. It also presents the impact potential for research in these areas by identifying the top-level impacts that advances in each topic area could have on the field of animal sheltering. While not intended to be all encompassing, this list captures the main topics generated by the authors and the consulted professionals.

Figure 1 provides an additional way of examining these topical areas. This figure provides examples of critical problems for research in animal sheltering and provides a way to compare and evaluate the areas in terms of the relative difficulty of studying the problems as well as the relative magnitude of the potential impact. In addition to evaluating these factors for the key research areas identified herein, this figures also shows a framework through which other researchers could evaluate the relative impacts and difficulty of other possible research topics.

TABLE 1 | The 7 key problem areas identified in this work and their impact potential in the space of animal sheltering. While not intended to be all encompassing, this list captures the main topics generated by the authors and the consulted professionals.

Topic area	Impact areas
Animal behavior	Reduce animal surrendered for behavior reasons, increase adoption potential of animals with known behavior issues, increase the likelihood of long-term placement post adoption.
Adoptions and special needs population	Increase lifesaving by finding economically feasible ways to increase the likelihood of placement for special needs animals.
Medical conditions	Increase lifesaving by improving outcomes for animals with medical challenges.
Disease transmission	Reduce suffering and euthanasia associated with transmissible disease. Reduce costs, stress and health hazards for shelters and their workers through novel ways to reduce transmission.
Community, ecology and wellness	Align animal welfare with other social movements aimed at increasing positive outcomes for humans, animals, and the environment.
Operations	Efficient and effective use of available resources. Reliable and valid ways to measure, compare and communicate success. Increase the number of animals that can remain in their homes to reduce shelter intake and improve human/animal welfare.
Public-private-academic-corporate collaboration	Build a body of knowledge practitioners can use. Increase the funding pool for animal welfare initiatives. Draw on the experience and expertise of a broader swath of individuals.

KEY AREAS FOR RESEARCH

Animal Behavior

Animal behavior is one of the most challenging and complex topics in animal sheltering. Leaving aside controversies surrounding the ethics of adopting out animals with known behavior challenges or the ending of the life of an animal, whether for the protection of the public, retribution for an incident, quality of life, or any other justification related to behavioral issues, such as biting or inappropriate elimination, the practical need to better understand and modify animal behavior to improve the lives of animals and their caregivers to improve their chances of adoption and/or their probability of remaining in the home (11) is substantial. Here, we highlight 4 key areas in animal behavior that may have the biggest impact in a shelter setting and that may be underrepresented in the literature.

Efforts to form a typology of dog behaviors that may be problematic in the home, and, specifically, dog behavior that may be averse to a successful adoption and retention in a home (12, 13) have been attempted in the past (14–16). Despite the interest in canine behavior in general rising sharply in the early 1990s and more recently (17), no consensus has been reached upon a singular behavioral classification and identification system that can be used to make decisions around best practices with dogs with histories of behavior problems or potential for behavior problems. Such a classification system should have the following properties [(18) for a more detailed discussion of the difficulties surrounding some of these issues]:

- Objective measurability and reproducibility.
- Characterization of common temporal progressions.
- Understood correlations between related behaviors.
- Clinical relevance to predictability and intervention.

Somewhat recent attempts (18, 19) at assessing the efficacy of behavioral evaluations have not been as promising as might be hoped given the 50+ year history of the field, and the impact of

FIGURE 1 | A Force Directed Graph showing the various problems discussed in this article. The size of a node represents the relative impact a solution would have. The color represents the relative difficulty of studying the problem (with red being more difficult). Links relate the topics. An interactive version can be found here: https://codepen.io/kevroy314/pen/jONoXma. Click to isolate nodes and their neighbors. Drag to move around. Scroll to zoom.

such a system, especially in establishing new interventions that can help these animals be successfully placed in homes, could be enormous given the extreme difficulty in achieving successful outcomes for dogs with behavior issues.

One key factor in negative animal behaviors, especially as pertaining to the adoptability of animals, is the stress they experience while in a shelter setting (20–22). Studies of animal stress date back to 1926 (23) with animals have often serving as a model for human stress (24, 25). Practical tools are needed to assess the impact of shelter environmental improvements. Using Biomarkers to assess stress (26) across species (27–29) have shown significant success in recent years. Unfortunately, the practical measurement of such biomarkers in shelter settings remains unlikely due to resource and practical constraints. Non-invasive measures of stress are possible in many species [including thermographic (30, 31), salivary (32), visual (33), and multimodal (34) systems], though their efficacy as an intervention target is unclear. A more thorough understanding of best practices around the reduction of stress for animals in shelters will allow for significant improvement in the quality of life of long-stay animals as well as the adoptability of animals that may show fewer behavioral issues once removed from a stressful environment, with some evidence showing changes in cortisol levels, a common biomarker for stress, with even a single night removed from the shelter environment in adult dogs (35).

A key element in the success of an animal with behavioral issues, post-adoption is not simply the cessation of negative behaviors, but also the match with an adopter who can maintain the environment necessary for permanent improvement in behavior as well as following up with those adopters to ensure continued success is achieved. Preparing adopters and proper matching is key given the frequency of post adoption behavioral issues among shelter animals (36). This problem comes down to two key sets of questions:

Given evidence suggesting choice of pet is often tied to factors like appearance more than behavioral considerations (37),

how should shelters best match behavioral issues with potential adopters who can handle the maintenance surrounding those issues to reduce the chance of return (36, 38, 39) and adverse incidents such as bites or escape from a yard?

What risks (i.e., environment impact on biting) (40) exist in the home that might exacerbate issues surrounding behavior?

Finally, when it comes to animal behavior, especially canine behavior, one of the most critical incidents that can occur is a bite incident since these can result in serious injury to persons and potentially result in liability claims against the shelter (41). The previously mentioned issues all likely contribute to the probability of a bite incident occurring, but predictions of such events, even in aggregate across a city (42), are challenging at best. A successful bite prediction system would also pose ethical issues as individuals, shelters, and cities may choose to use such a system to decide which animal's lives should be preemptively ended, to avoid the potential risk and liability. It is critical, therefore, that the predictability of bite incidents increase at the same rate as our ability to reasonably intervene to prevent the incidents.

Adoptions and Special Needs Populations

The core problem with adoptions at shelters is always "how do we get as many animals out to good homes as quickly as possible?." Of course, as with so many seemingly simple problems, the posing of the question in such a general manner means no obvious solutions present themselves. Properly reframing the question often begins to imply solutions. Preventing the surrender of animals to the shelter system is certainly a key component to assuring positive outcomes for animals and people alike. New programs, such as the Human Animal Support Services project, are focusing heavily on programs aimed at keeping animals out of the shelter altogether and in their original homes whenever possible. Further, this paradigm shift has the potential to profoundly impact positive outcomes for community cats, who may not be best served through adoption. Although adoption is not the only possible positive outcome for all animals that enter a shelter system, for many animals (and the humans who manage the systems of sheltering), it remains an important practical and ethical outcome. Here, we review 3 key areas in adoptions that remain complex and difficult despite extensive efforts in the sheltering community. For a more complete list of these challenge areas, see the American Pets Alive! Documentation on the topic ("American Pets Alive! Resources;" https://americanpetsalive.org/resources) (43).

First and most critically, large dogs, often considered to be those weighing over approximately 35 pounds or 16 kilograms, consistently have more difficulty in being adopted (44–46). This can be due to factors such as the general public perception around larger breeds (47, 48), city ordinances banning ownership of certain breeds (49), housing restrictions implemented at the facility level (50), or concerns around safety, behavior, and compatibility with other home residents (51). These issues are exacerbated by the difficulty in accurately identifying breed information in shelter animal populations (52). As a result of these complications around getting large breeds out of shelters, shelters often end up with a stagnant population of these animals that has less turnover than other, easier to adopt categories (puppies of any breed, for example). This can create a perception that the only populations present are these large breed animals. These factors result in many of these animals having long stays and, as mentioned in prior sections, increased stress and overall wellness difficulties that further worsen their adoptable potential. Moreover, animals in the shelter are less likely to behave the way they might otherwise in a home (53), further decreasing their chances for a positive outcome. A strategy around breaking this cycle and helping large dogs would alleviate significant amounts of trapped resources as site maintenance and housing can create substantial costs and reduce flexibility in serving other populations. The importance of providing an equal opportunity for these large breed dogs to stay in their home is one consideration beyond adoption in strategy design. For example, policies that disallow the use of size of a dog as criteria for access to housing (as discussed above) would help keep these animals out of the shelter system in the first place. Adequate access to resources to behavior training could be another community level intervention that could allow more of these animals to stay in their homes.

Other Special Populations

Beyond these major issues, there are numerous conditions of decreasing commonality that require increasingly complex adaptations of program and policy to accommodate. This article cannot enumerate all such conditions, but the following list, sorted roughly by difficulty, captures some of the most critical special needs populations that require specially trained homes to inhabit, making them more difficult to adopt out:

- Geriatric Animals.
- Animals with Chronic Allergies.
- Hospice Animals.
- Feline Leukemia Virus (FeLV) Cats.
- Kidney Failure Animals.
- Diabetic Animals.
- Behavior Animals.
- Animals with Paralysis and/or Incontinence.

Much of the care, maintenance, and treatment of these populations is well understood, but the problem of placing them in amenable homes is still a significant one. More research around interventions that can increase the likelihood of placement as well as the factors that impact the likelihood of special population placement may provide actionable insights [see (54) as an example in geriatric animals].

Finally, and significantly, a more thorough understanding of how to match adopters to animals (37, 55), how to evaluate homes for safety and longevity of adoption outcomes (13, 56), how to optimize placement of animals in homes (57), and what preferences exist when it comes to adoption practices around marketing, visitation, and engagement is desperately needed. This understanding will likely depend significantly on local cultural distinctions in populations (58, 59) and is, therefore, difficult to examine systematically. More best practices around adoption matching and marketing

would greatly simplify one of the most critical functions in animal shelters.

Unique Challenges of Cats

Another, potentially less obvious problem in sheltering is the difference in positive outcomes for cats vs. dogs. Best Friends, a national non-profit that provides the most comprehensive summary of annual shelter statistics reports that cats are still dying in shelters at a ratio of 2:1 when compared with dogs (60) despite approximately one-fourth of US households providing a home for cats (61). Many shelters consistently report difficulties in adopting out adult cats once they no longer have the appearance of a kitten (62). Further, shelter or municipal policies around the extermination of community cats (63) may also be a significant contributor to the numbers of cats not having successful outcomes in shelters.

Approaches to improving live outcomes for cats require shelters to explore ideas outside of the traditional intake to adoption framework. Some strategies that are specifically applicable to cats have been evaluated and shown to be effective such as trap-neuter-return and shelter-neuter-return, which could reduce the number of un-adoptable cats entering the shelter system (64, 65), but more research into the social drivers and potential interventions for this issue are warranted. A development of the recognition of the ecology of community cats is an additional issue that is elaborated on in Section Operations.

Medical Conditions

In addition to its capacity as an adoption agency for unowned animals, animal shelters often perform a variety of medical services. These services depend on the location, resources, and risk tolerance each organization has, and it is often difficult for organizations to decide what to treat and what to not treat (whether euthanasia is then called for or not). One critical element of this that remains a challenge for all shelters is the effective, actionable diagnosis of disease [see, (66)]. Many diseases have reliable tests (such as canine parvovirus) while others have a much more complicated history in the development of a reliable test [such as canine distemper, though many strongly claim RNA tests should be considered reliable; (67–69)]. Cost is also a critical factor in shelter tests as even a relatively inexpensive (50 dollars) test in an outbreak scenario can be entirely impractical in a population of just a few dozen animals. Further research into low-cost testing is certainly needed for a wide variety of diseases.

Once the disease is identified, shelters often lack the resources for what would be considered "standard" care in a private practice. Some shelters opt to not offer reduced care and, instead, euthanize, while others choose to offer whatever care they can within their own ethical limitations of suffering and quality of life considerations. The need for significantly more research into evidence-based medical guidelines, and especially those that are specifically optimized for triage situations with limited resources and around medical conditions seen in shelters, is widely apparent. Some conditions, such as kitten diarrhea, may be somewhat understood in a general medical sense, but the treatments and time course do not scale appropriately for the model of a medium to large shelter.

Although many diseases could use additional scrutiny for the purposes outlined above, the following are of particular interest due to the costs, in either lives or resources, associated with typical treatment or management (T; indicates specific transmissible disease relevant to Section Disease Transmission):

- (T) Canine parvovirus (70, 71).
- (T) Feline panleukemia (72).
- (T) Canine distemper (73).
- (T) Feline leukemia virus (FeLV) (74).
- (T) Feline immunodeficiency virus (75–78).
- Kitten diarrhea (79).
- Fracture and trauma management.

Disease Transmission

More so than the treatment of disease, the prevention of disease spread in the shelter environment is one of the most challenging, concretely measurable in the form of infection rates, yet ambiguous (difficult to diagnose in source) tasks a shelter may face. Shelters are examples of anthropogenic biological instability due to the housing of transient, displaced mixed-species of animals that may not have prior veterinary care or have been scavenging during times of homelessness (80). The disease transmission in shelters is further complicated by situation of overcrowding, poor levels of hygiene, and housing of multiple species which can add significant sources of stress for the animals and create a perfect environment for pathogen emergence and transmission (80). This transmission can quickly lead to a crisis in the shelter (81). Shelters that treat infectious disease like the canine parvovirus establish isolation areas in which only that disease is treated, but little is known about the ease with which these diseases spread under different quarantine practices.

Although there are many interesting diseases that are typically seen in shelters, some (such as those listed in Section Medical Conditions) are considered more impactful/deadly than others and, therefore, would make excellent targets for more detailed studies of disease spread.

While it is not officially recommended as a best practice (82), when shelters experience disease outbreaks, some may opt to depopulate, i.e., end the lives of their entire population, (83) rather than have it persist through many generations of animals flowing through the system. Better understanding of how to stem these outbreaks rapidly, efficiently, safely, in a resource-efficient manner, and given the constraints of a shelter environment (space, staffing, facility design, and the need to maintain normal operations) will allow shelters to avoid mass culling and take an approach that increases lifesaving with more confidence.

Community, Ecology, and Wellness (One Health)

Beyond the scope of the basic operations of a shelter in managing the conditions of individual animals and placing them in appropriate homes, shelters also serve a critical role in the community as providers of services that can enhance public perception and wellbeing (84). This collaboration requires an engaged community that recognizes the importance of animal welfare in the health and wellness of the larger, shared space.

Best practices around establishing this type of engagement are not well identified in the existing body of knowledge. This is further confounded by variation in the distribution of resources and community attitudes in different geographic areas.

As animal shelters continue to evolve in response to societal shifts in attitudes toward animals, the focus of operations are changing from centering on adoptions to centering on the prevention of surrender of animals to the shelter in the first place [see (11) for a review]. This has already been discussed as it relates to community cats and behavior/health but there are many other human-centered reasons that animals are surrendered to shelters such as guardian health problems, housing insecurity, domestic violence, and many others (85). Our understanding of how human welfare intersects with animal welfare has the potential to have a dramatic impact on the way shelters operate in their communities. Some communities have hotlines, spay and neuter programs, and other medical/behavioral services that can potentially contribute to this issue, but the efficacy of such systems and the gaps they leave are not well understood. More significant study of the needs of local populations as they relate to shelter success is needed.

Local populations also differ in their perception and support of shelter policies, ethics, and the local system of laws that are intertwined with these efforts. No unified system of ethics is established in animal sheltering, and communities often do not understand the nuances of practices in shelters (especially regarding resource allocations and euthanasia practices). This makes galvanizing community support difficult, even in communities that have achieved remarkably high live release rates. Public perception, messaging, and ethical alignment will undoubtedly continue to be an ever-evolving socio-cultural landscape that is sorely in need of attention.

The mental health of volunteers, staff, and veterinarians (86) in animal shelters also requires much more attention than it often receives. Individuals that participate in euthanasia are reported to have higher work stress and lower job satisfaction than their counterparts (87). Suicide rates are significantly higher in the field of animal welfare than other high-stress fields (88, 89), and more understanding and support is needing to help those working in these areas receive the help they need to continue to serve the community in a sustainable, healthy manner.

Access to Care

Access to veterinary care is emerging as a critical issue in animal welfare. Access to care is an aspect of the One Health approach to considering animal welfare due to the zoonotic potential of various diseases that can find reservoir in companion animals (90). In addition to being a risk to public health, lack of access to veterinary care can result in surrender of animals to shelters, stress to the caregiver/family (91) as well as stress to veterinarians who must counsel caregivers who cannot afford the recommended care (92). Shelters feel the impact of this as downstream recipients of animals when owners surrender due to an inability to access needed care. This can both drive surrender to shelters and result in a greater financial burden for shelters to meet medical needs that may be complicated by a historic lack of access to preventative or early intervention care. Further, shelters themselves compete in the market to employ veterinary professionals and support staff that may be further complicated by a shortage of veterinarians (93, 94).

Access to care can be seen as a problem with multiple causes from cost to lack of transportation to the unequal distribution of veterinary resources across the landscape. Cost was identified as the most common barrier to accessing veterinary care in the Access to Veterinary Care Coalition report on this issue (91). In the past decade, costs for veterinary care have been outpacing increases in human health care (95). The average American spends 47% more on equivalent veterinary care today than a decade ago (96). The functional impact of this increasing cost is that fewer people are seeking care for their pets (97) resulting in what is considered the greatest current threat to companion animal welfare in the US (91). More research that identifies efficient, effective, and sustainable solutions to the cost of veterinary care will be key for animal shelters.

Key research questions in access to care can come down to three key areas:

Advances in areas like incremental care or spectrum of care, which are not equivalent but present different perspectives on the issue of cost-benefit analyses in treatment protocols, could reduce costs and prevent shelter surrenders but could also help shelters mitigate the increasing expense of medical treatment for animals in their care.

A deeper understanding of the number of animals surrendered for medical reasons, the types of these conditions and potential treatment routes pre-surrender would also add valuable knowledge to the animal sheltering and animal welfare communities.

Development of community-based solutions that focus on disease prevention when the cost is likely lower than when a disease process is more advanced. This includes the prevention of infectious disease transmission in the community and the development of effective education around other preventable conditions by pet guardians.

Ecology/Environment

The study of the ecology surrounding community cats has received significant attention over the past several years (63, 64, 98–102), and debates are likely to continue in this area to determine the most effective ways to ensure the health and safety of community cats and the organisms with which they interact. Additionally, ecological perspectives on the interaction between stray and roaming animals in general and the community are also of interest, but often only actively studied due to concerns over infectious disease spread such as the Rabies virus. Finally, the interaction of wildlife systems with domesticated animals may be of some interest both due to the spread of infectious disease and the more complex interactions these two animal groups may have with one another.

As animal welfare incorporates a One-health approach, further research that identifies strategies to reduce the environmental impact of shelter operations cannot be ignored. Effective ways of cleaning outdoor kennels without contributing to contaminate run-off, ecological disposal of animal waste and the evaluation of how large-scale animal transport can contribute

to environmental degradation are just a few examples of the interaction of sheltering and the environment that are open for additional exploration.

Operations

In addition to the study of animal-centric, adoption-centric, and community-centric aspects of sheltering, the study of the operations that contribute to the ability of shelters to continually adapt, and advance is of critical importance if we are to have systems robust to disaster and capable of implementing our values and ethics on a global scale. Although blueprints do exist that can guide communities in setting up new shelters and enhancing existing shelters, significant problems remain in the space beyond the distribution of known solution resources. Here, we discuss 4 key operations problem areas with varying levels of complexity.

Data Problems

Shelters need to collect data to know how they are serving their animals, adopters, volunteers, staff, and community, and how to improve operations in all areas of the shelter. While the industry recognizes the need for quality data, significant barriers have been identified such as a lack of training and resources [(103), additionally, see the Associate for Veterinary Informatics (AVI) for additional information on this topic; https://avinformatics.org/]. Solutions such as ShelterLuv, Chameleon, and PetPoint for database management go a long way to improving situations for shelters, but the ability to flexibly collect and curate all manner of useful data (including electronic medical records, location-based event history, and other meta-data about entities that comprise shelters) remains an open problem. It is also essential that the prioritization and understanding of the critical importance of data is shared by line staff as well as senior management. When line staff fail to understand the importance of complete data collection this action can be de-prioritized in fast paced shelter environment.

Beyond this, shelters need methods of protecting themselves in the sharing of data with the public, academic institutions, and each other. The public, which support shelters through taxes or donations, show widespread support, for example, for programs that reduce levels of shelter euthanasia shelters (104). The best practices around of performing data sharing and managing data access for shelters have yet to be established (though some progress has been made in recent months at the Municipal Shelter level). Over time, there have been attempts to create a single authoritative collection of sheltering data but to date, none have achieved high success. The current initiative that has achieved the most progress is Shelters Animals Count (SAC). SAC is a national database that relies on the voluntary participation by shelters and animal rescues to upload monthly sheltering summary statistics. Unfortunately, there is still relatively poor participation. For example, in 2020 there was participation by only 422 municipal shelters, 359 private shelters and 516 rescues (105). This can be contrasted with a 2014 estimate by the Humane Society of the United States of 3,500 municipal and non-profit shelters and over 10,000 rescue organizations (106). Despite the move toward increasing transparency in government, only a small handful of states and municipalities require reporting to their state and local governments, with even fewer providing enough clarity as to what should be reported for such reporting to be of use to the wider sheltering community. The result of this paucity and irregularity of data provides a significant challenge to researchers and policymakers in understanding what is happening across the nation regarding sheltering, though the contributions of states in which reporting is mandated effectively have provided a valuable starting point for these efforts.

KPI Problems

Once data is collected, linking that data down to trackable KPIs (Key Performance Indicators) that are useful to shelters in improving outcomes for animals is a challenge in and of itself. The standardization of KPIs and their strict definitions has suffered from some of the disagreement and difficulties surrounding data collection. The most marked attempt to create unified KPIs occurred in 2004 resulting in the Asilomar Accords. The Live Release Rate, and methods of fairly but consistently calculating it materialized as a critical outcome of the Accords (107). This measure has never been without controversy and is limited, in part, by the wide variance in the various ways in which animal shelters operate in their community and what their priority services are (108). As the operation of shelters have changed, with more innovative programs designed to prevent animals from ever entering the shelter system appearing, advancements in medical and behavioral interventions, and the geographically biased nature of animal population distributions (109), the use of a single KPI will likely remain a source of both conflict and difficulty for many shelters. A more diverse set of KPIs will allow for shelters to perform more nuanced comparisons of their successes and failures that will enable better sharing of solutions and resources. What this list of KPIs should entail remains an open problem [see (110)].

Growth Problems

Finally, as some shelters begin to stabilize the animal welfare situation in their cities, adapting to the varying degrees and paces of growth in various organizations to ensure resources are being properly utilized to the benefit of animals and the community is a challenge, to say the least. The field of Health Economics in humans has a rich history (111), and a similar field in Animal Health Economics (112, 113) will likely need to be expanded beyond its traditional focus on production animals so that organizations are not put in a position to blindly guess at the proper allocations or resources toward different intervention programs (such as a canine parvovirus treatment program, FeLV treatment program, behavior program, or kitten foster program).

One particularly challenging program area for shelters to understand in the context of growth, integration, and resource allocation is the management of foster programs. Foster programs have been fantastically successful as a method of expanding the effective capacity of shelters, increasing live outcomes (114), enhancing community engagement, increasing quality of life of animals in care (35), and providing special assistance for more difficult to adopt populations. However, a

thorough understanding of how to best engage, utilize, and grow foster programs is lacking.

Diversity Equity and Inclusion

Researchers have evidenced that the oppression of non-human animals, disabled humans, and people of color are deeply interconnected (115). If animal shelters are to continue to function as key members of diverse communities it is essential that they pay increasing attention to issues of diversity, equity, and inclusion in their operations both internal and external. While the community of research in this space has assembled a basic understanding of some inequities that currently exist, many others have yet to be explored in a thorough way. For example, we know that African Americans are underrepresented in leadership positions (116). The homogeneity of animal shelters is not confined to the workforce alone. Two large survey-based studies found similar results in evaluating the demographics of animal welfare volunteers concluding that most volunteers were White females in the middle to upper middle class (117, 118). Questions of why this lack of diversity persists and what successful strategies could be used to improve conditions would be of benefit as representation of communities within organizations that serve them allow those organizations to supply the appropriate services to maximize the community benefit and foster a highly participatory, engaged, fair, enthusiastic, and ethical social system.

Beyond direct engagement with shelters as volunteers or employees, there are fecund areas for research in the provisioning of shelter operations. As increases in public-private partnerships place more animal shelters in the business of providing animal control operations, the enforcement of ordinances becomes a key issue in balancing public demand for action and the ethics and priorities of animal welfare. A recently published commentary on the subject argues that there is inherent bias in the design and enforcement of public policy around animal welfare and urges a shift from enforcement to resource provision (119). Evaluating policies and enforcement and implementation of these policies and whether biases are leading to unequal burden are not well understood though it is difficult to not draw comparisons to the arena of policing and the long, complicated relationship between marginalized communities and law enforcement personnel. Additional challenges persist in understanding potential inequities between the surrender of animals and the adoption of animals and whether these differences enforce equity imbalances or are based on existing biases and structural inequities (120).

Public-Private-Academic-Corporate Collaborations

A less visible and virtually unstudied problem in animal sheltering is the ability for organizational entities of different types and with different incentives to collaborate to the benefit of animals, their owners, the community, and each other. The social network analysis of Reese and Ye (121) is a prime example of the complex collaborative relationships that can emerge between organizations to advance lifesaving in a community. Many questions in this space exist around the best ways for these organizations to interact (i.e., what roles are best served by what organizations, what incentives are best to ensure ethical treatment of all parties, and what restrictions should be put on various types of interactions). Legal restrictions around the use of shelter animals in research may be a barrier that exists to research collaborations between shelters and academic institutions. Dialogue, consensus, and potential legislative change may be needed between animal shelters, the veterinary community, and academia to address the negative consequences of legislation originally intended to protect animals from harm.

Public-private partnerships in other areas of medicine have become increasingly common and valuable (122), and corporate sponsorship of shelters has become increasingly common. Public-private shelter partnerships are also on the rise with some proposing this structure as the new standard in the field (123). Academic collaboration with animal shelters, where academic institutions take advantage of the wealth of available subjects and data in shelters, is still a relatively new concept. Though many potential pitfalls exist in these collaborations (including issues with credit attribution, resource allocation, and ethical alignment), the potential to accelerate the state of the art in animal sheltering via these collaborations is huge thanks to the varied strengths of each organizational type.

DISCUSSION

The seven key areas for research in animal sheltering outlined above are not the only areas that might be of interest to shelter practitioners and their partners. Some additional areas of interest were not mentioned specifically in this manuscript due to the well-researched nature of the topics, the lack of clear definition in the space, and/or their relative distance from the typical practices of an animal shelter. These areas, nonetheless, merit some mention due to their importance to the area of animal welfare research at large and potential intersection with some shelter practices (depending on specific shelter policy, philosophy, and operations).

A variety of interventions have been proposed that might address some of the problems mentioned in this manuscript. On the behavior side, playgroup services have been proposed that may aid in social development and lead to more positive behavioral outcomes for dogs (124). Moreover, foster programs that take advantage of these and other medical or behavioral services to accelerate positive outcomes for animals deserve significant attention (35, 125). Foster programs can serve as an additional reservoir for animal populations, increase community engagement in the shelter system, and encourage positive outcomes for animals in the foster system through positive environmental enrichment in homes. In situations where foster homes are not available, additional environmental enrichment to achieve similar aims may be found through clever building and facility design at the shelter site (126, 127). Finally, a variety of programmatic and procedural interventions around lost and

found animals, self-service rehoming, and intake-to-placement optimization, and field services optimization that aim to prevent animals from entering the physical shelter facility can serve as systems optimizations that improve outcomes for all parties; though, more research is needed in these areas to examine their efficacy. Each of these intervention areas, and other innovations in sheltering, deserve significantly more attention than can be afforded in this outline, and future work should attempt to address them more directly.

In addition to a variety of community and ecology problems and interventions, ethical problems in the industry of animal sheltering are not specifically addressed in this work as these are not research topics *per se*, but more in the realm of philosophy. Future work should examine ethical questions surrounding the topics outlined in this manuscript and other sociological research questions related to the ethics of animal shelter practices.

In this work, we present a conceptual organization of topics for research in Animal Sheltering. These topics vary significantly in difficulty and impact but represent a large swath of needed scientific contributions in the literature. Many of these areas are being actively worked upon by various research institutions (i.e., significant work in animal diseases has occurred), but some have received little attention yet (i.e., operations research). Moreover, some of these areas are being examined, but due to resource and/or methodological constraints, progress is slow. By enumerating these problems, the community of researchers attempting to improve the function of shelters for animals, staff, volunteers, and the community can more carefully and wholistically consider the breadth of applicability of their ideas and investigations and hopefully, more productively contribute to the literature.

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The above document was drafted and originated by KH with review, added sections on community cats, DEI, and Access to Care and most edits provided by SN. Figures were generated by KH. Both authors contributed to the article and approved the submitted version.

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Emergency Fostering of Dogs From Animal Shelters During the COVID-19 Pandemic: Shelter Practices, Foster Caregiver Engagement, and Dog Outcomes

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Each year, millions of dogs enter thousands of animal shelters across the United States. Life in the shelter can be stressful, and one type of intervention that improves dogs' experience is human interaction, particularly stays in foster homes. Prior research has demonstrated that fostering can reduce dogs' cortisol and increase their resting activity. Despite these benefits, little is understood about the utilization of foster caregiving in animal shelters, and even less so during a crisis. On March 11, 2020, the World Health Organization deemed the coronavirus outbreak a worldwide pandemic, and subsequently a nationwide emergency was declared in the United States. Nearly all states issued stay-at-home orders to curb the spread of the virus. During this time, media outlets reported increased interest in the adoption and fostering of shelter pets. This study explores canine foster caregiving at 19 US animal shelters during the first 4 months of the COVID-19 pandemic. In our investigation, we found that shelters' utilization of foster caregiving increased from March to April 2020 but returned to initial pandemic levels by June 2020. Slightly less than two-fifths of foster caregivers were community members with no prior relationship with the shelter, and these caregivers were over four times more likely to adopt their fostered dogs than those with a pre-existing relationship to the shelter. Individuals fostering with the intention to adopt, in fact, adopted their dogs in nearly three-quarters of those instances. With regards to shelters' available resources, we found that very low-resource shelters relied more heavily on individuals with prior relationships to provide foster caregiving while very high-resource shelters more often recruited new community members. We also found that our lowest resourced shelters transferred more dogs out of their facilities while more resourced shelters rehomed dogs directly to adopters. To our knowledge, these findings represent the first in-depth reporting about

dog fostering in US animal shelters and, more specifically, foster caregiving during the COVID-19 pandemic. In total, they provide greater understanding of how monetary and human resources were utilized to affect the care and ultimately, the outcomes of shelter dogs during this time.

Keywords: dog, animal shelter, foster care, COVID-19 pandemic, welfare, adoption, emergency

INTRODUCTION

Each year, millions of dogs enter thousands of animal shelters across the United States. These dogs are most often rehomed to new adopters with a smaller proportion returned to their owners, and yet a smaller proportion euthanized (1–3). While in the animal shelter, dogs' daily experience is stressful when compared to that of dogs living in homes (4, 5), likely due to the excessive noise in kenneling areas, restrictions to movement, loss of control, lack of a routine, and social isolation [for more about these issues, see (6)]. Cortisol levels for dogs living in shelters are elevated, and dogs are less rested in this environment than homes (6–8).

Enrichment interventions, aimed at improving the dogs' proximate welfare, have been successful in improving this daily experience (9–11). Human interactions are one of the most well-studied and consistently effective interventions in the animal shelter [see (12) for a review]. One type of human-interaction intervention, foster caregiving, allows dogs to leave the shelter for a period of time, escaping the stressors of this environment. Gunter et al. (6) found that one- and two-night stays with foster caregivers resulted in cortisol reductions while in the home; and although dogs' cortisol did rise upon return to the shelter, those levels were no higher than their baseline values prior to fostering. Fehringer (13) also demonstrated that 3 days in a foster caregivers' home lowered dogs' cortisol compared to levels measured in the shelter. However, it appears that brief excursions from the animal shelter do not confer the same benefits, as dogs provided only two-and-a-half hour outings away from the shelter (typically into the community but not in a home) led to higher cortisol, not lower, even after accounting for the dogs' overall activity levels (12).

Time in a home is likely beneficial for dogs' proximate welfare as they await adoption, but it is also possible that fostering affects their ultimate welfare by facilitating placement into an adoptive home (14, 15). Trial adoption programs, in which dogs are cared for by individuals who are interested in adopting them, have been shown to reduce the likelihood of return by adopters (14). Return rates are also lower when dogs are fostered by caregivers who are responsible for their placement. Mohan-Gibbons and colleagues found that adopters of fostered dogs used information provided by foster caregivers in their adoption decision-making more often than adopters of shelter dogs used information provided by the staff who were caring for the dogs. They also found that the adopters of fostered dogs resided in different areas of the community than those adopting directly from the shelter, suggesting that placing animals in the homes of foster caregivers can expand the visibility of animals awaiting adoption (15).

Despite the potential benefits of foster caregiving, little has been characterized in the scientific literature about the prevalence and utilization of these programs in animal sheltering. In a recent survey of US animal shelters and rescues, fewer than half of the responding organizations had foster programs for their homeless pets and placed very few dogs in foster care (16). In a study of a municipal animal shelter in the American Southwest, Patronek and Crowe (17) reported that <10% of dogs that entered the shelter from 2015 to 2016 were placed in foster care, with many of the dogs needing behavioral or medical treatment prior to adoption. Nearly 98% of these fostered dogs had a live outcome (i.e., adoption or transfer to another agency) compared with the overall rate for dogs that was under 90%.

Over 90 million households in the US, equaling 70% of all households in the country, own a pet (18). Hazardous events, such as natural disasters, can have profound effects on the lives of pet owners and their animals. During Hurricane Andrew in 1992, tens of thousands of pets were abandoned in southeast Florida, and over a thousand dogs and cats were euthanized because animal welfare agencies had nowhere to house them (19). Since the 1990s, animal sheltering's response to natural disasters has improved and continues to do so. For example, when Hurricane Charley impacted southwest Florida in 2004, the euthanasia of pets because of a lack of physical space was virtually non-existent, due in part to a coordinated emergency response and a local network of foster caregivers who took animals into their homes (20). Hurricane Katrina and its aftermath impacted hundreds of thousands of owners and their pets, but the event was a catalyst for change. Emergency management and disaster response became more inclusive of people with their pets. Animal transport, born out of the necessity of moving dogs and cats out of hurricane-affected areas, has now grown into a vast network of animal shelters and rescues, moving animals from in-need shelters to those that are more resourced (21, 22).

On March 11, 2020, the World Health Organization (WHO) declared the coronavirus outbreak a worldwide pandemic (23); and 2 days later, the US president declared a nationwide emergency with all states approved for disaster assistance (24). Unlike other types of disasters, the COVID-19 pandemic differed in significant ways for people and their pets. It was not a localized geographic or meteorological event, and there was no widespread destruction of infrastructure. Instead, animal shelters, pet owners, and foster caregivers continued to have the capacity to house their pets. In March and April 2020, 90% of American states or parts of American states issued stay-at-home orders for their residents (25). This resulted in an unprecedented number of people remaining in their domiciles,

discouraged to travel or physically interact with non-cohabiting friends and family.

During this initial phase of the pandemic, veterinary medicine programs specializing in the care of animals in shelters recommended decreasing the number of on-site staff to help curb the spread of the disease. To do this, shelters were encouraged to reduce the intake of new animals, find adoptive homes for the animals that were living in the shelter, and place the remaining pets into foster care (26). As such, many shelters implemented these operational changes, including seeking new foster caregivers within their communities (27). Media outlets reported that animal shelters across the United States were receiving increased inquiries about fostering and the adoption of pets (28, 29). In the present study, we explored the utilization of foster caregiving at 19 US animal shelters during the first 4 months of the COVID-19 pandemic. Additionally, we examined qualities of the shelters and foster caregivers that were related to foster care utilization as well as the outcomes for dogs that participated in these foster programs.

MATERIALS AND METHODS

Animal Shelters

Animal shelters utilizing canine fostering in March 2020 were eligible to participate in the study. Organizations and their staff that expressed interest in participation, in response to email and online announcements, were contacted, and those that were able to collect data about their canine foster care programs were enrolled in the study.

These shelters provided demographic information about their organizations, including location, admission policy (i.e., open, managed, or limited admission), organization type (i.e., municipal, private non-profit, or private non-profit with municipal contracts), and 2020 operating budget. Open admission was defined as those facilities with unrestricted intake of animals in the areas they served. Shelters with managed admission policies controlled the arrival of animals coming into their facilities while limited admission shelters restricted the animals accepted into care (30). We also collected the number of animals that were brought into the shelters in 2019 as well as that year's live release rate for dogs (calculated by dividing the total live outcomes for dogs by all outcomes for dogs that came into care).

To learn more about the shelter's processes and procedures, we queried the shelters about the presence of a foster program prior to the pandemic, whether they conducted behavioral and dog-to-dog assessments, as well as whether the organization had behavior staff. We also asked whether the shelter had reduced the number of in-house veterinarians able to perform spay-neuter surgeries during the first 4 months of the COVID-19 pandemic and whether such surgeries were required prior to adoption. Additionally, we gathered more information about adoption procedures during this time, including their requirements for meeting adoptable dogs, the handling of adoption paperwork, and how the physical acquisition of the animal was conducted. (Adoption procedures about paperwork handling and animal acquisition methods were not mutually exclusive categorical variables).

Dogs and Foster Caregivers

Dogs placed into foster care and included in this study's dataset did so from the date of the WHO's declaration of a global COVID-19 pandemic, March 11, 2020, until June 30, 2020. Animal shelter staff determined which dogs in their care were suitable for fostering, identified dogs with continuing behavioral or medical needs as well as the criteria and training for foster caregivers. While each shelter determined what defined ongoing needs, common behavioral issues included dogs that were shy or nervous around people, did not get along with other dogs, or were failing to thrive in the shelter environment. Continuing medical needs often included dogs that were on medication, such as antibiotics, treatment for ear or eye infections, or pain control, or monitoring post surgery. The duration of foster care was decided upon by shelter staff and their caregivers.

Foster experiences were categorized as being either puppy fostering (dogs under 8 weeks of age) or dog fostering (dogs 8 weeks and older). Data about dogs that were fostered by potential adopters (people primarily interested in adopting those dogs) were also collected, though on a more limited basis, as these experiences were typically carried out by adoption, not foster, department staff.

We collected information about the animals using the shelter's database system and other sources including intake date and type (i.e., stray, owner surrender, returned adoption, transfer in), estimated date of birth, sex, weight, date of spay-neuter (if not already altered when brought into the shelter), and the animal's outcome (i.e., adoption, rescue/transfer, euthanasia). For dogs that were adopted by their foster caregivers, length of stay calculations ended when they notified staff of their intention to adopt, in order to account for additional time processing paperwork or other shelter procedures that may increase these lengths of stay.

Additionally, we categorized the timing of an animal's spay-neuter surgery (based on intake, surgery, foster entrance and exit dates) as having occurred: (1) prior to arriving at the shelter, (2) in the shelter, (3) during foster care, (4) while in a foster-to-adopt, (5) after a foster caregiver informed the shelter of their intention to adopt, or (6) after the dog was adopted or transferred to a rescue. Shelter staff also indicated whether the animal bit a person or dog during its foster stay and the reason foster care ended, such as adoption, a scheduled return as coordinated by the shelter, or a behavioral, medical, or caregiver-related issue. **Table 1** describes these categorizations and specified reasons associated with them.

We collected information about the foster caregivers, including the caregiver's age, number of dogs in their home, the method by which the caregiver obtained their foster dog (i.e., placement of the animal inside the caregiver's vehicle, or the caregiver collecting the dog by coming inside or outside of the shelter), and whether the foster caregiver adopted their fostered dog. We also characterized the caregiver's relationship to the animal shelter. These foster caregiver roles were: (1) a member of the community who had not previously fostered for the organization, (2) a volunteer fostering for the first time, (3)

TABLE 1 | Categorization of reasons for the return of a fostered dog.

Category	Specific reasons
Adoption	Fostered dog is being adopted
Behavioral	Behavior of the fostered dog and/or resident pet(s) has become undesirable or unmanageable during fostering
Medical	Fostered dog has undesirable or unmanageable medical needs
Caregiver-related	Travel, change in schedule, change in housing, personal circumstances of foster caregiver, foster experience was not meeting caregiver's expectations, health of the foster caregiver, their household, or resident pet(s)
Scheduled return by the shelter	Adoption marketing of fostered dog, transfer to another animal welfare organization, placement with another foster caregiver

a returning caregiver who fostered prior to the pandemic or more than once during pandemic, (4) a community member (role 1) fostering again, (5) a staff member, (6) a finder of a lost dog in the community who agreed to foster the dog, or (7) an owner rehoming their pet with the assistance of the shelter and continuing to care for their pet during that time. For the purposes of our study, finders and owners, who represented a very small portion of foster caregiving, were aggregated into a single category.

Foster Utilization Ratio (FUR)

To understand the utilization of foster caregiving at each shelter and across our multi-shelter dataset, we calculated a Foster Utilization Ratio (FUR) by counting the number of dogs and puppies in foster care each day divided by the daily number of dogs and puppies with foster caregivers and those in the shelter combined. To determine the number of dogs in foster care on any given day, shelters' data collection spreadsheets were used to tally the number of dogs currently recorded as being in foster care. To establish the number of dogs living in the shelter, daily inventory and population reports were used. (Thomasville–Thomas County Humane Society was not included in this analysis as their recordkeeping did not allow for this type of data to be collected on a daily basis.) When discrepancies were found in a shelter's records about a dog's location, we used other methods to resolve those inconsistencies, including investigating database records and conversations with staff. A shelter's monthly FUR reflects the monthly average of their daily FUR.

Statistical Analysis

Because this study was a natural experiment in its design, we used chi-square goodness of fit tests to test for distribution differences among various shelter, dog, and foster caregiver demographic variables; and Pearson correlation tests to measure the linear relationships between dogs' length of stay and adoption procedures. Test assumptions were checked through descriptive statistics.

With chi-square analyses, all cells contained at least one observation, and 80% or more contained at least five observations. In cases where cells contained less than five observations, categories were either combined with other logically consistent categories or removed from the analysis if the categories had consistently low counts. When conducting correlational analyses, variables were reviewed for normality and outliers. With the exception of dogs' total length of stay, no substantial outliers were found. Outliers in dogs' total length of stay were verified but remained in the dataset.

A multiple linear regression analysis with backward elimination was used to determine whether a shelter's average foster utilization could be predicted from its organization type, admissions policy, budget, canine intake, live release rate, or canine length of stay. Dummy variables were created for all categories within the variables of organization type and admissions policy, except for private non-profit and open admission, as these were the largest groups within these predictors and were used as the comparison groups.

To test whether FUR values differed across time, by organization type, or in an organization-by-month interaction, we analyzed shelters' FUR values with a linear mixed model. Shelter and intercept were entered as random effects. Month, organization type, and an organization-by-month interaction along with the covariate of the previous year's average length of stay for dogs were entered as fixed effects. (The factor of organization type and covariate of average length of stay were identified in the multiple linear regression analysis.) A variance covariance matrix was employed, and a diagonal covariance matrix for the repeated time point measure. The method of Restricted Maximum Likelihood (REML) was used for estimating parameter values.

Ethical Statement

Study procedures were approved by the Arizona State University Institutional Review Board (STUDY:00008751).

RESULTS

Shelter Demographics, Processes, and Procedures

Data were collected from 19 animal shelters across the United States. Shelters differed in their geographic location, admission policy, organization type, number of dogs brought into their facilities the previous year, and number of dogs and foster experiences that they contributed to the dataset (**Table 2**). Four animal shelters concluded data collection earlier than June 30, 2020: Carroll County Animal Services, Thomasville–Thomas County Humane Society, and Roice–Hurst Humane Society ended on June 29, 2020; and City of Irving Animal Services on June 26, 2020. (The municipalities where these shelters were located lifted their stay-at-home orders prior to June 30, 2020).

Over three-quarters (78.95%) of animal shelters were private, non-profit organizations with one-third of these organizations fulfilling contracts with neighboring municipalities. Nearly two-thirds of shelters (63.16%) were open admission facilities with the remaining either managing (21.05%) or limiting (15.79%) their

TABLE 2 | Location of animal shelter, organization type, admission policy, 2019 canine intake, and number of dogs fostered & foster experiences recorded (March 11–June 30, 2020).

Shelter demographics				Study participation		
Shelter	**State**	**Organization type**	**Admission policy**	**2019 canine intake**	**Dogs fostered**	**Foster experiences**
Animal Care Sanctuary	PA	Pnp	Limited	387	28	31
Carroll County AS	GA	Municipal	Open	2471	29	29
Irving AS	TX	Municipal	Open	2650	30	32
Stockton AS	CA	Municipal	Open	6374	79	88
Good Shepherd HS	AR	Pnp	Limited	121	15	21
HS of Pinellas	FL	Pnp	Managed	1386	84	102
HS of Wicomico County	MD	Pnp+Contracts	Open	795	68	76
Nashville Humane Association	TN	Pnp	Limited	2604	414	603
New River HS–Fayette County ACC	WV	Pnp+Contracts	Open	1025	109	115
Pasadena HS & SPCA	CA	Pnp	Open	3659	89	101
Pets in Need	CA	Pnp+Contracts	Open	825	63	140
Roice–Hurst HS	CO	Pnp	Open	424	47	52
Sand Springs Animal Welfare	OK	Municipal	Open	531	18	18
Souris Valley AS	ND	Pnp	Managed	252	13	13
St. Hubert's Animal Welfare Center	NJ	Pnp	Managed	4363	197	238
Thomasville–Thomas County HS	GA	Pnp+Contracts	Open	1153	62	74
Wadena County HS	MN	Pnp	Open	560	95	117
Wisconsin HS	WI	Pnp	Open	4841	112	128
Young–Williams Animal Center	TN	Pnp+Contracts	Managed	4566	431	597

Shelter abbreviations: AS, Animal Shelter; HS, Humane Society; ACC, Animal Control Center; SPCA, Society for the Prevention of Cruelty to Animals. Organization type abbreviations: Pnp, Private non-profit; Pnp+Contracts, Private non-profit with municipal contracts.

admissions. All shelters except one had some sort of dog fostering program prior to the pandemic.

For the year prior to the pandemic, live release rates (LRR) for dogs varied across shelters, with an average rate of 93.66% (SD = 9.61) with a range of 67.00 to 99.80%. Shelters' annual operating budgets for 2020 ranged from $100,000 to $12,000,000 ($M$ = 2,840,497, SD = 3,733,186). Their mean yearly animal intake for 2019 was 3,956 animals (SD = 4,313) with a range of 223 to 16,357 animals. By using annual operating budgets and intake of animals, we estimated each shelter's available resources on a per animal basis. Based on this calculation, shelters were categorized into five resource groups, due to clear breaks in the resource ranges: very low ($116–207/animal), low ($304–396), moderate ($557–734), high ($837–990), and very high ($1,547 −2,305). **Table 3** describes the average and median operating budgets and annual intakes by resource group, including the count of shelters and animals within each group.

Concerning the processes and procedures used by shelters, slightly more than half were conducting routine behavioral assessments with their dogs (52.63%), and 57.89% of organizations were assessing dogs' abilities to interact with other dogs. Of the shelters that were conducting dog-to-dog assessments, 45.45% were conducting them one-on-one with another dog, another 45.45% used a combination of one-on-one and group interactions, and the remaining shelter was assessing dog skills while out in groups with other dogs. More often than not, organizations did not have behavior personnel on staff. During the first 4 months of the pandemic, nearly two-thirds of shelters (63.16%) stopped or reduced the number of spay-neuter surgeries they were performing, and over a quarter (26.32%) were not requiring spay-neuter prior to adoption. **Table 4** describes these processes and procedures, including counts and percentages of shelters in each category.

With regards to shelter adoption procedures during the early months of the pandemic, nearly 90% of organizations did not require all family members to meet the dog prior to adoption, and only 21.05% of shelters required meetings between any resident dog(s) and the shelter dog. In fact, over three-quarters of shelters (78.95%) had no meeting requirements whatsoever prior to adoption. As for the meet-and-greet venues, 84.21% of organizations were conducting meetings between adopters and dogs at the shelter, and 42.11% of shelters had foster caregivers handling meet-and-greets with potential adopters. Nearly all shelters (94.74%) were processing adoption paperwork at the shelter with the adopter, and 78.95% were processing it online with their adopters. Almost one quarter (26.32%) of shelters had foster caregivers handling the adoption paperwork in person with the adopters of their fostered dogs, and only one shelter had foster caregivers handling the paperwork online with them. Except for one shelter, all facilities were open for adopters to pick up animals inside their buildings. Over half of the shelters (52.63%) utilized a drive-through method of placing adopted animals directly in adopters' vehicles without

TABLE 3 | Shelter resource levels and associated annual budgets, animal intake numbers, and resources per animal.

Resource level	*M, Mdn* Annual budget	Annual budget range (Min–Max)	*M, Mdn* 2019 Animal intake	2019 Animal intake range (Min–Max)	*M, Mdn* Resources per animal	Resources per animal range (Min–Max)	Shelters	Animals
Very Low	973K, 538K	100K–2.71M	2341, 1743	862–4418	162, 162	116–207	4	186
Low	1.32M, 1.52M	250K–3.70M	3526, 2018	726-9344	353, 355	304–396	4	304
Moderate	6.40M, 5M	2.20M–12M	9605, 8971	3486–16357	636, 618	557–734	3	957
High	2.30M, 668K	391K–6M	2502, 1591	467–6797	928, 954	837–990	5	404
Very High	4.66M, 1.6M	370K–12M	2891, 694	223–7575	1837, 1659	1547–2305	3	132

M, Millions; K, Thousands. Annual budget and resources per animal and their associated ranges are in US$. Resources per animal is an estimated value calculated by dividing a shelter's annual budget by the previous year's number of animals brought into the facility.

TABLE 4 | Behavior and veterinary processes and adoption procedures undertaken by shelters during the COVID-19 pandemic.

	Shelters	% (of shelters)
BEHAVIOR AND VETERINARY PROCESSES		
Behavior		
Routine behavioral assessment	10	52.63
Dog-dog assessment	11	57.89
One-on-one with another dog	*5*	*45.45*
Combination of one-on-one & group interactions	*5*	*45.45*
Group interactions	*1*	*9.09*
Behavior personnel on staff	8	41.60
Veterinary		
Stopped or reduced number of spay-neuter surgeries	12	63.16
Reduced number of in-house veterinarians	7	36.84
Reduced partnerships with outside veterinary clinics	3	15.79
Did not require spay-neuter surgery before adoption	5	26.32
ADOPTION PROCEDURES		
Meeting requirements		
Humans in the household	2	10.53
Dogs in the household	4	21.05
Meeting location		
Meet at shelter	16	84.21
Meet at foster caregiver's home	8	42.11
Paperwork location		
Completed at shelter	18	94.74
Completed with foster caregiver	5	26.32
Completed with shelter, remotely	15	78.95
Completed with foster caregiver, remotely	1	5.26
Adopted dog pick-up		
Inside the shelter	18	94.74
Drive-through, at shelter	10	52.63
At foster caregiver's home	11	57.89

All bolded categories include processes and procedures that are not mutually exclusive, except for dog-dog assessment. Shelter staff conducted these assessments either one-on-one with another dog, in group interactions with multiple dogs, or used a combination of both methods. The associated percentage of shelters is reflective of only those conducting dog-dog assessments.

the adopters coming into the shelter, and 57.89% were allowing adopters to pick-up their dogs directly from the foster caregiver's home (**Table 4**).

Between March 11 and June 30, 2020, 1,155 dogs and 323 puppies were placed into foster care, and 747 dogs were fostered by potential adopters at 19 animal shelters for a total of 2,225 animals. Most of these animals entered their shelters as transfers from another facility (40.18%). Over a quarter arrived to the shelter as a stray (28.42%), and one fifth were surrendered by their owner or were a failed adoption (20.25%). Males and females were practically equally represented (males: 50.78%). Excluding puppies, dogs were slightly over 3 years of age at the time of entering foster care (M = 38.47 months, SD = 36.16) and weighed, on average, 17.64 kg (SD = 10.43). Since dogs could be fostered more than once during data collection (such as multiple foster experiences during a single shelter stay or across multiple shelter stays), we also collected information about their individual foster experiences. Overall, dogs and puppies had 1,331 and 371 foster experiences, respectively, and there were 869 foster-to-adopt experiences for a total of 2,571 foster experiences.

Foster Caregivers and Their Experiences

When describing the caregivers that provided fostering, 39.60% were new caregivers in the community, fostering for this shelter for the first time. Almost five percent (4.88%) were already volunteering for the organization but had never fostered prior to the pandemic. Over a third of foster caregivers (34.49%) had previously fostered for the organization, and 12.81% were new caregivers that started fostering during the pandemic and returned to foster again. Over seven percent of caregivers (7.29%) were staff, and less than one percent were finders and owners fostering dogs. **Table 5** provides the foster caregivers and their relationship to the shelter by foster type. For statistical analysis, caregivers were further categorized as having a relationship (or not) to the shelter. Those individuals considered to have a prior relationship included staff, returning foster caregivers, shelter volunteers who were fostering for the first time, and new caregivers that began fostering during the pandemic but returned to foster more than once. (Dogs that were fostered by the finder or owner were excluded from relationship analyses. The incidence of these fostering situations was quite rare, and it was unclear whether these individuals had a preexisting relationship with the shelter).

The average age of foster caregivers was 36.01 years old (SD = 13.07). We found that the presence of a dog was not equally

TABLE 5 | Foster caregivers and their relationship to shelter by fostering type and number of resident dogs living in the home.

Caregiver's relationship to the shelter	Fostering type	*n*	Number of resident dogs (% of foster caregivers)				
			0	1	2	3	4+
No prior relationship							
New community member	Puppy	52	71.15	21.15	5.77	1.92	–
	Dog	622	74.60	18.33	5.14	1.29	0.64
Prior relationship							
Shelter volunteer*	Puppy	16	62.50	18.75	12.50	6.25	–
	Dog	67	70.15	19.40	4.48	5.97	–
Returning community member**	Puppy	72	80.56	12.50	6.94	–	–
	Dog	146	69.86	15.75	4.11	2.74	7.53
Returning foster caregiver	Puppy	187	28.88	15.51	27.27	17.11	11.23
	Dog	400	43.75	29.00	11.00	12.00	4.25
Staff	Puppy	44	–	34.09	20.45	20.45	25.00
	Dog	80	10.00	20.00	13.75	27.50	28.75
Finder/owner	Puppy	0	–	–	–	–	–
	Dog	16	43.75	18.75	18.75	–	18.75
Overall		1702	56.52	20.68	9.93	7.58	5.29

*Puppy fostering is the caregiving of puppies that are under eight weeks of age when fostering commences. *Shelter volunteers are foster caregivers that volunteered at the shelter but had not previously fostered. **Returning community members are new community members that fostered again. The category of finder/owner was excluded from relationship analyses.*

distributed across foster types, $X^2(1, N = 1686) = 196.84$, $p < 0.0001$. Puppy caregivers were more likely to have resident dog(s) in their home (57.14%) as compared to adult dog foster caregivers (39.67%). Additionally, if a foster caregiver of either type was dog-owning, the caregiver most often had one dog (47.57%) followed by two (22.84%), and three (17.43%), and the smallest proportion of homes were those that had four or more dogs (12.16%). This pattern of fewer foster caregivers as the number of resident dogs increased in the home was consistent for both puppy and dog caregivers (**Table 5**).

During the pandemic, novel approaches to foster animal pickup were implemented in an effort to increase social distancing and reduce the spread of the coronavirus. The most common approach included a drive-through style in which caregivers remained in their vehicles, and shelter staff placed foster animals inside. Around one third of foster experiences (36.13%) began this way. A further third (31.73%) were more typical, with the caregiver going inside the shelter to collect their foster animal. Almost one quarter of pickups were conducted outdoors with shelter staff (28.38%), and 3.76% occurred in some other way (i.e., foster caregiver swap, delivery of dog by the shelter to the foster home, or if a finder of a lost dog became its foster caregiver).

To understand whether resources influenced the types of caregivers that were fostering at these organizations, we tested whether relationship type (those with and without a prior relationship to the shelter) and individuals that fostered with the intention to adopt, were equally distributed among shelter resource levels. We found that the types of foster caregivers differed significantly by resources ($X^2(16, N = 1719) = 160.12$, $p < 0.0001$). Very low-resource shelters utilized more caregivers with prior relationships to their organizations during the pandemic, representing 78.79% of all foster experiences. Conversely, the largest proportion of foster caregivers at the highest resourced shelters were new foster caregivers from the community (60.63%). Lastly, moderately resourced shelters showed a far higher rate of foster-to-adopt arrangements (43.77% of foster experiences) versus the next closest foster-to-adopt rate demonstrated by high resource shelters (32.84%).

Approximately a fifth of foster experiences were with dogs that had additional behavioral needs when they entered foster care. Puppies needing behavioral management were virtually absent (0.62%). Dogs and puppies needing medical management represented 32.90 and 21.67%, respectively, of foster experiences. Bites to a person or animal rarely occurred. Only 15 bites (1.1% of dog foster experiences) were reported, with a roughly even split amongst incidents involving other dogs (seven bites) and people (eight bites). Additionally, bites were more often inflicted by dogs without known behavioral concerns (66.66%) compared to those that did (33.33%).

We found the reason that foster care ended significantly differed by foster type ($X^2(5, N = 686) = 141.02$, $p < 0.0001$). Not surprisingly, puppies most often had a scheduled return to the shelter (44.74%), likely due to their age (i.e., reaching 8 weeks) and a change in availability, followed by a return for adoption (39.62%), with 11.33% returning to the shelter due to issues related to their caregiver. The majority of adult dogs (62.43%) left foster care because of a potential adoption, with 16.30% having the return previously scheduled by the shelter, and 9.02% returning to the shelter for behavioral issues. Returns of

TABLE 6 | Proportion of foster care returns by reason and fostering type.

Reason foster care ended	Puppy	Dog
Adoption	39.62	62.43
Behavioral	1.08	9.02
Medical	3.23	2.10
Caregiver-related	11.33	10.15
Scheduled return by the shelter	44.74	16.30

fostered dogs that were caregiver-related comprised 10.15% of foster experiences (**Table 6**).

We also examined whether dogs that were sent out to foster care in need of medical or behavioral management were returned by their foster caregivers for a similar issue. We found 49 out of 288 behaviorally managed foster experiences ended for behavioral reasons, representing 17.01% of all foster experiences that needed behavioral management. Conversely, dogs without behavioral issues were returned in 5.30% of foster experiences, and this difference in returns between dogs with and without behavioral management was statistically significant, $X^2(1, N = 1{,}702) = 48.57$, $p < 0.0001$. We found that 23 out of 508 foster dogs needing medical support were returned because of medical issues, representing 4.53% of all medically managed foster experiences. This is significantly more than the 1.42% of non-medically managed experiences in which dogs were returned ($X^2(1, N = 1{,}702) = 14.96$, $p = 0.0001$). Though statistically significant, its practical significance may be limited.

Fostered Dogs: Outcomes and Length of Stay

Over 93% of fostered dogs and puppies had positive outcomes: 83.35% were adopted to new owners, most often directly from the foster caregiver's home or from the shelter with just a very short time at the facility prior to pick-up. Transfers to other agencies for placement constituted 9.45% of outcomes, and a minuscule percentage (0.27%) of dogs were returned to their owners. More puppies were transferred out (15.02%) than adult dogs (7.82%). At the end of the study, slightly over five percent of both dogs and puppies remained in the care of their organizations, either in a foster home (4.15%) or at the shelter (1.22%). Less than two percent of all fostered animals had negative outcomes: 0.34% were lost in care (and unable to be found), 0.20% died in care, or were euthanized for behavioral (0.54%) or medical (0.48%) reasons; however, no puppies were euthanized for behavior.

Combining both time in the shelter and foster care for an animal's total length of stay, dogs (both those fostered by potential adopters and foster caregivers) and puppies spent an average of 43.35 days ($SD = 51.49$, $Mdn = 31.00$, IQR = 40.00) in the care of their organization. When considering separately the duration of that time that was spent in foster care, these animals were fostered an average of 19.52 days ($SD = 23.99$, $Mdn = 11.00$, IQR = 21.25) with a range of 0 to 176 days. A value of zero for length of stay refers to someone who cares for a dog they found that is then reunited with its owner within the same day. Additionally, we found that age was positively correlated with adult dogs' length of stay (r (1,702) =0.124, $p < 0.0001$), such that as a dog's age increased, so did their time in foster care.

When examining dogs' lengths of stay, we found that the number of days spent in foster care was not uniformly distributed across foster type ($X^2(1, N = 1{,}686) = 131.22$, $p < 0.0001$). Dogs that left the shelter with potential adopters remained in their care for an average of 16.18 days ($SD = 26.60$, $Mdn = 6.00$, IQR = 14.00) while fostered dogs spent 20.93 days ($SD = 22.68$, $Mdn = 13.12$, IQR = 22.15) and puppies, 22.29 days ($SD = 22.17$, $Mdn = 16.98$, IQR = 22.02) in foster care. Furthermore, this duration in foster care differed if the dogs were adopted by their potential adopter or foster caregiver. Adopted foster-to-adopt dogs spent 15.74 days ($SD = 23.62$, $Mdn = 7.00$, IQR = 16.62) with their potential adopter and 17.37 days ($SD = 33.36$, $Mdn = 3.00$, IQR = 12.75) if the person did not adopt. Dogs that were fostered by a caregiver who adopted them, spent on average 28.58 days ($SD = 25.21$, $Mdn = 21.08$, IQR = 26.02) in foster care, and 19.61 days ($SD = 21.16$, $Mdn = 11.94$, IQR = 20.58) when the caregiver did not adopt; while puppies were fostered for an average of 41.61 days ($SD = 33.13$, $Mdn = 34.71$, IQR = 29.03) if their caregivers adopted them, and only 20.77 days ($SD = 19.20$, $Mdn = 16.14$, IQR = 20.20) if they did not.

We found that the lengths of stay of dogs and puppies were not uniformly distributed across surgery timing categories, $X^2(5, N = 1{,}471) = 17.04$, p =0.004. As expected, dogs that arrived already spayed or neutered had the shortest length of stay, on average, with 43.59 days ($SD = 52.03$, $Mdn = 28.50$, IQR = 41.75). For puppies, their length of stay was shortest when altered after adoption. Conversely, dogs that were altered during foster care had, on average, the longest length of stay (90.66 days, $SD = 241.94$, $Mdn = 45.50$, IQR = 49.00). Puppies had the longest lengths of stay when they were spayed or neutered during their time with a foster caregiver. **Table 7** provides the counts of fostered dogs and puppies and associated lengths of stay in each of the surgery timing categories.

In considering the associations between dogs' length of stay and various adoption practices used during the pandemic, many of these practices were often carried out (e.g., completing adoption paperwork at the shelter or remotely) or not carried out (e.g., required meetings for humans or dogs in the household) by a majority of participating shelters (see **Table 4**), creating the possibility that detected correlations may be more reflective of those shelters and less about the particular practice itself. With this in mind, we examined three practices in which shelters were equally or nearly equally split in their usage: allowing potential adopters to meet with foster caregivers, and two types of adoption pick-up methods, at the foster caregiver's home and drive-through at the shelter.

To identify potential relationships between these adoption practices and dogs' foster length of stay, we used Pearson correlation tests. (In these analyses, we excluded dogs that had behavioral or medical concerns that could have impacted their lengths of stay as well as dogs that were adopted by their foster caregivers.) We found that when shelters allowed potential adopters to meet fostered dogs at the caregiver's home, these dogs had shorter lengths of stay in foster care ($M = 13.72$ days, SD

TABLE 7 | Length of stay (in days) by timing of spay-neuter surgery and fostering type.

Timing of spay-neuter surgery	Fostering type	*n*	*M*	*SD*	*Mdn*	IQR
Before intake to the shelter	Puppy	1	38.00	–	38.00	–
	Dog	443	43.59	52.03	28.50	41.75
At the shelter	Puppy	99	37.36	20.24	38.00	36.50
	Dog	301	48.86	49.76	33.00	39.00
In foster care	Puppy	10	57.70	26.33	53.00	13.25
	Dog	62	90.66	241.94	45.50	49.00
During a foster-to-adopt	Puppy	36	56.08	27.45	50.00	34.00
	Dog	68	57.40	26.33	48.50	20.25
After leaving the shelter	Puppy	166	25.67	23.42	16.50	40.50
	Dog	184	60.04	92.72	25.00	47.25

IQR, Interquartile range.

FIGURE 1 | Proportions of outcome types by shelter resource level.

= 16.43, *Mdn* = 10.00, IQR = 18.80) compared to shelters that did not (*M* = 21.95 days, *SD* = 17.03, *Mdn* = 16.17, IQR = 23.20). This relationship was weakly but significantly correlated, r (1,825) = −0.206, $p < 0.0001$. We also found that when shelters allowed adopters to pick up their dogs directly from the foster caregiver, dogs at these shelters had shorter lengths of stay (*M* = 15.86 days, *SD* = 18.85, *Mdn* = 11.07, IQR = 22.55) compared to dogs at shelters that did not allow this type of pick-up (*M* = 20.83 days, *SD* = 14.45, *Mdn* = 15.88, IQR = 22.07). This was a weak yet statistically significant correlation, r (1,825) = −0.163, $p < 0.0001$. Lastly, dogs' lengths of stay at shelters that had a drive-through pick-up option were slightly longer (*M* = 18.20 days, *SD* = 14.33, *Mdn* = 14.76, IQR = 21.70) than dogs at shelters without this mode of acquisition (*M* = 17.77 days, *SD* = 20.74, *Mdn* = 11.73, IQR = 21.74). However, when we consider the conflicting nature of the test coefficient, r (1,825) = −0.171, $p < 0.0001$, in addition to these average lengths of stay and their large standard deviations, this finding is difficult to interpret.

In order to examine the role that shelter resources may have played in outcomes, we tested whether the numbers of animals in the various outcome categories were uniformly distributed across our five shelter resource levels. We found differences in outcomes based upon the resource level of the organization (X^2(4, *N* = 1,983) = 614.19, $p < 0.0001$). Specifically, very low resource shelters made substantially greater use of transferring animals out of their facilities (49.46%) than low or moderately resourced shelters (6.58 and 1.67%, respectively). Additionally, the adoption rate at very low resource shelters was 43.01%, while shelters at all other resource levels placed fostered dogs directly with adopters at rates above 80% (**Figure 1**).

We found that dogs fostered by their potential adopters (as in a foster-to-adopt) or by a foster caregiver with a dog or puppy had different likelihoods of adoption (X^2(5, *N* = 2,555)

TABLE 8 | Adoption of fostered dogs and puppies by caregiver's relationship to the shelter.

Caregiver's relationship to the shelter	Adopted *n*	Did not adopt *n*	Adopted (%)
No prior relationship			
New community member	195	484	28.72
Prior relationship			
Shelter volunteer	12	70	14.63
Returning community member	18	194	8.49
Returning foster caregiver	31	558	5.26
Staff	8	116	6.45
Potential adopter (foster-to-adopt)	634	235	72.96

= 902.00, $p < 0.0001$). Nearly three-quarters (72.96%) of foster-to-adopt experiences ended in adoption, while only 18.03% of dog and 7.28% of puppy foster experiences ended in adoption (**Table 8**). Thus, individuals that were fostering with the intention to adopt were, in fact, the most likely to adopt, yet dog foster caregivers were twice as likely to adopt their fostered dog as puppy caregivers.

In further examining the outcomes of fostered dogs by the type of relationship the caregiver had with the shelter, we found that adoptions by foster caregivers were not uniformly distributed across relationship type ($X^2(1, N = 1{,}686) = 148.23$, $p < 0.0001$). New caregivers with no prior relationship to the shelter adopted their fostered dogs at a rate of 28.72% while those with a relationship, such as returning foster caregivers, shelter volunteers, and staff, did so at a combined rate of 6.85% (**Table 8**). Additionally, we found differences in the likelihood of adoption by foster caregivers with and without a relationship to the shelter, dependent upon the number of dogs in their home ($X^2(4, N = 1{,}686) = 208.10$, $p < 0.0001$). New caregivers without a relationship to the shelter or resident dogs in their home were more likely to adopt their fostered dog (77.39%) than new caregivers with any number of dogs in their home (22.61%). The same was true for foster caregivers with a prior relationship to the shelter with some differences. Those without dogs adopted most often (46.15%) as compared to those with one (30.65%), two (14.52%), or three or more dogs (9.68%).

Foster Utilization Ratio (FUR)

A multiple linear regression analysis with backward elimination was used to identify whether a shelter's average foster utilization could be predicted from characteristics about the shelter, including the previous year's canine intake, live release rate, and length of stay as well as the shelter's organization type, admissions policy, and current year's operating budget. Two variables, including the shelter's 2019 length of stay for dogs 6 months and older and organizations that were public municipal agencies, remained in the equation and accounted for 39.90% of the variability in shelters' average foster utilization, $F\ (2, 13) = 5.97$, $p = 0.014$.

We found that the classification of the organization as a public municipal agency was significantly predictive of foster utilization compared to private non-profit shelters ($\beta = -30.17$, $p = 0.011$), such that the FURs of public municipal agencies were 30 points lower when compared to private non-profits. Additionally, shelters' 2019 canine length of stay trended toward predicting their foster utilization ($\beta = -0.384$, $p = 0.073$). This marginal finding would suggest that for each day that a shelter's 2019 length of stay was shorter, their FUR increased by slightly more than one-third of a point.

Using shelters' daily utilization of foster care for March through June 2020, we analyzed these values to detect an effect of month, organization type, or a month-by-organization-type interaction with shelters' 2019 average length of stay for adult dogs added as a covariate in the model based on the regression analysis. With this model, the variables of month, organization type, and the month-by-organization-type interaction were significant (at $p < 0.05$). The length of stay variable, however, was not significant in the model ($p = 0.105$) but was retained.

The main effect of month was significant, $F\ (3, 1761.00) = 99.71$, $p < 0.001$, indicating that foster utilization changed across time. We found in *post-hoc* comparisons that shelters had significantly higher utilization in April as compared to all other months ($p < 0.001$). May was also higher than March ($p = 0.006$) and June ($p < 0.001$), and lower than April ($p < 0.001$). June was not significantly different than March ($p = 0.173$). A main effect of organization type was also detected, $F\ (2, 12.00) = 4.22$, $p = 0.042$, signifying that the estimated marginal means for foster utilization varied across different types of shelters. In *post-hoc* comparisons, we found that public municipal agencies had the lowest foster utilization ratios ($M = 14.52$, $SE = 9.04$), however these organizations only marginally differed from private non-profits in their daily foster utilization ($p = 0.058$) and not from private non-profits that had government contracts ($p = 0.140$).

The interaction of organization-type-by-month was significant, $F\ (6, 1761.00) = 19.62$, $p < 0.0001$, indicating that shelters' daily FURs varied each month in different ways based on their organization type. When examining these organizational monthly differences in detail, private, non-profit shelters had significantly higher foster utilization in April and May as compared to March and June ($p < 0.001$). Very little change in foster utilization occurred for these shelters between April ($M = 48.86$, $SE = 6.25$) and May ($M = 47.48$, $SE = 6.25$). For private, non-profit shelters with municipal contracts, foster utilization in April was significantly higher than all other months ($p < 0.032$). However, May FUR was not significantly higher at private, non-profit shelters with municipal contracts than March foster utilization ($p = 0.998$), as was seen with private, non-profits.

For municipal shelters, April was again the month of highest foster utilization compared to all other months ($p < 0.001$), but a return to FUR levels seen at the beginning of the pandemic (March $M = 10.74$, $SE = 9.11$) was already occurring in May ($M = 10.22$, $SE = 9.08$, $p = 1.00$). Moreover, this level of foster utilization in May by municipal shelters was significantly lower than utilization by private, non-profit shelters ($p = 0.015$) and trending lower compared to private, non-profit shelters with municipal contracts ($p = 0.084$). By June, FUR for municipal agencies had dropped to an estimated marginal mean of 8.27

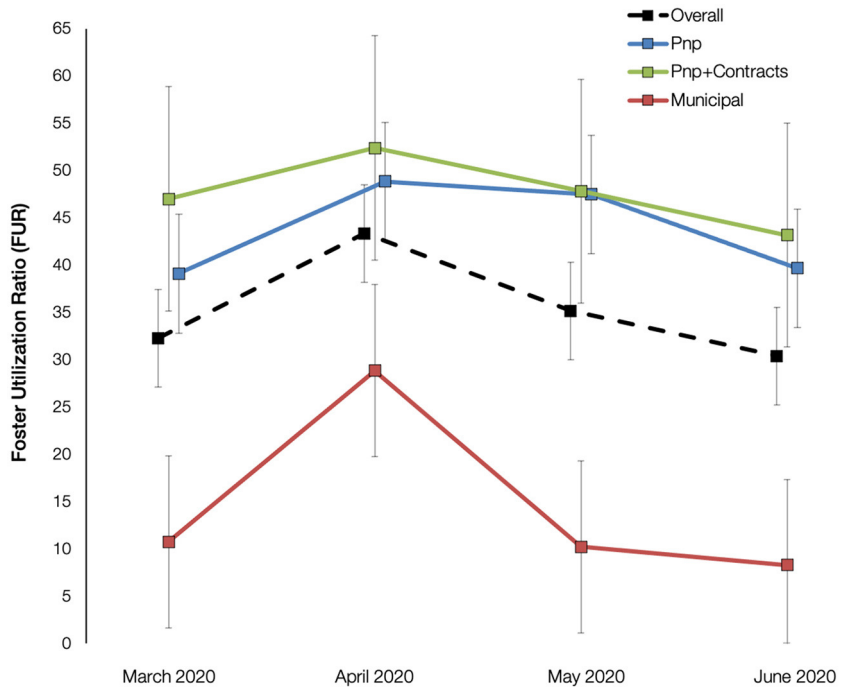

FIGURE 2 | Estimated marginal means and standard errors of foster utilization by organization type from March96June 2020.

($SE = 9.09$), which was significantly less than private, non-profit shelters ($p = 0.041$). **Figure 2** presents the estimated marginal means and standard errors of the foster utilization ratios at the three organization types from March through June 2020.

DISCUSSION

This investigation found that shelters' utilization of foster care during the COVID-19 pandemic increased from March to April 2020 but returned to initial levels by June 2020. This effect was more pronounced for municipal agencies (compared to both categories of private, non-profit shelters) in that they experienced similar April increases in foster caregiving, but their foster utilization returned to initial pandemic levels by May 2020. Additionally, we were able to characterize new variables, specifically a shelter's available resources and foster caregivers' relationships to the shelter, that explained the behavior of the animal welfare organizations and their caregivers' adoptive behavior.

Shelter Resources

Our analysis of shelters' modes of animal placement showed that the behavior of the organization depended on the resources available to them. While shelters across resource levels had similar live release rates for their fostered dogs (between 93 and 100%), how shelters accomplished those outcomes varied. Shelters at every resource level except the very lowest resourced, used adoption as their main method of dog placement. Prior to the pandemic, Woodruff and Smith (1) found that private non-profit shelters were most likely to adopt out dogs directly from their facilities, more so than municipal shelters and even private non-profits with municipal contracts. In our study, all high and very high resource shelters were private non-profit organizations. During the pandemic, shelters submitting their data to the Shelter Animals Count database utilized adoption as their predominant placement approach, irrespective of resources (31).

The lowest resourced shelters in our study, a mix of municipal and private non-profit shelters with municipal contracts, did not use adoption as their primary approach when placing dogs. Instead, they used a combination of transfer and adoption programs, relying more heavily on the former than the latter. In fact, shelters with very low resources transferred dogs out of their facilities at a rate of nearly 50%, which was several times higher than that of better resourced shelters. Pre-pandemic, Woodruff and Smith (1) found that municipal and private non-profit animal shelters with municipal contracts, were also more likely to transfer dogs out of their facilities than were private non-profits. Transferring dogs out of the shelter to another organization reduces the number of days an animal is in the care of the originating shelter and can be a cost-effective strategy to achieve live outcomes (17).

Resources, or lack thereof, also played a role in the individuals that shelters engaged to provide foster caregiving during the pandemic. Very low and low-resource shelters relied more heavily on foster caregivers who had a prior relationship with the shelter. Volunteers are a valuable resource to animal shelters (32), and foster caregivers voluntarily care for animals in their

homes. For shelters with minimal budgets relative to the number of animals that they serve, depending on known caregivers, a majority of whom that had previously fostered, was likely the most economical approach of administering an external caregiving program throughout this time.

Conversely, our highest resourced shelters relied more heavily on new community members for their foster caregiving. Choosing to utilize likely less experienced caregivers is a more expensive decision for organizations as it requires responding to their initial inquiries and providing new caregiver training and fostering support. Previous research has shown that high quality training of volunteers can be costly (33), and the onboarding of new volunteers and their management during a crisis can be labor-intensive (34). While nearly all shelters had some sort of dog fostering program prior to the pandemic, it is possible that highly resourced shelters recruited foster caregivers because they had not previously invested in adult dog fostering programs given the resources available to them at the shelter.

Foster Utilization Ratio (FUR)

We observed significant changes in the number of dogs cared for in foster care, relative to those living in the animal shelter. Specifically, we found an escalation in foster utilization in April 2020, a month where shelters had 43% of their dogs in foster care, an increase of over 30% compared to the start of the pandemic. For the municipal shelters, the difference was much greater; foster utilization rose by 270% relative to March 2020.

In addition to higher levels of foster caregiving, April's higher FURs were likely related to fewer animals entering shelters. Animal welfare organizations submitting inventory data for April 2020 reported sharp decreases in the number of animals taken into their facilities, reaching the lowest monthly levels reported since 2019 (31). Based on how FUR is calculated, decreases in intake during April 2020 would reduce the number of animals cared for in the physical shelter, thereby increasing the proportion of foster caregiving relative to the total number of animals in the organization's care. Conversely, increases in intake, with more animals living in the shelter than foster homes, would decrease FURs. This may explain why shelters were unable to maintain the high levels of foster caregiving observed in April, and to a lesser degree, May. Data from Shelter Animals Count suggest that animal intake returned to levels comparable to or higher than those reported in the months leading up to the pandemic by May and June 2020 (31).

Another explanation for decreased foster utilization may be related to the caregivers themselves. Foster caregivers with no relationship to the shelter prior to the pandemic comprised over half of all caregivers, yet fewer than a quarter of these caregivers returned after their initial experience. Overall, we found that only 25% of foster caregivers, regardless of their relationship to the shelter, fostered more than once during our four-month data collection. While long stays in foster homes may explain an inability for caregivers to foster additional dogs, this was not the case. Dogs typically remained in foster care for less than 3 weeks with a total length of stay (shelter and foster care) of a month-and-a-half. Thus, it is possible that caregivers could have fostered another dog, particularly as reported increases in intake in May and June would have provided new opportunities. Dog adoptions by foster caregivers, particularly by new community members, may be one explanation for why new caregivers failed to foster again.

Foster Caregivers

The rise of volunteerism during the pandemic was not a surprising response to such societal uncertainty. Having the opportunity to care for an animal in need and join the animal shelter's community of volunteers would be a way to increase one's social support (35). In their exploration of pets and mental health during the early months of the pandemic, Ratschen et al. (36) found that pet owners reported smaller declines in mental health and smaller rises in loneliness compared to non-pet owners, suggesting a potential social buffering effect of pet ownership. While foster caregivers did not own the dogs they were caring for and thus the mental health benefits may have been less pronounced, it is likely that this caregiving experience provided a much-needed distraction from the pandemic (37).

When examining foster caregivers' relationships to their animal shelter, we found that new caregivers from the community were much more likely to adopt their fostered dogs, over four times more likely than caregivers who had a prior relationship to the shelter. Additionally, we found that individuals that fostered a dog with an interest in adopting did adopt their dogs in nearly three-quarters of those instances. This increased propensity for adoption, particularly with new foster caregivers from the community and potential adopters fostering their dogs, provides new insights into trial adoption programs.

To our knowledge, a study by Normando et al. (14) provides the only empirical evidence regarding the use of trial adoptions at an animal shelter. In their study, they found 100% of 110 dogs in an Italian animal shelter were adopted by individuals who used a trial period before formalizing their decision. In the United States, published evidence about the impact of such programs on adoptions has been scant, although they are recommended by animal welfare organizations (38). Our findings indicate that foster-to-adopt programs more often result in potential adopters becoming the dogs' owners. Even if a decision not to adopt results in the dog's return to the shelter, previous research has shown that a few days away from the stressful shelter environment are beneficial to dogs' psychological wellbeing (6).

The higher rate of adoption by new foster caregivers suggests that these caregivers may be more similar to potential adopters fostering with the intention to adopt than traditional foster caregivers. When we weigh the costliness of training new volunteers (33), animal shelters may be better served regarding first-time foster caregivers as individuals fostering with the potential to adopt. Not only would this approach reduce the consumption of resources involved in the onboarding of new caregivers (39), it would likely result in faster placement of dogs into caregivers' homes, thereby reducing their time in the shelter, providing additional cost savings to the organization (40). Consequently, it would appear that foster-to-adopt programs are an evidence-based best practice that improve both the proximate and distal welfare of shelter dogs.

While dogs that were fostered by potential adopters were most often adopted by those individuals, we found that traditionally fostered dogs were adopted by their caregivers in nearly one-fifth of foster experiences. Only 7% of puppy foster experiences ended in adoption by the caregiver. These dogs' lengths of stay in foster care varied, however, depending upon (1) whether a potential adopter or foster caregiver was providing the care and (2) whether the caregiver decided to adopt. Dogs that were fostered by potential adopters had shorter lengths of stay than dogs or puppies in traditional fostering programs. Furthermore, when potential adopters adopted, those dogs' lengths of stay were shorter than when they did not.

One possible explanation for this speedier decision-making from potential adopters, specifically from those that adopted, is that these individuals were already contemplating adoption. They had chosen a dog and were taking it home on a trial basis to gather more information. Shelters that allow adopters to foster prior to formalizing their decision may be reducing the perceived risks associated with adoption, allowing would-be owners to focus on the benefits of adding a dog to their household. Lenient return policies in the retailing literature have been shown to increase purchasing as well as return behavior of consumers (41). This would likely explain the high rate of conversion to adoption in nearly three-quarters of foster-to-adopt experiences as well as the increased rate of return compared to more traditional adoption programs (42). It is unclear, however, what impact fostering prior to adoption has on overall adoption rates.

Conversely, lengths of stay for both puppies and dogs that were adopted by foster caregivers were significantly longer than those that were placed with adopters. A possible explanation for the additional time that these dogs and puppies spent in foster care may be related to the caregivers changing their minds. Unlike potential adopters who foster because they are interested in adopting, caregivers typically foster with no declared interest in adopting. If their intentions changed during their foster experience, they may have needed additional time to arrive at those decisions.

It is likely that pet ownership, including newly adopted and other resident pets, influences foster caregiver retention and recruitment. In previous research, caregivers most often indicated that the needs of their own pets and adoption of previously fostered pets were reasons why they were no longer participating in foster programs (43). We found that the proportion of foster homes with resident dogs was slightly higher than the estimated percentage of canine-owning households in the US (44). In our study, over 56% of foster homes were without dogs, and those that were canine-owning most often had just one dog. It is possible that the acquisition of new dogs by foster caregivers and those fostering with the intention to adopt, may explain reduced foster utilization in May and June 2020. While the pandemic may have aided shelters in the recruitment of new foster caregivers and the adoption of shelter dogs (45), it is unclear whether it had the same effect on the retention of foster caregivers.

Despite the positive mental health benefits of foster caregiving during the pandemic (35–37), it is worth noting that animal fostering is a form of high stakes volunteerism (46, 47). Fostered pets, just like those that are owned, need supervision and daily husbandry, and caregivers develop strong emotional relationships with their animals. Recent research by Thielke and Udell (48) found that fostered dogs form secure attachments to their caregivers at similar rates to owned dogs. For the shelters that encourage foster caregivers to assist in adoption promotion and placement, caregiving may involve communicating and meeting with potential adopters. Considering the physical and emotional commitments involved, it is possible that new caregivers did not return to foster another animal because of a mismatch between their expectations and the reality of the position (49).

Fostered Dogs

The outcomes for dogs were overwhelmingly positive with over 93% of dogs being either adopted, returned to their owners, or transferred to other agencies. Less than six percent of animals remained in the care of their organizations at the end of data collection, and more than three-quarters of those dogs were doing so in a foster home. Just over one percent of fostered dogs were euthanized for medical and behavioral issues, and only one fifth of one percent died in care. Live release rates of fostered dogs during the study were slightly higher than shelters' 2019 live outcomes for all dogs. We also found that dogs' length of stay in foster care was related to their age, such that as age increased, so did time in foster care. While this relationship has been observed with dogs awaiting adoption in the shelter (50, 51), this adopter preference for younger dogs in foster care has not been previously characterized.

Crowe and Patronek (17) found similar evidence of a positive relationship between foster care and live outcomes for shelter dogs. They found that the likelihood of live release for fostered dogs was over five times higher than that of stray and owner-surrendered dogs that did not experience foster care. In their study, dogs were often placed in foster care needing additional medical or behavioral treatment, while less than 15% of non-fostered dogs, that were adopted directly from the shelter, had behavioral or medical concerns. Taken together, our findings offer further evidence that foster caregiving is a worthwhile intervention for promoting the ultimate welfare of shelter dogs.

We identified that 21% of foster experiences included dogs that needed some sort of behavioral management, and roughly one-third of dogs required medical treatment during foster care. While more dogs entered foster care needing medical support, returns for medical-related issues with these dogs occurred in less than 5% of cases (compared to under 2% of returns for non-medical foster experiences). Yet, dogs needing behavioral management by their foster caregivers were returned three times more often for behavioral issues (17%) than non-behaviorally managed dogs (5%). Based on these findings, we would suggest that more specialized assistance for dogs entering foster care with known behavioral issues is needed.

Dogs with behavioral concerns prior to adoption placement have also been shown to have higher rates of return to the animal shelter. Recently, Friend and Bench (52) found that dogs displaying aggression to other dogs, when also factoring in their

breed and size, have a greater risk of adoption failure. In a prior study exploring the use of behavioral assessments in the shelter, dogs that stiffened or growled during assessment were more likely to be returned by their adopters for behavior-related issues (53). However, the presentation of problem behaviors in the shelter does not necessarily predict similar behavioral issues in the home. Clay et al. (54) found that friendly and fearful behaviors that dogs displayed in a shelter assessment were also observed by adopters in the home. However, other behaviors, such as those related to separation and aggression, were not.

Still, it appears that animal shelters should consider providing support to adopters and foster caregivers of behaviorally-challenged dogs. In a review of adoption and relinquishment of dogs in the animal shelter, Protopopova and Gunter (42) identified that successfully supporting new adopters may involve providing more than general behavior advice or short counseling sessions, particularly if the dog's behavioral issues are more complex. Yet little in the scientific literature has described or experimentally tested these types of behavioral interventions (55, 56). Nevertheless, the returns of behaviorally managed fostered dogs in our study and adopted dogs due to behavior issues found by Hawes et al. (56), indicate a need for additional post-placement assistance to foster caregivers and adopters of these dogs.

Shelter Processes

Differences in the timing of spay-neuter surgeries impacted length of stay. Puppies' lengths of stay were shortest when they were spayed or neutered after adoption compared to performing the surgery while in the shelter or in foster care. Thus, simply removing the need to sterilize while in the organization's care resulted in the shortest stays. Furthermore, puppies and dogs whose spay-neuter surgeries occurred any time during foster care had the longest lengths of stay. It is possible that the logistics of sterilizing animals that no longer reside in the shelter may have contributed to prolonged stays with these organizations.

The surgical sterilization of pets prior to adoption placement is a standard practice in US animal shelters to control the number of unwanted animals in communities. By altering soon-to-be-adopted animals before they are owned and living in homes, the spay-neuter procedure is assured to be completed (57). Our results suggest that animal shelters would reduce their lengths of stay for underage puppies by placing them in adoptive homes as quickly as possible and scheduling spay-neuter surgeries post-placement. (Most puppies in our study were not fostered as part of a litter, so this suggestion does not consider the behavioral benefits of fostering with other littermates until 8 weeks of age.) This arrangement, however, would likely lead to low compliance amongst adopters in the sterilization of their dogs (58).

Alternatively, shelters could place puppies in their adoptive homes as fostered dogs with owners who intend to adopt. Although this timing of spay-neuter resulted in the longest lengths of stay, it would likely ensure higher compliance with follow-up sterilization appointments if the adoption was formalized post-surgery (59) and achieve a similar result that adoption prior to spay-neuter surgery accomplishes: reducing the need for placement in a foster caregiver's home and acclimating the puppy sooner to the environment in which it will be living. Previous research has indicated the behavioral benefits of early exposure to people, objects, and experiences for dogs (60) while the effects of pediatric and early neutering on canine physical and behavioral health have become points of debate within the veterinary community (61).

Some of the adoption practices that we compared provide insights into ways in which animal shelters may be able to reduce length of stay in foster care. We caution that because this study was a natural experiment, we could not use random assignment and other techniques customary in experimental designs to control for dog-related variables that may have influenced the results. Furthermore, coefficients of these correlational tests range from very low to low, suggesting a likely small influence, if any, on dogs' length of stay. Thus, we report these findings for future studies to explore.

At the onset of the pandemic, animal shelters were encouraged to implement a variety of practices to accelerate placement into foster and adoptive homes, including caregiver-facilitated meet-and-greets and adoption directly from foster care (62). In our examination of these types of practices, we found that shelters that allowed foster caregivers to meet with potential adopters and adopters to pick up dogs from their foster caregivers, had dogs with shorter lengths of stay than shelters where these practices were not in place.

Practices which allow foster caregivers to interact with adopters and direct placement decisions could be described as a new form of open adoptions (63). Originally discussed in an American Humane Association forum in 1999 (64), open adoptions are a less restrictive approach to animal placement that encourage conversations between sheltering staff and potential adopters to inform placement decisions. In the two decades since this forum, open adoptions have become the predominantly recommended approach in animal sheltering (11, 65, 66).

Enabling foster caregivers to perform adoptions relies on the knowledge of caregivers and experiences with their fostered pets to inform placement decisions. Thus far, foster caregiver-directed adoptions have been shown to provide potential adopters with more useful information about the fostered dog and its behavior in a home and led to lower return rates when compared to dogs adopted from the animal shelter (15). While our correlational data would also support foster caregivers' involvement in the adoption process, future studies are needed to compare these types of foster caregiving practices and those by Mohan-Gibbons et al. (15) to more traditional forms of fostering without adoption components.

Limitations

When considering the limitations of our study, it is likely that not all dogs at our participating shelters were made eligible for placement in foster care or had a caregiver who was interested in providing foster care due to various behavioral or medical issues. As we have identified in previous studies (6, 12), dogs with aggression issues are often not selected by staff for interventions with volunteers or members of the community. This safety bias may have led to fostered dogs having better outcomes, including higher live release rates, than shelters' 2019 data which included

all dogs under the shelter's care. Despite this potential preference, dogs with behavioral and medical issues were still represented in the dataset.

While every effort was made to enroll animal shelters of various organization types, private non-profit organizations were over-represented in our dataset when compared to municipal shelters and, to a lesser degree, private non-profit shelters with municipal contracts. To address these shortcomings, we conducted analyses, not only at the organizational level, but created a shelter resource variable to better understand how monetary assets, relative to the number of animals a shelter served, influenced organizational decision-making. Nevertheless, private non-profit shelters accounted for all instances of very high and high resource shelters. The inclusion of more shelters with smaller budgets and/or more animals cared for annually would have likely changed the resource levels used in our analyses.

The foster utilization ratio (FUR) is a novel approach to understanding the proportion of dogs living in foster homes relative to all dogs in an organization's care, calculated on a daily level, and allows for utilization analyses across shelters of varying sizes. We anticipated this need as shelters' 2019 canine intake data range from 121 to 6,374 dogs; and during data collection the number of dogs placed in foster care ranged from 13 to 431 (which did not correspond to inventory alone). Despite the strengths of this method, it does not account for changes in intake or outcomes, which could potentially influence FURs, irrespective of increases or declines in foster placements. Nevertheless, FUR is not intended to describe why the proportion of animals living in foster care is changing; but instead to represent on a daily level how the shelter is utilizing its resource of foster homes.

Conclusion

This study demonstrates that canine foster caregiving increased 1 month into the COVID-19 pandemic as compared to March 2020, but returned to initial levels of foster utilization by June 2020. The available resources of a shelter were related to the types of foster caregivers they relied upon, caregivers with and without prior relationships to the shelter, as well as how shelters primarily placed their dogs: adoption or transferring to other facilities.

New community members fostering for the first time represented the largest proportion of caregivers, and they were much more likely to adopt their fostered dogs than caregivers with a prior relationship to the shelter. Animal welfare organizations would likely save resources and speed the placement of animals into foster homes by regarding new caregivers as individuals fostering with the potential to adopt and reserving training until subsequent foster experiences. Nearly three-quarters of individuals fostering with the intention to adopt adopted their dogs, suggesting that foster-to-adopt and temporary foster programs are beneficial for shelter dog welfare and should be utilized by animal shelters as evidence-based best practices.

Only one quarter of caregivers fostered more than once during the four-month data collection. Over half of foster caregivers were not dog-owning, and resident dogs in the home reduced a caregiver's likelihood of adopting their fostered dog. Behaviorally managed dogs were more frequently returned from foster care for behavioral reasons than dogs without behavioral management, highlighting a need for additional caregiver support for these dogs. Adoption practices, such as foster-facilitated meet-and-greets and adoption from caregiver homes, may reduce dogs' time in foster care, but additional studies are needed to address variables that could not be controlled in this natural experiment.

DATA AVAILABILITY STATEMENT

Data described in the present study can be found in this online repository: https://dataverse.asu.edu/dataset.xhtml?persistentId=doi:10.48349/ASU/DQLNHM.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Arizona State University Institutional Review Board.

AUTHOR CONTRIBUTIONS

LG: conceptualized the study and prepared the manuscript. LG, EB, RG, AF, JR, LI, and EF: designed the study methodology. EB, RG, JR, and LI: carried out data collection. EB, RG, JR, LI, and AF: validated data that were collected. LG, RB, and AF: analyzed the data. LG, EB, and RB: visualized the data. LG, EF, and CW: supervised the project and acquired the funding. All authors reviewed and edited the manuscript and have read and agreed to the published version of this manuscript.

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Direct and Indirect Factors Influencing Cat Outcomes at an Animal Shelter

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Animal shelters play a vital role for pets, such as transitioning animals between homes, from outdoor communities into homes, caring for unadoptable and community animals, and providing a breadth of veterinary and welfare services. The goal of shelters is to move cats to their appropriate outcome as quickly as possible, which for many animals, is to rehome them as quickly as possible through adoption. Therefore, the ability to identify pre-existing factors, particularly those occurring outside the walls of the shelter, which result in specific outcomes is vital. In this study, we used structural equation modeling to test four hypotheses addressing how to predict cat outcome from a shelter in Washington, D.C. We developed four hypotheses that described how cat outcomes could be predicted, based on four general factors: (1) The characteristics of the cats; (2) The location of origin; (3) The type and date of intake; (4) The length of stay. Using 4 years of data from the Humane Rescue Alliance in Washington, D.C., we found support for each of our hypotheses. Additionally, we tested and found support for a global model, which comprised an amalgamation of our all our predictors. From the global model, we can conclude that many factors are at play in predicting cat outcomes in this shelter and very likely in many others as well. Critically, these factors are interconnected, indicating, for example, that cat characteristics mediate the influence of intake location on outcome type. Furthermore, our study highlights the importance of incorporating influences beyond the shelter when attempting to understand cat outcomes. Therefore, to modify cat outcomes most efficiently, such as increasing adoption probabilities, our results show that efforts may be most effective when incorporating multiple factors.

Keywords: adoption, structural equation modeling, shelter intake, Washington, D.C., intake location

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INTRODUCTION

Animal shelters play a critical role in addressing companion animal welfare by establishing pets with new owners, returning pets to previous owners, identifying and monitoring stray populations, and euthanizing animals in an ethical manner when necessary. In 2019, shelter intake for each animal shelter in the United States averaged more than 1,500 animals, where cats accounted for 49% of intakes (1). In 2016, it was estimated that 25% of households in the US had pet cats, with 31% of those originated from an animal shelter or rescue group (2). In the same year, 7% of households relinquished their cat to an animal shelter (2). Shelters provide new homes for cats, with 61% of cat intakes resulting in adoption (1). Animal shelters may also provide essential services for stray

cats in and outside of the shelter. The vast majority of the 48% of stray animal intake in the US are cats (1), Although only a small proportion of stray cats are returned to their owners (only about 5% in 2019, 1), animal shelters may provide the opportunity to improve welfare for stray cats through the provision of targeted trap-neuter-return and return-to-field programs (3–5). It is clear that animal shelters act as a vital transition place for cats, providing numerous roles in the community: adopting relinquished cats to new owners; transitioning cats from stray status to ownership through adoption; supporting stray populations through return to field programs; managing stray cats in the environment *via* trap-neuter-return; and providing humane euthanasia as necessary (6). Additionally, many shelters offer veterinary care services, often providing reduced or no-cost sterilization (2).

Capacity is a major issue in many animal shelters and many shelters are functioning over their capacity to provide adequate care for the animals (7). When shelters function over capacity, this adds stress to the shelter resources, the animals residing at the shelter, as well as to the shelters' staff. Programs such as Capacity for Care focus on modifications to shelter policies and practices and are making major strides in rectifying this issue (8, 9), though challenges persist. Accessing veterinarians with shelter animal knowledge and limited financial support which compromise cat physical and psychological health, making the welfare of animals in shelters of major concern (10). Therefore, identifying ways of most effectively addressing shelter animal outcomes and exploring the importance of factors occurring beyond the specific practices of the shelter are crucial.

A common goal for shelters is to maximize live outcomes, to reduce the length of shelter stays, and to implement programs which assist in achieving these goals. Identifying predictive components which result in different outcomes are vital, and typically, the focus is on characteristics of the cats as well as the type of intake. Regarding the physical attributes of the cat, coat color is considered a strong predictor of adoption (11–13). Age is a prominent factor as well, where younger cats are more likely to be adopted than older cats (14–16). Length of stay is a commonly used metric among shelters, where shorter lengths of stay increase shelter efficiency by increasing animal turnover, improves animal welfare, and reduces risk of illness. While some studies find that coat color influences length of stay (14, 16), others do not (15). Breed (exotic vs. domestic shorthairs) and sex influenced length of stay in a case study conducted by Janke et al. (15), however other studies have found no effect of breed and sex on outcome (16). In addition, the type of intake may also be a strong predictor of outcome type. Clearly, there are many components that can, and often do, influence outcome type, although these effects vary substantially across studies, likely influenced by sample size, geography, and other human-related factors. The inconsistency of results across studies indicate that local conditions are highly relevant, beyond the specifics policies and practices of the individual shelters. It is also likely that these factors work in concert with other predictors, highlighting the need for multivariate models which incorporate the complex interactions between predictors in describing the whole system.

Understanding potential factors influencing the outcome of cats in animal shelters is both necessary and challenging, particularly because of the many overlapping factors involved. Previous studies have focused on the use of correlations (17) or linear regression models (especially logistic regression), which predict an outcome based on suites of measured variables (14–16). These studies have substantially contributed to animal welfare research and practice. However, in questions such as ours, the relationships among the measured co-variates are as important as their relationship to the outcome variable of interest, using a whole systems approach. Linear models are unable to capture the complex relationships among multiple explanatory variables, some of which are multifaceted on their own (18, 19). Suitable analytical alternatives to address these data include ensemble methods which include boosted regression trees (20) and structural equation modeling [SEM; (18, 19)] Incorporating SEM in animal welfare is a novel approach in the field and enables the identification of factors related to outcome types as well as the connections and relationships between factors. The strengths of our approach of SEM lie in its ability to use existing knowledge of complex systems to build path models identifying those relationships based on a priori hypotheses. SEM has been previously used to analyze opinions of stakeholders on free roaming cat management techniques (21), but not to animal shelter data. In this study, we applied SEM to test 4 hypotheses describing outcomes of cats in one animal shelter organization. In each hypothesis, we measured both the direct effects of predictor variables on cat outcome as well as the indirect effects between predictors and their resulting effect on outcome. We constructed the following 4 hypothetical models to explain what factors influence cat outcome (**Figure 1**): (1) Cat outcome depends on the physical characteristics and health status of the cat; (2) Cat outcome depends on the location and timing of intake; (3) Cat outcome depends on human influences (including intake type and intake location characteristics) prior to intake; (4) Cat outcome depends on experiences prior to outcome. Additionally, we constructed a global theoretical model, which represents a combination of all our hypotheses. We used an extensive dataset from a shelter serving the entire Washington, D.C. area, understanding that our model results apply specifically to these data and are not necessarily representative of all shelters. In testing our hypotheses using data from a single location, our goals were to explore the complexity of the relationships between factors influencing outcome, particularly those outside of the shelter. Therefore, we do not address the internal policies of the shelter in this study, as we are interested in examining predictors outside of the shelter itself.

MATERIALS AND METHODS

We established four hypotheses to isolate predictors of cat outcomes and how they interact with each other. We followed a two-step process in hypothesis development: first, we assessed leading hypotheses from published literature; second, we discussed each hypothesis with specialists from the field of animal welfare and animal shelters. Finally, we convened a group of

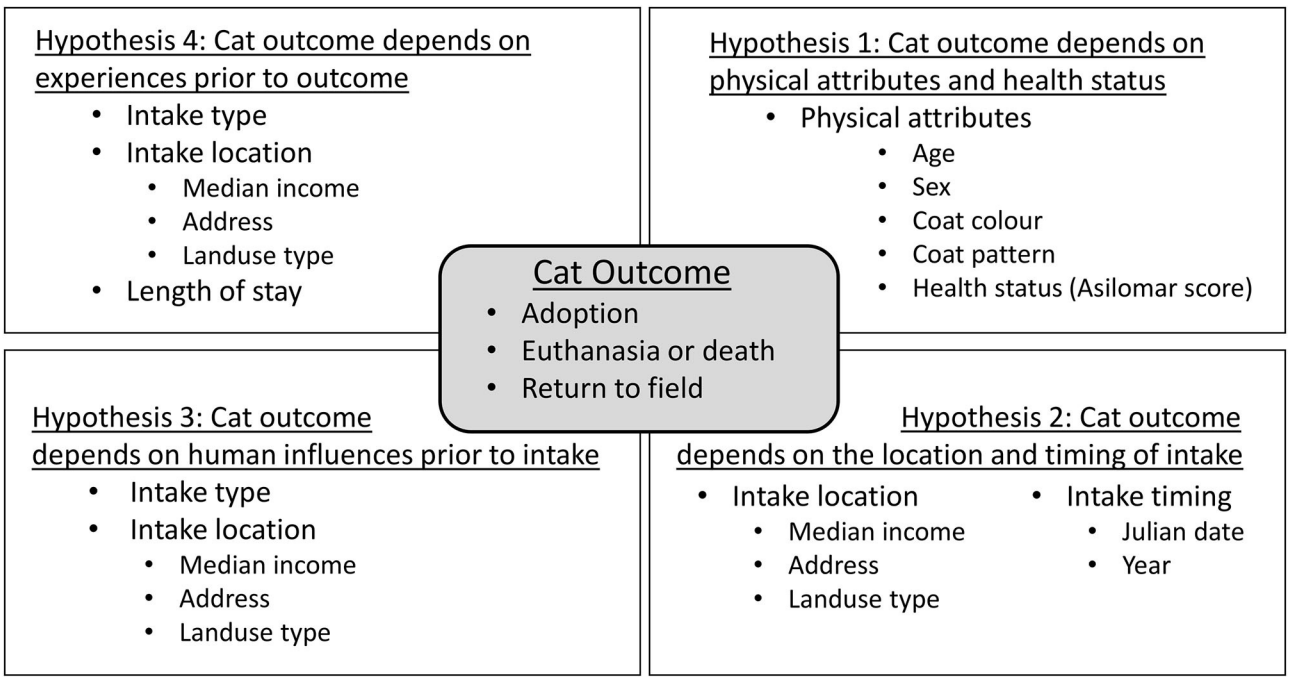

FIGURE 1 | Summary of hypotheses describing the factors used to predict cat outcomes.

workers from the animal shelter where the data was collected to propose, refine, and articulate how each hypothesis may operate in a local context and detail the paths among variables in each model. We used 4 years of data (July 2016 through May 2020) from an animal shelter in Washington, D.C. to test each of our hypotheses.

Models and Hypotheses

The 4 developed hypotheses offered alternative, though not mutually exclusive, predictions of outcome type (**Figure 1**). Each hypothesis highlighted the relationships between multiple variables and how they ultimately related to outcome type. We used the following variable categories in constructing our hypotheses, which are described in further detail below: physical attributes and health of the cat; the location of origin (hereafter called intake location); time of intake (date and year); the type of intake; the length of stay at the shelter; and the type of outcome. For each hypothesis, we constructed a theoretical path model that identified the relationships and the direction of the effects between variables (see more details below). Our last model was not a unique hypothesis but was synonymous with a global model, effectively acting as a merger of hypotheses 1–4.

Hypothesis 1: Outcome Depends on the Physical Attributes and Health Status

We began with a simple model wherein a cat's outcome is entirely predicted by its physical characteristics and health status at intake (**Figure 1**). We began with a conceptual variable (also called a latent variable, see below) called physical attributes. This variable represented several physical characteristics of each cat: age, sex, primary coat color, coat pattern of the individual, and the animal's health status at intake, which was judged using the Asilomar score.

Hypothesis 2: Outcome Depends on the Location and Date of Intake

In this hypothesis, we assessed how two factors influence outcome: the temporal and the geographic features of intake (**Figure 1**). We constructed another conceptual (latent) variable called intake location with four components: the latitudinal and longitudinal coordinates of the precise location of origin; the median income in the year of intake for that location; a categorization of the land use type of that location. To account for the temporal components, we incorporated the day of the year, using the Julian calendar, and the year of intake. Based on a preliminary examination of the data and a priori conversations with specialists, we did not hypothesize that these two factors (location and time of intake) would influence the other. Instead, that both these factors influenced cat outcome separately.

Hypothesis 3: Outcome Depends on Human Influences Prior to Intake

To address the role that associated humans, including degree of ownership, might influence outcome, we developed a model incorporating intake location and intake type (**Figure 1**). As in hypothesis 2, we incorporated the location of origin conceptual variable, as this provided some information on the characteristics of the people surrounding the cat. Intake type provided information into the ownership-type (owned or unowned), and thus general degree and type of human interactions. We

hypothesized that intake location and intake type would both directly influence outcome type. Additionally, we expected intake location to influence intake type, as geographic characteristics could influence the likelihood of ownership. For example, cats from high density urban areas may be more or less likely to be relinquished by their owner, or cats who arrived as strays may be more likely to have originated from a low-income neighborhood.

Hypothesis 4: Outcome Depends on Experiences Prior to Outcome

This hypothesis described how aspects of a cat's life prior to its intake at the shelter as well as its shelter experience influenced its outcome (**Figure 1**). Pre-shelter life is described through the conceptual variable intake location as well as intake type, as in hypothesis 3. These variables described the degree of ownership, types of human interactions, as well as some information of the owners and the cat's geographic origin. In this hypothesis, we added length of stay, which provided information on shelter experience. We predicted that each factor (intake type, intake location, and length of stay) would directly influence outcome type. Additionally, we expected cats of different intake types to be more likely to have a certain length of stay, for example, stray cats may have longer length of stay, regardless of outcome. Similarly, intake location may have influenced length of stay if certain geographic qualities, such as median income, altered the likelihood of a longer or shorter length of stay. Also, as with hypothesis 3, we expected intake type to be directly influenced by intake location.

Global Model

Out last hypothesis described a global model, which allowed us to identify relationships among factors which were not depicted in our hypotheses. Therefore, this model included outcome type and all five of our previously described factors (intake type, physical attributes, intake location, timing of intake, and length of stay). To manage model complexity, we merged intake timing and type into a composite variable called intake attributes, which was described by intake type, intake date, and intake year. In addition to each variable directly influencing outcome type, we further expected length of stay to be influenced by intake attributes, intake location and physical attributes. Intake attributes would be influenced by intake location and, additionally, physical attributes of the cat. The physical attributes describe how a cat's age, sex and appearance influence the type of intake, such as if older cats are more likely to be brought in as owner relinquishment. We also predicted the physical characteristics of a cat to be influenced by the intake location, for example if cats from certain geographic areas are more likely to be of greater or poorer body condition. Cat physical attributes were also expected to be predicted by intake attributes, as stray cats are more likely to be younger and in poorer body condition. This model does not describe any specific hypothesis but demonstrates the interrelatedness of the factors we expected to influence outcome in our previous hypotheses and identifies potential mediating factors.

Data

To understand predictors of cat outcomes, we used information collected by the Humane Rescue Alliance, Washington, D.C. (HRA) between July 2016 and May 2020 from PetPoint software. The Humane Rescue Alliance is the sole animal welfare and animal control organization serving Washington D.C. and as such the data is assumed to represent a full census of relevant individual cats with no requirement for sampling to draw conclusions across Washington D.C. The shelter will intake cats for a variety of reasons including relinquishment by owners, acquisition or presentation of lost, stray, or abandoned animals, temporary intake for TNR surgery, or animal control seizure. Outcomes may include return to field, return to owner, adoption to a new owner, or euthanasia for medical or safety reasons. Data used in the current study included animal identification number, sex, date of birth, primary color, intake date, intake type, intake location, outcome type, outcome date and were provided by HRA records. When a cat had been brought to HRA multiple times, we included only its first record in our analysis. The eligibility criteria described in each category below resulted in the removal of 4,937 entries from the initial PetPoint dataset. A summary of the data, corresponding to outcome types, can be found in **Table 1**.

Outcome Type

We considered three possible outcomes for cats in our study: Adoption, Died and Return-to-field. Outcomes were merged into these three categories to represent the major categories of outcome, reflecting live outcomes, death, and potential degree of ownership as well as to account for some outcome categories have small sample sizes relative to the major outcome types. Live outcomes were classified based on the degree of ownership and human responsibility. Adoption includes cats who were adopted into new homes and cats who were returned to previous owners. Died includes individuals who were euthanized and individuals who died by natural causes after intake. We did not include individuals who were classified as dead on arrival, as their outcome was predetermined on arrival. Return-to-field describes cats who were brought to HRA as strays and were subsequently returned to their outdoor location. While return-to-field is a live outcome, the cats with this outcome generally were not adoptable and therefore have a lower potential for ownership compared to those cats that were adopted. We only included cats whose live outcomes were in the Washington, D.C. area. The most common outcome was adoption, followed by those who died and lastly return to field (n = 8,445; 1,737; and 945, respectively, **Table 1**; **Supplementary Figure 1**). Outcome type was our variable of interest in each model, and as we were most interested in adoption, we used this as our reference category in our models.

Physical Attributes

Consistent with previous studies, we predicted that various characteristics of the cat itself influenced the type of outcome for that individual. As such, we included data on age at time of outcome, sex, two features of the cat's appearance (the coat pattern and primary coat color) and the health status at intake,

TABLE 1 | Summary statistics for outcome types across variables used in this study, from July 2016 through May 2020.

Variable	n	Outcome: adopted** (*n* = 8,445; 75.9%)	Outcome: Died (*n* = 1,736; 15.6%)	Outcome: return to field (*n* = 945; 8.5%)
Age (years) (mean ± standard error)	11,126	2.0 ± 0.03	7.0 ± 0.2	2.3 ± 0.1
Intake Type				
**Owner/guardian surrender	3,969	2,844 (71.7%)	1,004 (25.3%)	121 (3.05%)
Return	52	46 (88.5%)	5 (9.6%)	1 (1.9%)
Seized/Custody	180	166 (92.2%)	8 (3.3%)	6 (4.4%)
Stray	6,925	5,389 (77.8%)	719 (10.4%)	817 (11.8%)
Primary Color				
Black	3,723	2,810 (75.5%)	601 (16.1%)	312 (8.4%)
Brown	2,283	1,764 (77.3%)	305 (13.4%)	214 (9.4%)
Buff	282	233 (82.6%)	33 (11.7%)	16 (5.7%)
Cream	141	110 (78.0%)	15 (10.6%)	16 (11.3%)
Grey	2,389	1,778 (74.4%)	407 (17.0%)	213 (8.9%)
Orange	1,118	831 (74.3%)	192 (17.2%)	95 (8.5%)
White	1,087	868 (79.9%)	148 (13.6%)	71 (6.5%)
**Other	94	51 (54.3%)	35 (37.2%)	8 (8.5%)
Sex				
**Female	5,487	4,264 (77.7%)	802 (14.6%)	421 (7.7%)
Male	5,173	4,173 (80.7%)	815 (15.7%)	443 (8.6%)
Unassigned	208	8 (3.8%)	119 (57.2%)	81 (38.9%)
Coat Pattern				
Calico	317	230 (72.5%)	60 (18.9%)	27 (8.5%)
Dilute	260	222 (85.4%)	27 (10.4%)	11 (4.2%)
Marble	141	110 (78.0%)	20 (14.2%)	11 (7.8%)
Point	146	120 (82.2%)	11 (7.5%)	15 (10.3%)
Solid	382	301 (78.8%)	49 (12.8%)	32 (8.4%)
Tabby	3,708	2,946 (79.4%)	448 (12.1%)	314 (8.5%)
Tiger	142	89 (62.7%)	38 (26.8%)	15 (10.6%)
Torbie	301	261 (86.7%)	22 (7.3%)	18 (6.0%)
Tortoiseshell	446	352 (78.9%)	61 (13.7%)	33 (7.4%)
Tuxedo	478	360 (73.6%)	65 (13.6%)	53 (11.1%)
Van	151	138 (91.4%)	10 (6.6%)	3 (1.9%)
**Other	125	95 (76.0%)	14 (11.2%)	16 (12.8%)
N/A	4,529	3,221 (71.1%)	911 (20.1%)	397 (8.8%)
Asilomar status				
**Healthy	1,793	1,570 (87.6%)	78 (4.3%)	145 (8.1%)
Treatable-manageable	52	30 (57.7%)	7 (13.5%)	15 (28.8%)
Treatable-rehabilitatable	151	98 (64.9%)	23 (15.2%)	30 (19.9%)
Unassigned	8,760	6,701 (76.5%)	1,309 (14.9%)	750 (8.6%)
Unhealthy-Untreatable	338	20 (52.6%)	317 (93.8%)	1 (0.3%)
N/A	32	26 (81.3%)	2 (6.2%)	4 (12.5%)
Intake date (Julian) (mean ± standard error)	11,126	193.4 ± 1.0	190.7 ± 2.4	188.5 ± 3.3
Intake Year				
**2016	2,245	1,698 (75.6%)	371 (16.5%)	176 (7.8%)
2017	2,801	2,047 (73.1%)	456 (16.3%)	298 (10.6%)
2018	2,763	2,136 (77.3%)	410 (14.8%)	217 (7.8%)
2019	2,729	2,131 (78.1%)	411 (15.1%)	187 (7.9%)
2020	588	434 (73.8%)	87 (14.8%)	67 (11.4%)
Length of stay (mean ± standard error)	11,126	30.0 ± 0.4	6.9 ± 0.5	13.1 ± 0.7
Landuse Type				
**Natural	43	32 (74.4%)	7 (16.3%)	4 (9.3%)
Developed/high intensity	1,643	1,305 (79.4%)	257 (15.6%)	81 (4.9%)
Developed/low intensity	2,902	2,229 (76.8%)	403 (13.9%)	270 (9.3%)
Developed/medium intensity	6,243	4,648 (74.5%)	1,031 (16.5%)	564 (9.0%)
Developed/open space	295	231 (78.3%)	38 (12.9%)	26 (8.8%)
Median Income (at intake) (mean ± standard error)	11,126	57,544.9 ± 368.2	65,391.5 ± 938.5	57,025.7 ± 1,020.3

For continuous variables, mean and standard error are provided. For categorical variables, counts, and proportions (in percentage) are described.
** *Indicates reference category.*

recorded as the Asilomar score. Age was estimated based on dental development, dental health (such as gum wear and plaque buildup), and tooth wear, techniques commonly used to estimate cat age (22). We included only cats under the age of 30. Asilomar scores refers to the standardized 4-point scale describing the health status of the cat: healthy, treatable-rehabilitatable, treatable-manageable, and unhealthy/untreatable and have been used in other studies to identify health status (23). HRA defined Asilomar scores as based on previously described definitions (24). Asilomar scores could also be classified in "unassigned" if they were not assigned a score immediately upon intake. While specific breeds were not incorporated in this model, the specificity of some coat colors provides some indicator of breed type. Coat length was not incorporated in the physical description. The classification of all components physical attributes was designated by HRA staff at time of intake.

We found a diversity of all attributes among cats included in our analysis (**Table 1**, **Supplementary Figure 2**). The average age of cats at intake was 6.0 years (median: 4.9 years). There were nearly equal proportions of male and female cats at intake (female: 49.3%; male: 48.8%; unknown sex: 2.0%). The most common primary coat color was black (33.5% of intakes) and the most common coat pattern was tabby (33.3%). All colors or patterns with fewer than 100 counts were merged and are listed as "Other." Asilomar score at intake was predominantly Healthy (16.1%), although most cats were listed as "unassigned" (78.7%).

Intake Date

We hypothesized that the date and year of intake influenced the outcome of a cat. For this analysis, we separated date into the year of intake and the Julian calendar day of the year, a scale ranging from 1–365, where 1 is January 1 and 365 is December 31. Using these two variables we were able to capture differences between years and days within years (and thus seasonality). Year of intake was between 2016 and 2020, any cats whose intake year was prior to our date range were removed from this analysis. There were 6 months of intake data for 2016, 5 months for 2020, and 12 months for 2017, 2018, and 2019. It should further be noted that there was a sharp decline in intake numbers in 2020 as a result of the SARS-CoV-2 pandemic. With respect to Julian calendar date, most intake dates occurred in spring, summer, and early fall, with pulses of intakes in late spring (May/June; days 120–180, approximately) and again in early autumn (September; days 240–273, approximately) (**Table 1**; **Supplementary Figure 3**).

Location of Origin

Upon intake, information the address of origin for each cat is collected. Intake address refers to the home address of the owner if intake type was owner relinquish, or the address, or nearest intersection, where the cat was found. We included only cats who originated from within the boundaries of Washington, D.C, and whose precise intake location was noted. A map of intake locations can be found in **Supplementary Figure 4**.

In our analyses, we included the precise geographic location, as described through latitude and longitude coordinates, as well as median income and landuse type. From the street address, we could obtain other geographic and socioeconomic information, which were described based on a 400 m-by-400 m grid. For each square, we summarized the land use, sum of residential units and the annual median household income. Median income and the number of households in each grid square was determined based on the year of cat intake using the census tract-level 2016–2019 American Community Survey (ACS) 5-Year Estimates from the U.S. Census Bureau (25). Income data for 2020 was from an ESRI data product using the same methodology as the ACS data (26). Landuse type was obtained from the National Land Cover Database (27) and reclassified into 5 levels: high-intensity developed; medium-intensity developed; low-intensity developed; open-space developed; and natural, which described areas with forest, croplands or waterways (**Table 1**; **Supplementary Figure 5**). Median income ranged from $13,595–$242,208 (median: $46,594; mean: $57,727) and most cats originated in medium intensity developed landuse types (56.1%) (**Table 1**; **Supplementary Figure 6**).

Type of Intake

We expected a strong relationship between intake type and outcome type, both directly and indirectly. Intake type refers to the classification of the reason for which the cat is brought to the shelter. Intake categories in our study were as follows: owner surrender, seized/custody; return (recently adopted cats who are being returned to the shelter within 30 days following adoption), and stray (cats with no known owner). The majority of intake types were stray (61.0%), and owner relinquish (36.9%; **Table 1**; **Supplementary Figure 7**).

Shelter Attributes: Length of Stay

Following the date of intake, a cat's outcome is likely influenced by elements of its shelter stay. In our study, we incorporated the length of stay as a predictor of outcome type. For cats in our study, the average length of stay was 24.9 days (range: 0–861 days; median: 12.0 days; **Supplementary Figure 8**), however this varied across outcome types (**Table 1**).

Structural Equation Models

Our data were a combination of continuous and categorical, which comprised both endogenous variables (which are described by other variables and have arrows directed toward them) and exogenous variables (which are used to describe other variables, and only have arrows directed away them). All continuous variables (age, median income, Julian calendar dates) were converted to z-scores to reduce homoscedasticity in latent regression models. Categorical variables were either binomial or incorporated as dummy variables.

We used a combination of observed, latent, and composite variables in our models. Observed variables refer to variables which have been directly measured. Latent variables (previously called conceptual variables) refer to variables which are not directly observed but instead are inferred or estimated through other observed variables. Latent variables are particularly useful when describing a concept which cannot be objectively quantified and observed variables capture only a portion of the variance. In other words, latent variables capture broad concepts, where some portion of the concept is unmeasured or unmeasurable.

We used latent variables in our models to describe the physical attributes of individuals as well as their locations of origin. Therefore, we expected that there may have been other variables describing the physical attributes and the intake location which were important in the model but unmeasured and thus not included here (19). In the construction of our latent variables, we did not include covariances between the observed variables. We had no expectation to account for this variance *a priori*. Composite variables are construct variables that are described in their entirety by a collection of observed variables, and thus have no variance. In contrast to latent variables, composite variables do not described concepts but act as a collection of related variables which can manage model complexity and aid in generalizing variables (19).

We used diagonally weighted least squares (DWLS) to estimate model parameters, as suggested for use among ordinal variables (28). In all models, we did not impose restrictions on y-thresholds. Model fit was assessed using three criteria: Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). CFI indices were considered acceptable at >0.95; RMSEA values were considered acceptable at < 0.08 (and <0.05 are considered good); SRMR < 0.10 were considered acceptable (29). CFI, RMSEA and SRMR are most appropriate measures of fit for large sample sizes (19). We incorporated robust test statistics that were adjusted for mean and variance using the Satterthwaite approximation, also recommended for categorical variables and large sample sizes (30, 31). Satterthwaite approximations provide robust test statistics, which are reported here, unless otherwise indicated. Standardized parameter estimates and standard errors were estimated through bootstrapping, with 1,000 draws.

Model analysis began with complete models and was subsequently modified to improve fit while keeping within the original hypothesis. Variables were removed if their inclusion prevented estimation of the model. Prior to inclusion in the SEM models, we used confirmatory factor analysis to assess the fit of latent variables, again using CFI, RMSEA and SRMR fit indicators. CFA and SEM were conducted in the lavaan package (32) in R (33).

RESULTS

Data from cat intakes and outcomes ($n = 11{,}126$ cats) at the HRA were fit to the proposed models. Confirmatory factor analysis showed both measurement models (physical attributes and intake location) had good model fit to the data (**Table 2**) and were thus included in structural equation models. As such, we did not account for covariances between observed variables describing each latent variable. Sex was not included in the physical attributes model (Hypothesis 1), as there was insufficient variation in outcomes between male and female cats. That is, there was not a considerable difference in the outcome types between males and females at the HRA (**Table 1**) Primary coat color at this shelter was not a statistically significant contributor to the physical attributes but was kept in the latent variable as it contributed to model fit. All other observed variables were statistically significant contributors to the latent variables. All observed variables describing intake location had a statistically significant influence, although median income at year of intake was the strongest contributor.

Post hoc adjustments were made if initial models were not a good fit, and revised models were nested within original models and were supported by expert opinion and the current literature. Each of our models showed acceptable goodness of fit metrics in all three measures (CFI, RMSEA, and SRMR) (**Table 2**). Based on how our outcome variable was coded, variables which had negative direct effects on outcome, represented by negative β values in the text, indicate a positive relationship between the variable and the likelihood of adoption. Therefore, negative direct effects refer to increased adoptions at HRA. Likewise, variables which have a positive direct effect on outcome indicate a negative relationship with the likelihood of adoption, or positive direct effects refer to decreased adoptions at HRA. Error terms describe the amount of variance unique to that variable and are incorporated into the calculation of the standardized parameter estimates.

In hypothesis 1, we found that cat physical attributes were significant predictors of cat outcome ($\beta = 0.47$, $SE = 0.02$, $p < 0.01$; **Supplementary Figure 9**). Within the latent variable, age and Asilomar score were the strongest contributors to the effect [age: $\beta = 0.57$, $SE = 0.02$, $p < 0.01$; Asilomar score: $\beta = 0.57$, $SE = 0.02$, $p < 0.01$)], followed by coat pattern ($\beta = -0.10$, $SE = 0.01$, $p < 0.01$). Primary coat pattern had weak and non-significant influences ($\beta = 0.03$, $SE = 0.02$, $p = 0.08$) on our latent variable.

In our second hypothesis, examining the temporal and geographic attributes of intake, location of origin was the strongest predictor of outcome type ($\beta = -0.06$, $SE = 0.01$, $p < 0.01$; **Supplementary Figure 10**). Intake year also had a significant effect on outcome type ($\beta = -0.03$, $SE = 0.01$, $p = 0.02$), and significantly covaried with Julian date of intake ($\beta = -0.29$, $SE = 0.01$, $p < 0.01$). Additionally, Julian date of intake was also a direct predictor of outcome type ($\beta = -0.03$, $SE = 0.01$, $p = 0.02$). Within the latent variable, we found all our measured variables had a significant effect, with median income as the strongest contributor ($\beta = -0.84$, $SE = 0.01$, $p < 0.01$), followed by landuse type ($\beta = 0.06$, $SE = 0.01$, $p < 0.01$). The latitude and longitude coordinates were also statistically significant (longitude: $\beta = -0.02$, $SE < 0.01$, $p < 0.01$; latitude: $\beta = -0.02$, $SE < 0.01$, $p < 0.01$).

Hypothesis 3 examined the influence of intake location and type on outcome to identify the human component of predicting cat outcome. We found that intake type did not have a significant direct effect on outcome type ($\beta = -0.01$, $SE = 0.02$, $p = 0.67$) and that intake location did have a significant and direct effect on outcome ($\beta = -0.06$, $SE = 0.01$, $p < 0.01$). Furthermore, intake location had significant influence on intake type ($\beta = 0.05$, $SE = 0.01$, $p < 0.01$). The estimates for the measured variables describing location of origin were consistent with the results to hypothesis 2, where all variables were statistically significant and median income was the strongest contributor, followed by land use type (**Supplementary Figure 11**).

TABLE 2 | Summary of model fit criteria for latent variables (cat characteristics and intake location) and structural equation models.

Model	CFI (acceptable >0.90)	RMSEA (acceptable <0.05)	SRMR (acceptable <0.10)
Physical attributes	1.00	0.00	0.00
Intake location	0.99	0.04	0.01
Model 1	0.99	0.02	0.01
Model 2	0.99	0.02	0.02
Model 3	0.98	0.04	0.03
Model 4	0.99	0.03	0.02
Model 5 (global)	0.96	0.03*	0.03

Models 1 through 4 test our specific hypotheses and model 5 refers to the global model (see text for details).
** Indicates standard value. All other values represent robust estimates.*

The fourth model for the shelter and pre-shelter experience hypothesis incorporated intake type and length of stay as observed variables. The addition of length of stay altered the relationship between intake type and outcome. Indeed, all our hypothesized connections were statistically significant, although length of stay had the strongest effect on outcome type ($\beta = -0.54$, $SE = 0.03$, $p < 0.01$), followed by intake type ($\beta = 0.04$, $SE = 0.01$, $p = 0.01$) and intake location ($\beta = -0.03$, $SE = 0.01$, $p = 0.01$). As in hypothesis 3, intake location influenced intake type ($\beta = 0.05$, $SE = 0.01$, $p < 0.01$) and length of stay was also significantly predicted by both intake type ($\beta = 0.09$, $SE = 0.01$, $p < 0.01$) and intake location ($\beta = 0.05$, $SE = 0.01$, $p < 0.01$). The intake location latent variable was similarly described by measured variables as in hypotheses 2 and 3 (**Supplementary Figure 12**).

Lastly, we fit our data to a global model, which represented a culmination of our 4 hypotheses (**Figure 2**). In this model, we incorporated a new composite variable, labeled intake attributes, described by the measured variables intake type and intake date. Cat physical attributes and intake location were incorporated as latent variables, as in previous models. Therefore, we had four variables directly influencing outcome type: intake attributes, length of stay, physical attributes, and intake location. Length of stay had the strongest effect on cat outcome ($\beta = -0.51$, $SE = 0.03$, $p < 0.01$). The negative beta value between length of stay and outcome indicates that cats who were adopted tended to have longer lengths of stay than cats with other outcomes (death or return to field), as described in **Table 1**. We also found a significant effect of physical attributes ($\beta = 0.29$, $SE = 0.01$, $p < 0.01$). Intake attributes had a smaller, but still statistically significant influence ($\beta = 0.03$, $SE = 0.01$, $p < 0.01$). Our global model demonstrated no significant direct effect of intake location on cat outcome ($\beta = 0.02$, $SE = 0.01$, $p = 0.22$). Length of stay was significantly influenced by physical attributes ($\beta = -0.10$, $SE = 0.01$, $p < 0.01$), intake location ($\beta = 0.04$, $SE = 0.01$, $p < 0.01$), and intake attributes ($\beta = -0.03$, $SE = 0.01$, $p < 0.01$). We also found that physical attributes were significantly predicted by intake location ($\beta = -0.20$, $SE = 0.02$, $p < 0.01$) and by intake attributes ($\beta = 0.02$, $SE = 0.01$, $p < 0.01$). Furthermore, intake attributes were significantly, and strongly, influenced by physical attributes ($\beta = -0.38$, $SE = 0.01$, $p < 0.01$) and by intake location ($\beta = -0.03$, $SE = 0.01$, $p = 0.08$).

Based on all three model fit statistics we found nearly equal support for all our hypotheses (**Figure 1**). Therefore, we cannot reject any hypothesis in addressing factors that influence cat outcomes. Additionally, results from the separate hypothesis models were generally reflected similarly in the global model with additional connections among variables demonstrated how the hypotheses interrelate. However, the general consistency of results supports use of the global model as our final model for interpretation and understanding of the complex system, where specific interpretations apply only to the HRA shelter in Washington, D.C.

DISCUSSION

Animal shelters are often under pressure to maintain efficiency, given constraints on capacity, welfare, and resources. Generally, the ideal outcome for socialized cats coming into a shelter is adoption, although many cats face alternative outcomes, such as being returned to their outdoor location, as with stray cats, and euthanasia or death, with cats who are ill, injured. Therefore, expanding our knowledge of predictors of animal outcomes could greatly improve shelter efficiencies. In this study, we applied 4 years of shelter cat data from one organization to test four different, though not mutually exclusive, hypotheses: first, cat outcome depends on the physical attributes and health status of the cat; secondly, outcome depends on the location and timing of intake; thirdly, outcome depends on human influences prior to intake; fourthly, outcome depends on experiences prior to outcome. Additionally, we tested a global model, which was an amalgamation of our hypotheses, to examine the interactions between our predictors. We used structural equation modeling to explore each hypothesis, based on five general factors: cat characteristics (age, body condition, coat color, and coat pattern), location of origin (latitude, longitude, median income and landuse type), intake information (type and date), and length of stay. We found that each of our four hypotheses were supported by our models, indicating that factors represented in each model were important in predicting cat outcomes. Given that all our hypotheses were supported by our models, and that the hypotheses were not mutually exclusive, we concluded that the global model provides the best description of the system. While the results to our models are specific to the factors at a specific shelter (the Humane Rescue Alliance) in a specific location (Washington, D.C.), we provide here an overarching understanding of how cat specific factors outside of the shelter interact to predict cat outcome,

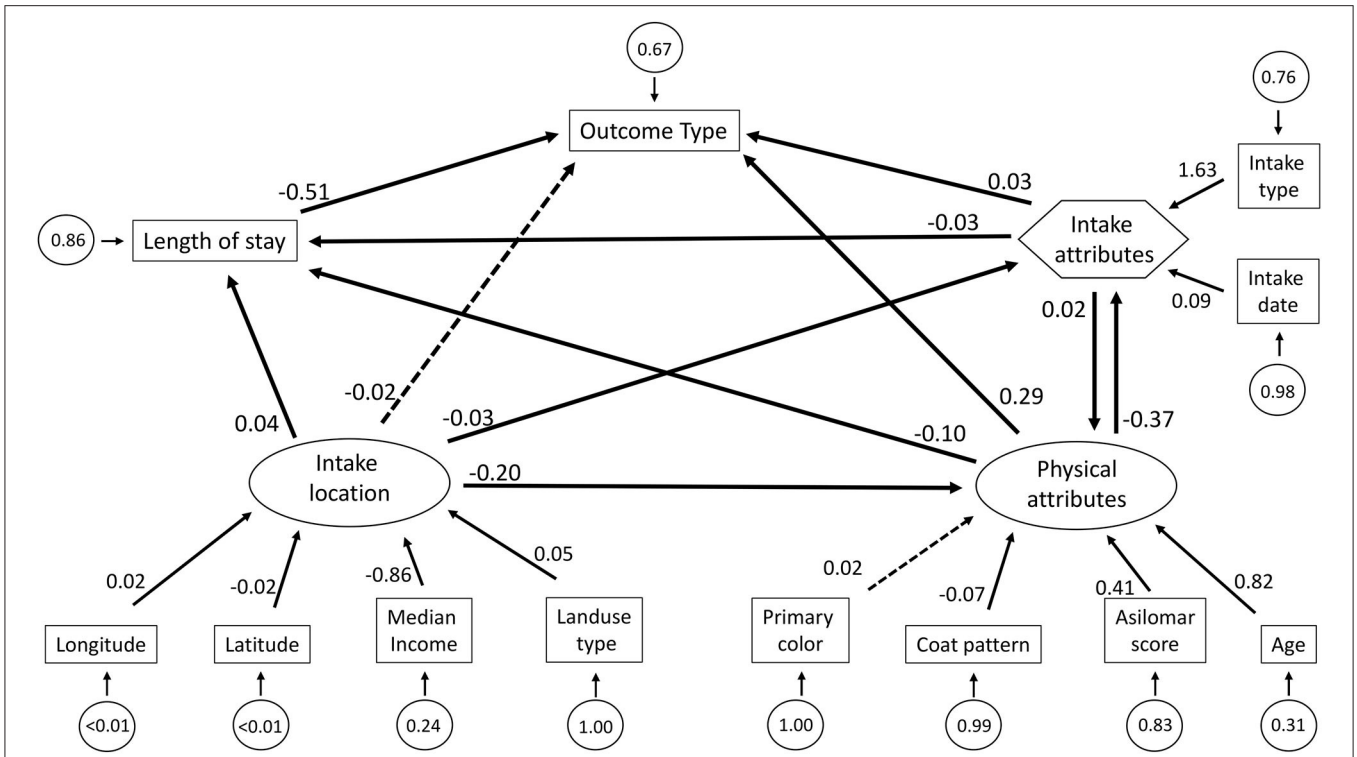

FIGURE 2 | The structural equation model describing our global model predicting cat outcomes. Arrows describe the direction of effect. Solid black arrows are statistically significant at $\alpha = 0.05$, dotted arrows indicate a lack of statistical significance. Numbers alongside the arrows are standardized path coefficients (beta coefficients). Measured variables are depicted in rectangles, latent variables are depicted in ovals, and composite variables are depicted in hexagons. The error terms, which describe the variance of the associated term, are in circles. Possible outcome types are adoption, death/euthanasia, and return to field. Based on how they were coded, negative coefficients indicate an increased likelihood of adoption and positive coefficients indicate a decrease in likelihood of adoption.

both directly and indirectly. We specifically do not include policies and practices internal to the shelter in our analysis. Our goal was to demonstrate both the importance of factors beyond the animal shelter in predicting outcome, as well as to encourage a similar exploration of factors at other shelters and locations.

Using SEM allows us to identify and quantify relationships within a whole system and provides novel insights in understanding outcome type. **Figure 2** highlights the complexities and nuances involved in predicting cat outcomes, demonstrating the importance of mediator and indirect effects in describing the whole system. Our global model results demonstrate two key points: first, we find that there is no singly important factor. That is, all five factors that we considered provided a significant contribution to the system, even if not directly influencing outcome. Secondly, the interconnectedness of the global model demonstrates how efforts to enact change in one part of the system can result in changes elsewhere, emphasizing that there are many ways to change outcome probabilities. Unlike most other studies predicting shelter outcomes which have relied on predictors specific to the animals or the shelter (34), our approach incorporates factors outside the shelter and animal which may be important. While this older approach is logical, the results can only inform modifications to practices within the shelter (35).

Consistent with other studies, we found evidence that in Washington, D.C., intake type, potentially indicating degree of ownership, and physical attributes of cats are both important components of the system relating to outcomes. We also found that these two factors interact in how they influence outcome. Marston & Bennett (36) described the relationship between cat characteristics, intake type and cat outcome, determining that stray cats who are adults and in poor body condition are more often euthanized. We further found that these two factors also play an important role in influencing length of stay in D.C. Additionally, we found a strong and significant relationship between length of stay and cat outcome, where cats with longer lengths of stay were more likely to be adopted. It is worth noting the substantial variation in lengths of stay across outcome types at HRA, as described in **Table 1**. Lengths of stay can be determined by multiple factors including policies specific to individual shelters and we used length of stay as a proxy. For example, many shelters have specific hold times for certain outcomes, such as if stray cats are brought to a shelter for TNR before being returned to their original location. Shelters may also impose a hold period prior to euthanasia. We did not incorporate shelter policies and specific practices in our model, as variation in practices between shelters highlight the challenges in identifying patterns generalizable to all shelters. Our global model described how length of stay is influenced by myriad factors, most

prominently by cat characteristics (**Figure 2**). Older cats brought to shelters as a result of owner relinquishment often have a longer duration of stay or are less likely to be adopted (37). Our global model indicates that in our system, age effects on adoption likely are influenced by the location of origin of the animal.

Intake location had an important role in our global model, although it did not have a direct effect on outcome type once all five factors were combined. GIS (Global Information System) data has been used to explore variation in cat abundance across urban areas (38, 39) where interpretation is often based on the landuse type. Spencer et al. (40) used GIS data to explore demographic information regarding the location of origin of stray dogs and cats and attribute local densities of abundance across Alachua County, Florida. Isolating the location of origin of cats upon intake can be used to determine where shelter resources may be most efficient. Consistent with previous findings, our model indicates that in Washington, D.C., the intake location does predict intake type, supporting the notion that strays or relinquished cats typically arrive from specific areas. However, our model also indicates there was no direct relationship between location of origin and outcome. That is, for example, stray cats may more commonly originate in certain geographic areas, we found no evidence that those stray intakes are more likely to result in a specific outcome in our system. Instead, we see how the effect of intake location on outcome is mediated by our other variables of interest, most strongly with characteristics of the cat. We also found that intake location predicts length of stay as well as intake characteristics. It is therefore clear that intake location is an essential component in predicting outcomes in this system, but efforts to change likelihood of adoption must incorporate other components as well. This relationship is described in previous studies describing how financial constraints influence decisions to relinquish cats to shelters (41). Our model results indicate that median income is the strongest contributor to the intake location latent variable, followed by landuse type. Additionally, it should be noted that our geographic locations were very precisely reported based on lat/long coordinates, as this allows us to capture the considerable geographic variation found in Washington, D.C. Given the variation in wealth across the Washington, D.C. area, this may not reflect other communities across the United States. However, a cat's intake location is rarely included in studies on determinants of cat outcome, and we encourage other studies to incorporate this factor when possible.

The limited resources of animal shelters and the ongoing demand for their services, require shelters to develop optimal strategies for allocating resources. Many shelters are often overburdened, such as in areas with increasing stray cat populations [for example, (7)]. As a result of the high volume of cats in need of shelter services and the limited resources of the shelter, the concept of optimality has been a major focus in the last several years. The Capacity for Care (or, C4C) management model, based on the guidelines established by the Association of Shelter Veterinarians (8), emphasizes the use of optimal strategies within the shelter to increase the volume of cats in their care over a set period of time. The goal of C4C is to increase the efficiency of shelters by focusing on reducing lengths of stay, increasing adoptions, and improving health and welfare of shelter cats (9, 42, 43). The suggestions described in C4C are based on changes within the shelter: the physical structure, housing, as well as general management (44, 45). That is, these refer to modifications that can be made within the shelter and through shelter policies and have resulted in improvements to the functionality of many shelters. Although internal policies were not considered in our analysis, there is little doubt that they influence cat outcome. Given that we relied on data from a single shelter, we therefore could not incorporate variation in internal policies in our study. In contrast, our model mostly considered factors outside of the shelter, and efforts such as C4C would be reflected in length of stay and the frequency of outcome types. As a result, our model provides a road map for shelters to understand the system and institute changes in the most effective way. For example, if older cats from low-income areas are more likely to require euthanasia or to have a very long length of stay at the shelter, then initiatives to support geriatric care (or other strategies) targeted to those geographic areas may be the best way of altering outcomes.

While this study provides a novel perspective on how many factors can influence cat outcomes, there were several limitations to our study. It should be noted that our results were derived from the data of a single shelter that serves to entire Washington D.C. area. Using a data from only HRA came with several benefits, such as that we could ensure relative consistency in data collection, and Washington D.C. encompasses a large geographic area, providing substantial variation in our geographic data. However, the results found here may not be applicable to smaller urban centers, or locations with different climactic, demographic, and geographic profiles. While our study area provided extensive variation in geographic factors such as median income and landuse type which are useful for SEM, basing our results on a single location prevents us from considering other factors. For example, climatic and seasonal changes have substantial impacts on stray cat population abundance and reproduction [(46), though see (47)], as well as the relative intensity of urbanization (48). Therefore, we discourage the use of our specific model results for determining allocation of resources in other shelters. Instead, we encourage the use of similar models to understand the complexities of the local systems. In using data from only one shelter, we were also constrained by the modes of data entry occurring here, particularly around how Asilomar score was categorized. Asilomar score was a strong and significant predictor in all models (**Supplementary Figure 7**; **Figure 2**) and there was substantial variation in outcome types across the categories (**Table 1**). However, we recognize the limitations in interpretation of this variable, given the proportion of "unassigned" cats (**Supplementary Figure 2E**). Other studies have considered how the transfer of animals from shelters to rescue groups increases adoption (49), which was also not considered in our analysis. We summarized shelter experience by a single measured variable, length of stay, which does not encapsulate many components of the shelter itself.

In this study, we provide a novel perspective toward understanding predictors of shelter cat outcomes. Using structural equation modeling on data specific to Washington, D.C., we found that cat characteristics, type and date of intake, and length of stay had direct influences on outcome type

at this shelter and in this region. Further, we found that location of origin played an important role as a mediator in influencing outcome type, although did not have a direct influence. From our global model, we have shown the vast complexity of the system in predicting outcomes in shelters, demonstrating not only the direct effects of multiple factors but also how these factors are themselves interrelated. As shelters often face conflicting demands of intake numbers and capacity, the appropriate allocation of resources to increase live outcomes and minimize euthanasia is vital. While our results refer specifically to Washington, D.C., our model results demonstrate the importance of incorporating factors outside of the shelter in addressing changes to outcome type, highlighting how many components can alter cat outcome. Additionally, as factors are themselves interconnected, increasing resources (such as community programming and support services) to specific cat populations are encouraged to explore relationships between factors, and models may identify the how outcome is intake type, physical characteristics, and intake location. Such model results could highlight a regional importance to distribute resources to, for example, stray cats in low-income areas or geriatric cats in high income areas. We encourage the use of path models in other geographic areas and systems as a means of addressing specific needs in other regions and maximizing the contributions of animal shelters to the communities they serve.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Materials**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

RK and DF conceived of the study, developed hypotheses and models, interpreted the data, and contributed to the writing of the manuscript. RK performed the statistical analysis. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2022.766312/full#supplementary-material

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Trends in Intake and Outcome Data From U.S. Animal Shelters From 2016 to 2020

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In this retrospective, exploratory study, intake and outcome data were compiled from 1,373 U.S. animal shelters for which such data were reported consistently across a five-year study period (2016–2020). Linear regression analysis was used to examine the five-year trends and the impacts of the first year of the COVID-19 pandemic (2020) on the overall trends in intake and outcomes in U.S. animal shelters. The results of the analysis reveal that total intake and euthanasia for both dogs and cats significantly decreased over the study period. The adoption, return-to-owner, return-to-field, and transfer (for cats) categories as a percentage of intake all showed significant increases. Live release rates as a function of total intakes and total outcomes for both dogs and cats showed significant increases over the study period. The findings from this study address a critical gap in the field by summarizing emerging trends at the national level in how cats and dogs are being served in U.S. animal shelters.

Keywords: animal shelters, intake, live outcomes, euthanasia, trend analysis, animal relinquishment, shelter statistics, COVID-19

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INTRODUCTION

The efforts to standardize data collection on sources of intake and outcomes for animals in the care of U.S. animal shelter and rescue organizations have been underway since the 1980s. However, relatively little research to date has assessed the overall trends in intake and outcomes nationally. This gap in data collection and comprehensive program evaluation is particularly notable given the growing recognition of the importance of pet keeping on individual and community health and the increasing number of essential pet support services these organizations offer to their communities.

When animal sheltering began in the United States, as early as 1866 with the founding of the American Society for the Prevention of Cruelty to Animals in New York City, animal control efforts were concentrated on removing dogs and cats from city streets to reduce the threat of rabies (1–3). Although removing "strays" would remain common practice for decades to come, it has been suggested that the related issue of "pet overpopulation" received relatively little attention before the 1940s (4). With the 1950s came the first public education campaigns on the subject, followed

by spay–neuter campaigns aimed at addressing the issue during the 1960s (4). It was not until the early 1970s, when publications began to draw attention to the increasing number of stray and unwanted dogs and cats in animal shelters (5) that the number of low-cost spay–neuter clinics began to rapidly increase (4). Along with these developments came a growing interest in basic shelter intake and outcome data (e.g., the number of animals admitted, the number euthanized). Intake estimates from the American Humane Association's Animal Shelter Reporting Study, 1985–1988, illustrate just how little reliable data were available at the time. This report estimated, for example, that anywhere between 16.9 and 28.1 million dogs, along with 10.7–17.8 million cats, entered U.S. animal shelters during 1985. Of these, an estimated 9.9–16.6 million dogs and 7.8–12.9 million cats were euthanized (4).

Recognizing that such uncertainty made it difficult, if not impossible, to measure improvements in a particular program's effectiveness—and in the animal sheltering system's capacity to support the community's animals, more generally—researchers called for a more careful accounting of shelter data. In a 1992 editorial, Rowan (6) referred to the lack of accurate data describing the number of animals entering and exiting U.S. shelters as "a statistical black hole," pointing out that even the number of operating animal shelters was a matter of considerable uncertainty at the time. It was, therefore, "hardly surprising that national estimates of animals euthanized in shelters vary by a factor of two to three" (6).

Although many of the larger animal shelters were beginning to keep "comprehensive statistics on the number of animals handled and their disposition (euthanasia, adoption, and redemption)," the practice was not universal (7). In addition, "there [was] no standard format for keeping statistical information" at the time (8). In 1993, the National Council on Pet Population Study and Policy was established in part "to gather and analyze reliable data that further characterize the number, origin, and disposition of companion animals (dogs and cats) in the United States" (9). Despite the Council's success in compiling data from an estimated 22–23% of shelters in the country, such efforts were hampered "by (1) shelter suspicion about how data would be used if reported publicly, (2) the birth and disappearance of organizations (e.g., rescue groups), (3) changes in the names and locations of shelters, and (4) the lack of a standard definition of shelter" (9).

As recently as 2008, Scarlett (9) lamented that, although

> "progress has been made toward eliminating Rowan's 'statistical black hole'… basic data still elude us, including: the actual number of animal shelters in the country, national shelter estimates of impoundments and dispositions (euthanasia, adoption, redemption), and the effectiveness of programs (e.g., spay/neuter, adoption counseling) in reducing euthanasia."

An important step in satisfying the need for "basic data" was addressed in 2004 with the adoption of the Asilomar Accords by industry leaders who agreed to a series of definitions that would "provide a standard way to categorize the dogs and cats who comprise the shelter population of the various organizations each year" (10). In 2011, a coalition of animal welfare organizations created the National Database, the management of which would be overseen by an independent nonprofit, Shelter Animals Count (SAC) (11). The organization's Basic Animal Data Matrix, a simple data collection tool, was designed to "facilitate the roll-up or merging of data at the local, regional, or national level by providing a common framework" (12). As of March 2021, SAC has compiled data from 2,046 animal shelters and rescue groups across the U.S. (13).

To build on the efforts of SAC, Best Friends Animal Society (BFAS) began compiling shelter data in 2016, an effort that first necessitated the identification of thousands of organizations across the country considered to be animal shelters (see definition below). Within the BFAS dataset, shelter metrics from SAC were combined with those shared directly with BFAS, as well as those obtained from other sources (e.g., public records) (14). The aim of this study was to use the data collected by SAC and BFAS to measure the trends in both intake and outcome data from 2016 to 2020 across two scales (actual number per year and percentage of total intake per year). These retrospective exploratory analyses of the data identified the emerging trends in the overall capacity of the animal sheltering system to serve animals in communities across the U.S.

MATERIALS AND METHODS

Data Compilation

Intake and outcome data were obtained from SAC and BFAS to generate a nationally representative sample of animal sheltering organizations that reported intake and outcome data consistently over the study period of 2016–2020. Since all data were publicly available or obtained from the organizations with permission to use for research and evaluation purposes, no human subject protection oversight or other forms of ethical approvals were required. For the purposes of this study, a *shelter* was defined as any organization housing animals in a facility, not located in a residence, that is open to the public at least 2 days each week, including municipal shelters (with more than 24 animals admitted annually), private nonprofit shelters with or without a government contract (with more than 99 animals admitted annually), and rescue groups with government contracts. Sources for shelter data that were obtained from SAC and BFAS included voluntary data submissions (including data submitted to SAC or obtained directly from BFAS "network partners" which includes organizations with which BFAS has ongoing working relationships) and other publicly available sources of data, such as organization or government websites. Within our sample population, seven organizations (0.5%) had multiple locations. One organization has four locations, one has three locations, and five organizations have two locations. These organizations that operate multiple facilities may have reported their data in aggregate or broken down by location.

The number of dogs and cats taken into the shelters and the outcomes for those animals were collected according to the industry standards established through the Shelter Animals Count Basic Animal Data Matrix (12). The categories for intake included stray or at-large: animals that were stated to be unowned or free-roaming; owner relinquished: animals that are admitted by their owner, including adoption returns; owner-intended

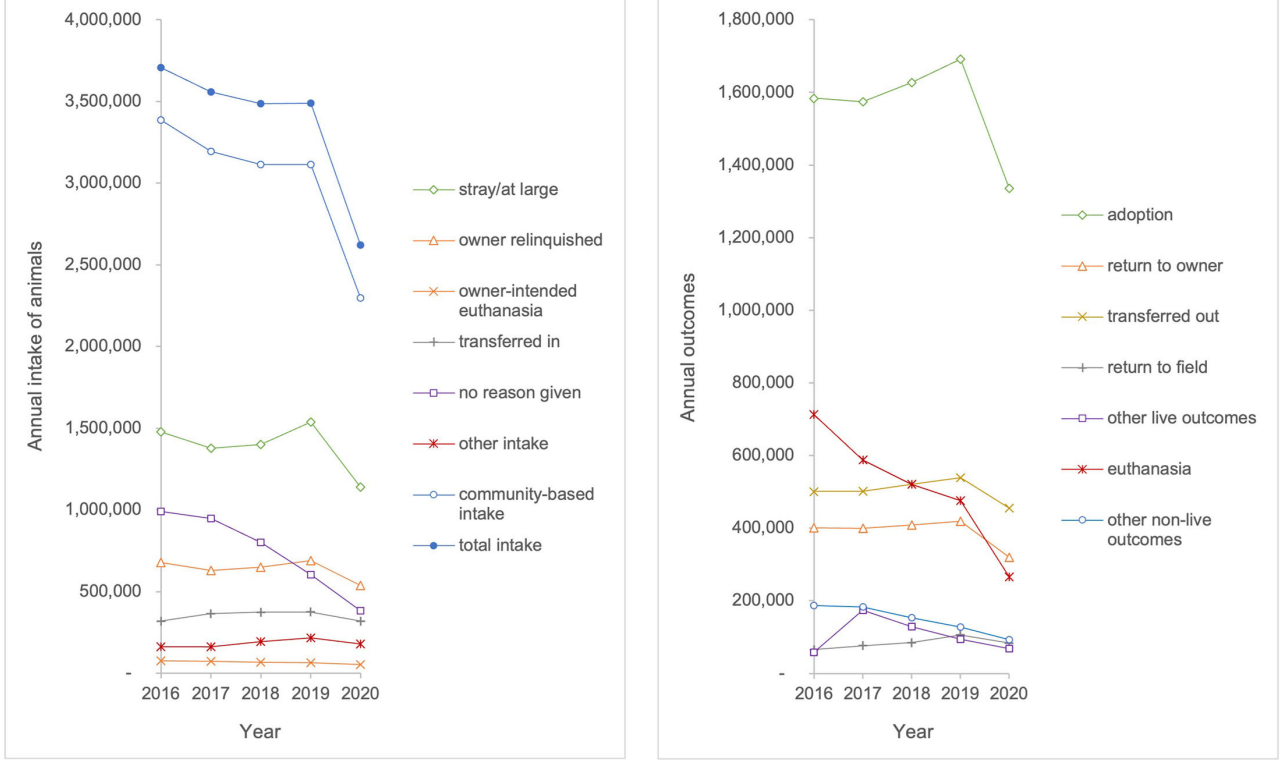

FIGURE 1 | (A) Annual intake and **(B)** annual outcomes for animals entering the shelters in the sample population (n = 1,373) from 2016 to 2020.

euthanasia: animals surrendered by their legal owner with the intent of requesting euthanasia; transferred in from another agency: animal admissions from another agency either locally or in a different state or territory for adoption or large-scale intake issues; no reason given: no reason for intake was recorded by the organization; and other: includes all admissions not captured above (e.g., animals born in care).

The categories for outcomes included euthanasia: animals that were euthanized by the facility other than those categorized as owner-intended euthanasia or other non-live outcomes; adoption: animals that were adopted, having permanently left the agency's possession, including barn cat programs resulting in adoption (this does not include animals in foster care or "trial" stays); returned to owner (RTO): stray or owner relinquished animals who are returned to their legal owner; transferred out: animals that were transferred to another facility, either locally or in a different state or territory; returned to field (RTF): animals included in intake, already altered, or altered after intake, and returned to stray capture location to be released (often referred to as shelter-neuter-return or SNR); and other non-live outcome: animals that died in care, were lost in care, or were euthanized as a result of an owner-intended euthanasia request; and other live outcomes: live outcomes not captured in the above (not captured in the outcome subtypes, an example would be the barn cat programs in some shelters).

Sample Description

The best estimates identify 4,400 animal shelters across the U.S.; however, data were available from SAC and BFAS for only 3,330 of these organizations (76%) during 2020 and datasets for previous years included fewer shelters (15). For this study, data were compiled for 1,373 total organizations that qualified as a shelter organization and reported data for all 5 years of the study period 2016–2020. The 1,373 organizations include at least one shelter from all 50 states and the District of Columbia accounting for about 31% of the estimated total number of shelters (4,400) in the United States (15). Regionally, the sample is distributed across all eight regions (Southeast n = 158; South Central n = 160; Pacific n = 146; Northeast n = 136; Mountain West n = 127; Midwest n = 140; Mid Atlantic n = 303; Great Plains n = 203). This sample of shelter organizations included 676 (49%) government animal service organizations, 388 (28%) shelter organizations without a government contract, 308 (22%) shelters with a government contract, and one (0.0007%) animal rescue with a government contract. Intake and outcome data were aggregated for all animals (both cats and dogs) and analyzed from the 1,373 organizations who reported data over the study period (**Figure 1**). Species-specific data were only available for a subset of the sample population. Therefore, intake and outcome data were aggregated and analyzed from 1,131 organizations that reported species-specific data on dogs and from 1,101

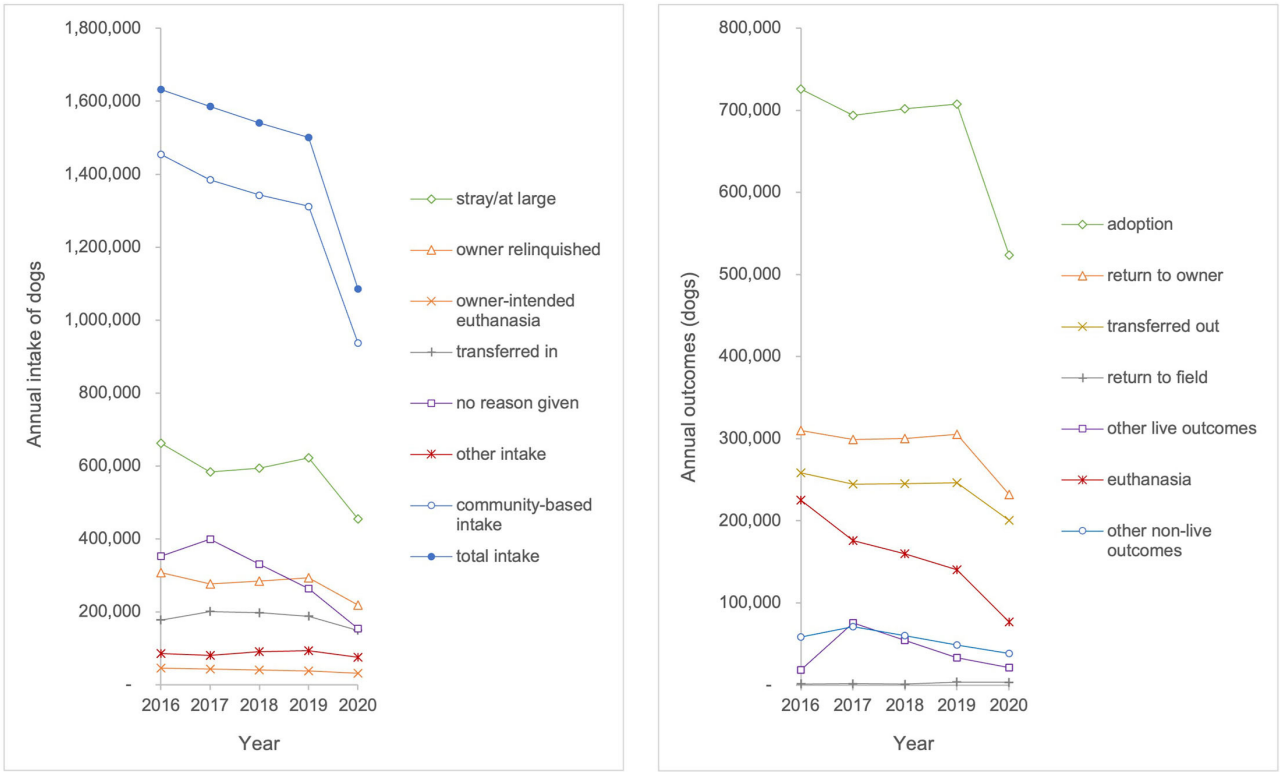

FIGURE 2 | (A) Annual intake and **(B)** annual outcomes for dogs entering the shelters in the sample population (n = 1,131) from 2016 to 2020.

organizations that reported species-specific data on cats during the study period (2016–2020) (**Figures 2**, **3**). Transfers of animals between multiple shelters may have resulted in some animals being represented in intake data more than once. The maximum proportion of possible intake errors (i.e., individual animals being accounted for twice in intake data), was calculated by dividing the aggregate number of transfers by the aggregate number of intakes for each species (total–25%, dogs–28%, and cats–22%). This calculation assumed that all transfers were between the 1,373 facilities included in the study. To explore the impact of transfers from other agencies on shelter capacity, descriptive statistics were calculated for community-based intake (e.g., stray, owner surrender, and other), often referred to as 'net intake' in the animal welfare field. This allowed assessment of differences in the trends observed for animals that were admitted to a shelter as a result of community needs (e.g., a lack of access to resources) rather than to facilitate shelter capacity, provide adoptable animals to the community, or optimize resource allocation.

Statistical Analysis

Trends in the aggregated total, intake subtype, and outcome subtype data (e.g., stray, owner relinquished, adoption, and euthanasia) for the described metrics across the five-year study period were identified by linear regression analysis. Prior to conducting analyses, the assumptions of linear regression were tested for our count and percentage/ratio data by examining normal Q–Q plots, scale location plots, and residual leverage plots. It was determined that the data met the assumptions of linear regression. This exploratory analysis assessed simple increases or decreases over time with the assumption that systemic heteroscedasticity was not an issue and that any changes over the interval were primarily monotonic.

To illustrate the linear nature of the intake and outcome data, **Figures 1**–**3** show raw data of aggregate intakes and outcomes by year for the study period 2016–2020. For linear regression plots, the y-intercept represented the magnitude for each intake category at the beginning of the study period (year 2016) and the slope represented the amount of change per year. No correction for autocorrelation was incorporated into the analyses, although the influence of data from a previous year on the next would have tended to flatten the trends. Slopes with p-values ≤ 0.05 were deemed to be significantly different from 0, whereas slopes with p-values >0.05 were deemed to have no statistical evidence of a trend during the study period.

To acknowledge the possibility that the COVID-19 pandemic, which began in 2020, may have skewed shelter operations, beginning in 2020, outliers in the dataset were determined using a two-sided Dixon outlier test. An additional linear regression analysis was then completed to explore the trends in the data with any data categories containing significant outliers in 2020 removed for analysis.

No adjustments for the multiplicity of testing were incorporated owing to the exploratory nature of the analyses; thus, the overall type I error could have been greater than the α

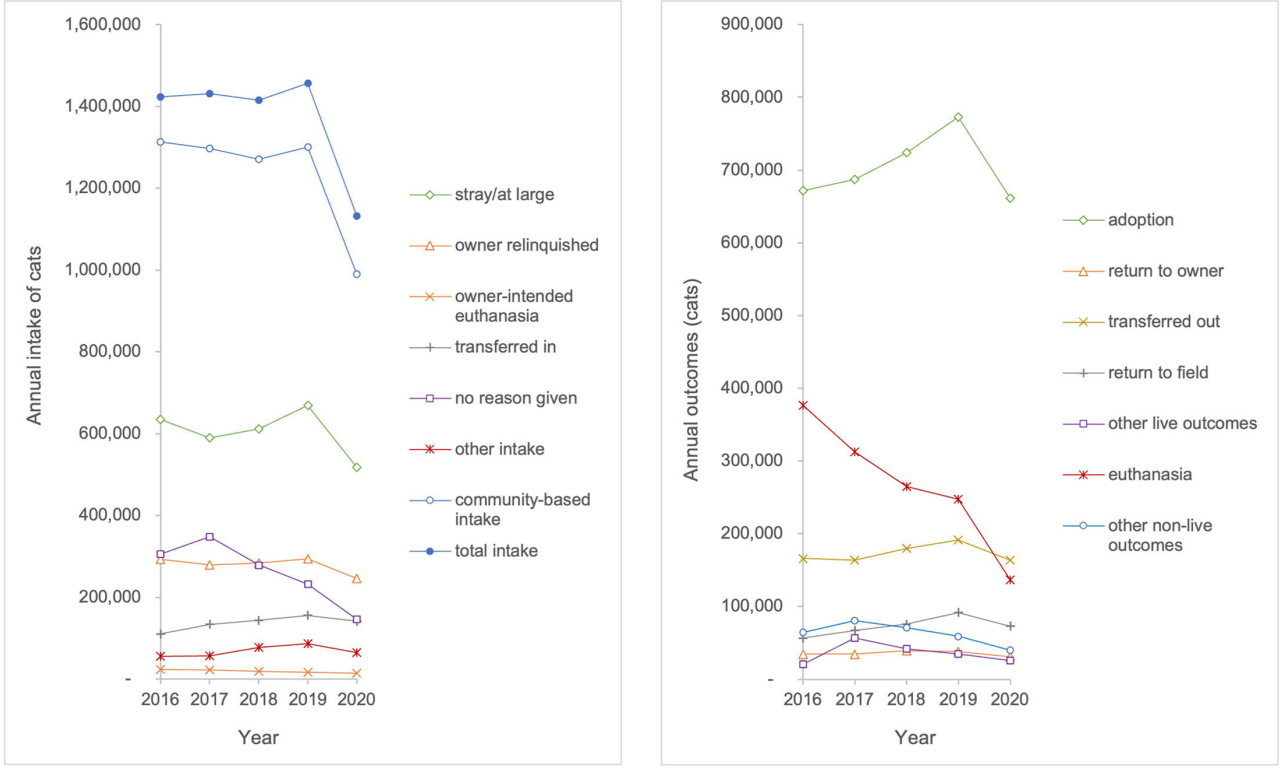

FIGURE 3 | (A) Annual intake and **(B)** annual outcomes for cats entering the shelters in the sample population (n = 1,101) from 2016 to 2020.

value (i.e., 0.05) for individual tests. The total change, final value (predicted year 2020 value), and percentage change for the trend line over the study period were calculated for all trends that had slopes significantly different from 0. Total change was calculated as the slope multiplied by the number of years of change that were analyzed (5 years) in the regression analysis. The final value of the trend line was calculated by adding the total change to the y-intercept, and percentage change was calculated as 100 times the total change divided by the y-intercept. For trend lines with slopes not significantly different from 0, the final value was assumed to be the same as the y-intercept.

Data were reported primarily as predicted values from linear regression analyses (not as actual/observed values). This was done because our interest was in examining trends over the entire five-year study period rather than year-to-year changes; reporting only observed values can be misleading since doing so ignores year-to-year variation and may not account for baseline data. Therefore, values for the first year in each analysis (2016) were reported as the predicted y-intercept for the linear regression, and values for subsequent years were calculated from the y-intercept and slope.

RESULTS

Trends in Intake

Trends in intake were assessed for all animals, dogs, and cats, based on total intake and intake subtype categories (**Table 1**). The total intake of all animals entering the 1,373 shelters and rescue organizations included in our sample decreased by 23% from 3,820,931 to 2,925,427 over the study period ($p < 0.01$). Owner-intended euthanasia for all animals decreased by 30% from 79,312 to 55,711 over the study period ($p < 0.01$). Owner-intended euthanasia for dogs decreased 28% from 46,651 to 33,561 ($p < 0.01$), and owner-intended euthanasia for cats decreased from 23,985 to 14,726, a decrease of 39% ($p < 0.01$). No reason given for intake of all animals decreased by 59% from 1,057,237 to 433,754 ($p < 0.01$). For dogs, no reason given at intake decreased by 52% from 406,846 to 193,964 ($p < 0.05$). For cats, no reason given at intake decreased by 50% from 349,118 to 175,190 over the study period ($p < 0.05$). The trendline analysis showed that there was no statistically significant change over the study period for total intake for dogs, total intake for cats, community-based intake, or intake subtypes (stray, owner relinquished, transferred in, and other) for all animals, dogs, or cats.

Trends in Outcomes

Trends in outcomes were assessed for all animals, dogs, and cats, based on total outcomes and outcome subtype categories (**Table 1**). The analysis identified no statistically significant change over the study period for adoption, return-to-owner, return-to-field, transfer out, or other live outcomes. The euthanasia outcome for all animals in our sample decreased by 56% from 713,557 to 311,054 ($p < 0.01$). Dog euthanasia

decreased by 60% from 222,104 to 89,080 ($p < 0.01$). Cat euthanasia decreased by 58% from 376,568 to 158,811 during the study period ($p < 0.01$). Other non-live outcomes decreased by 49% from 197,460 to 100,158 over the study period ($p < 0.01$).

Trends in Outcomes as a Percentage of Intake

Based on our sample of 1,373 animal shelters, the total number of animals euthanized as a percentage of intake in shelters across the country decreased by 44% from 2016 to 2020 ($p < 0.01$) (**Table 2**). Dog and cat euthanasia as a percentage of intake also decreased by 45% and 52%, respectively ($p < 0.01$). Adoptions of animals as a percentage of intake increased by 20%, and cat adoptions increased by 24% from 2016 to 2020 ($p < 0.01$). Dog adoptions also increased by 10% percent in the study time frame ($p < 0.05$). Return-to-owner outcomes as a percentage of intakes increased by 13% for all animals entering shelters across the United States ($p < 0.01$). The number of dogs returned to owner also increased by >13% from 2016 to 2020 ($p < 0.01$). Transfers for total animals increased by 27% over the study period ($p < 0.01$). Transfers for cats increased by 26% over the study period ($p < 0.05$). Animals that had other non-live outcomes decreased by 34% ($p = 0.01$). Other non-live outcomes for dogs decreased by 38% ($p < 0.01$), and for cats, the decrease was 48% over the five-year study period ($p < 0.01$). No statistically significant changes were identified for transfers of dogs or for animals that had other live outcomes during the study period.

Live Release Rates

Trend lines indicated that the live release rate (LRR) for dogs as a function of intakes increased by 15% from 2016 to 2020 ($p < 0.01$) (**Table 3**). The LRR for dogs as a function of outcomes increased by 24% from 2016 to 2020 ($p < 0.01$). For cats, LRR as a function of intakes increased by 12% from 2016 to 2020 ($p < 0.05$). The LRR for cats as a function of outcomes increased by 21% ($p < 0.01$). There was an increase for all animals of 20% for LRR as a function of intakes ($p < 0.01$) and 9% as a function of outcomes ($p < 0.05$).

Impacts of the COVID-19 Pandemic

The outlier test indicated that there were several categories of shelter operations in 2020 that differed significantly from previous years. The year of 2020 was an outlier in the dataset for the following categories: total intake, total community-based intake, total adoptions, total return to owner, and total transfers out (**Table 4**). Trends in intake and outcomes with the outlier year of 2020 removed were then assessed. The trend line in total intake for all animals and cats, without the outlier of 2020, did not change from 2016 to 2019. However, total intake for dogs, excluding the outlier of 2020, decreased by 12%. Similarly, the trend line in total community-based intake for all animals and cats, without the outlier of 2020, did not change. However, total community-based intake for dogs, excluding the outlier of 2020, decreased by 13%. The trend lines in adoption, return to owner, and transfer as an outcome, without the outlier of 2020, did not change.

DISCUSSION

This study included a sample of 1,373 animal shelter organizations across the U.S. While this dataset represents the most representative and accurate estimate of shelter intake and outcome on the national basis to date, there is still a need for increased participation by shelter organizations in reporting data to these national repositories. For example, only 2,386 of the 4,400 animal shelters known to exist in the U.S. (44%) self-reported a full year of data to SAC in 2020 and there was a lack of participation from the Midwestern and Southern regions (16). Some states have addressed this issue of lack of participation by legislatively mandating reporting of shelter intake and outcome data as a condition of licensing [see, e.g., (17)].

The overall trends observed in this study indicate that total intake and euthanasia are decreasing for both dogs and cats. Understanding trends in intake across the U.S. is important for assessing the overall capacity and resources of the sheltering system that could be made available to address community-specific needs. Previous studies have utilized geographic information system (GIS) mapping of intake sources for specific communities to inform program development and resource allocation, particularly for communities with high rates of intake (18). By presenting trends from a representative sample of organizations across the U.S., this study provides useful information on how current programs are impacting animal welfare on a national basis.

Impacts of the COVID-19 Pandemic

Many animal shelter practitioners are eager to examine how the COVID-19 pandemic has impacted the animal shelter system within the U.S. While there was an overall decrease in the trend in total intake from 2016 to 2020, it is notable that an estimated 2,622,682 million dogs and cats entered shelters in 2020, which represents a decrease of 25% from the 3,489,598 million total intakes reported in 2019. This stands in contrast to the modest change documented between 2018 and 2019, when admissions increased by 0.07%. The restricted services imposed by many shelters during the COVID-19 pandemic may have been a key factor in the decreased admissions recorded in this dataset during 2020. For example, in a statement outlining recommendations for animal control operations during the COVID-19 pandemic, the National Animal Care and Control Association emphasized the importance of reducing shelter admissions:

> "Animal control agencies should take active measures to reduce non-essential shelter intake. Measures taken should include returning pets in the field instead of impounding them, suspending non-emergency owner surrender intake, and encouraging owners who are ill to keep their pets at home whenever possible" (19).

Many organizations also embraced a "community-supported sheltering" model during the COVID-19 pandemic and created new programs or increased the availability of existing programs that proactively address the most common reasons for shelter intake (e.g., housing insecurity, access to veterinary care, and

TABLE 1 | Results of linear regression analysis of total intake and outcome data reported by animal shelter organizations in the United States (2016–2020).

Shelter metric	Slope	*P*-value*	Y-intercept	Total change	Final value	% change
Intake						
Total intake	*−223,876*	*<0.001*	*3,820,931*	*−895,504*	*2,925,427*	*−23*
Dogs	−117,771	0.07	1,704,366	NC	1,233,284	NC
Cats	−55,833	0.23	1,483,317	NC	1,259,985	NC
Total community–based intake	−226,154	0.07	3,473,481	NC	2,568,864	NC
Dogs	−110,818	0.06	1,507,634	NC	1,064,361	NC
Cats	−64,251	0.15	1,362,842	NC	1,105,838	NC
Total stray	−51,342	0.35	1,489,711	NC	1,284,342	NC
Dogs	−37,682	0.13	658,880	NC	508,151	NC
Cats	−15,381	0.47	635,547	NC	574,022	NC
Total owner relinquish	−21,860	0.31	681,063	NC	593,622	NC
Dogs	−16,015	0.15	308,526	NC	244,468	NC
Cats	−7,865	0.25	295,354	NC	263,895	NC
Total owner–intendedeuthanasia	*−5,900*	*0.008*	*79,312*	*−23,602*	*55,711*	*−30*
Dogs	*−3,272*	*0.003*	*46,651*	*−13,089*	*33,561*	*−28*
Cats	*−2,315*	*0.003*	*23,985*	*−9,259*	*14,726*	*−39*
Total no reason	*−155,871*	*0.005*	*1,057,237*	*−623,483*	*433,754*	*−59*
Dogs	*−53,221*	*0.046*	*406,846*	*−212,882*	*193,964*	*−52*
Cats	*−43,482*	*0.04*	*349,118*	*−173,928*	*175,190*	*−50*
Total other	10,091	0.20	164,953	40,364	205,316	NC
Dogs	−629	0.83	86,731	−2,515	84,216	NC
Cats	4,792	0.32	58,838	19,167	78,005	NC
Total transferred in	1,007	0.93	348,655	NC	352,682	NC
Dogs	−6,952	0.36	196,733	NC	168,923	NC
Cats	8,418	0.11	120,476	NC	154,147	NC
Outcomes						
Total shelter euthanasia	*−100,626*	*0.007*	*713,557*	*−402,502*	*311,054*	*−56*
Dogs	*−33,256*	*0.006*	*222,104*	*−133,024*	*89,080*	*−60*
Cats	*−54,439*	*0.006*	*376,568*	*−217,757*	*158,811*	*−58*
Total adoption	−37,782	0.46	1,638,195	−151,128	1,487,067	NC
Dogs	−39,154	0.15	748,958	−156,615	592,343	NC
Cats	6,529	0.71	690,344	26,114	716,458	NC
Total return to owner	−14,240	0.32	418,055	−56,959	361,096	NC
Dogs	−15,027	0.16	319,418	−60,107	259,311	NC
Cats	−361	0.78	36,172	−1,442	34,730	NC
Total return to field	6,617	0.19	69,967	26,469	96,437	NC
Dogs	622	0.09	852	2,488	3,340	NC
Cats	5,732	0.19	61,441	22,931	84,372	NC
Total transfer	−5,395	0.66	514,061	−21,580	492,481	NC
Dogs	−11,292	0.10	261,637	−45,169	216,469	NC
Cats	2,327	0.62	168,230	9,308	177,539	NC
Total other non–live	*−24,326*	*0.004*	*197,460*	*−97,302*	*100,158*	*−49*
Dogs	−6,216	0.11	67,770	−24,864	42,906	NC
Cats	−7,080	0.16	77,172	−28,319	48,853	NC
Total other live outcomes	−6123	0.74	117,106	−24,492	92,614	NC
Dogs	−3,668	0.70	47,896	−14,674	33,223	NC
Cats	−1,230	0.83	38,512	−4,920	33,592	NC

*Community-based intake categories are indented for clarity. NC, not calculated (i.e., the slope of the trend line was not significantly different from 0). *The p-value was calculated to assess whether the slope of the linear regression line was significantly ($P \leq 0.05$) different from 0; these values are denoted with italics. Total change = slope*4(years of study-1). Final value = (total change + y-intercept). Percent change = (total change*100)/y-intercept.*

TABLE 2 | Results of linear regression analysis of outcomes as a percentage of intake reported by animal shelter organizations in the United States (2016–2020).

Shelter metric	Slope	*P*-value	Y-Intercept	Total change	Final value	% change
Total shelter euthanasia	*−0.021*	*0.002*	*0.191*	*−0.084*	*0.107*	*−44*
Dogs	*−0.015*	*0.004*	*0.134*	*−0.061*	*0.073*	*−45*
Cats	*−0.034*	*0.001*	*0.259*	*−0.134*	*0.125*	*−52*
Total adoption	*0.021*	*<0.001*	*0.425*	*0.083*	*0.507*	*20*
Dogs	*0.011*	*0.02*	*0.437*	*0.043*	*0.480*	*10*
Cats	*0.028*	*0.008*	*0.461*	*0.110*	*0.571*	*24*
Total RTO	*0.004*	*0.002*	*0.109*	*0.014*	*0.123*	*13*
Dogs	*0.006*	*0.02*	*0.186*	*0.025*	*0.211*	*13*
Cats	0.001	0.14	0.024	0.003	NC	NC
Total transfer	*0.009*	*0.008*	*0.133*	*0.036*	*0.169*	*27*
Dogs	0.006	0.09	0.151	0.025	NC	NC
Cats	*0.007*	*0.02*	*0.112*	*0.029*	*0.141*	*26*
Total RTF	*0.004*	*0.002*	*0.018*	*0.015*	*0.033*	*85*
Dogs	*0.001*	*0.04*	*0.0003*	*0.002*	*0.003*	*696*
Cats	*0.007*	*0.002*	*0.040*	*0.026*	*0.067*	*65*
Total other non–live	*−0.004*	*0.01*	*0.053*	*−0.018*	*0.035*	*−34*
Dogs	*−0.017*	*<0.001*	*0.174*	*−0.066*	*0.108*	*−38*
Cats	*−0.037*	*<0.001*	*0.312*	*−0.149*	*0.163*	*−48*
Total other live	−0.0002	0.97	0.031	−0.001	NC	NC
Dogs	−0.001	0.87	0.029	−0.004	NC	NC
Cats	0.00003	0.99	0.026	0.00001	NC	NC

*See **Table 1** for key.*

access to pet food and supplies). Examples of these programs include pet food and supply banks (20), advocating for pet-friendly rental policies (21), shifting animal control operations from a punishment to support model (22), offering co-sheltering options for individuals in crisis (e.g., individuals experiencing homelessness or domestic violence) (23), One Health vaccine clinics (24), and examining how social and economic inequities affect shelter intake (25, 26). There are a number of other emerging program areas that may also be contributing to the measured decreases in total intake throughout the study period, including low- or no-cost spay–neuter services and other preventive veterinary care (27, 28); door-to-door outreach in underserved communities to overcome barriers in access to veterinary care (29), trap-neuter-return (30–32), and return-to-field programs (33, 34).

This study explored whether the first year of the pandemic (2020) functioned as an outlier in the overall trends in animal shelter intake and outcomes over the last 6 years. The results indicate that 2020 was, in fact, an outlier for the following categories of animal shelter intake and outcomes: total intake, community-based intake, adoptions, return to owner, and transfers out. Any differences in trends that have been observed with or without the 2020 data may be initial indicators of the impacts of the COVID-era programs that have been implemented by shelters in recent years. However, it is important to note that one would not typically remove any single year of data from a trends analysis solely based on the results of any one statistical test. Further investigation is recommended once the additional years of data following the pandemic (2021, 2022) are available, to assess the extent to which 2020 has been or will continue to be an outlier in the dataset. Further, future research should aim to measure the long-term sustainability and effectiveness of these programs while also identifying any remaining gaps in pet support services, particularly in historically marginalized communities.

Best Practices in Animal Shelter Intake and Outcomes

There are a number of emerging best practices in the animal sheltering field that likely inform the observed trends in intake and outcomes over the study period. The significant decreases in the trends of euthanasia for cats and dogs likely represent a focused effort of both local and national organizations to implement best practices both within the shelter organizations and in the surrounding community. Across the 1,373 animal shelters examined in this study, there were an estimated 265,578 dogs and cats euthanized in 2020, which represents a decrease of 44% from the 475,489 euthanasia outcomes reported in 2019. This stands in contrast to the modest change documented between 2018 and 2019, when euthanasia decreased by 9%. The literature indicates that these best practices for reducing shelter euthanasia include providing specialized medical and behavior care for animals in shelter care, reducing barriers to adoption (e.g., eliminating adoption fees), engaging in triage and appointment-based admissions, and increasing stakeholder engagement in shelter services (e.g., foster caregiving, partnerships with local private practice veterinarians) (35–39). Future research should continue to assess which

TABLE 3 | Results of linear regression analysis of dog, cat, and total live release rates as a function of total annual intakes and as a function of total outcomes by animal shelter organizations in the United States from 2016 to 2020.

Shelter metric	Slope	*P*-value*	Y-intercept	Total change	Final value	% change
LRR intakes	*0.033*	*<0.001*	*0.666*	*0.133*	*0.799*	*20*
Dogs	*0.025*	*0.007*	*0.696*	*0.101*	*0.797*	*15*
Cats	*0.023*	*0.02*	*0.774*	*0.094*	*0.868*	*12*
LRR outcomes	*0.018*	*0.03*	*0.792*	*0.072*	*0.865*	*9*
Dogs	*0.036*	*0.008*	*0.597*	*0.143*	*0.740*	*24*
Cats	*0.033*	*0.007*	*0.612*	*0.130*	*0.743*	*21*

*See **Table 1** for key.*

TABLE 4 | Results of linear regression analysis of intake and outcome subtypes (2016–2019), with intake and outcome subtypes in which 2020 was an outlier.

Shelter metric	Slope	*P*-value*	Y-intercept	Total change	Final value	% change
Intake						
Total intake	−72,503	0.09	3,669,558	NC	3,379,546	NC
Dogs	*−91,037*	*0.006**	*3,074,449*	*−364,148*	*2,710,301*	*−12*
Cats	8,166	0.41	1,419,318	NC	1,451,982	NC
Total community-based intake	−89,928	0.10	3,337,321	NC	2,977,609	NC
Dogs	*−46,931*	*0.02**	*1,443,746*	*−187,724*	*1,256,022*	*−13*
Cats	−6,434	0.53	1,305,025	NC	1,279,289	NC
Outcomes						
Adoption						
Dogs	−4,746	0.55	714,550	NC	695,566	NC
Total return to owner	6,439	0.08	397,376	NC	423,132	NC
Dogs	−1,357	0.66	319,418	NC	313,990	NC
Total transfer						
Dogs	−3,475	0.31	253,821	NC	239,921	NC

*Community-based intake categories are indented for clarity. NC, not calculated (i.e., the slope of the trend line was not significantly different from 0). *The p-value was calculated to assess whether the slope of the linear regression line was significantly ($P \leq 0.05$) different from 0; these values are denoted with italics. Total change, slope*4(years of study-1). Final value, (total change + y-intercept). Percent change, (total change*100)/y-intercept.*

populations of animals are most likely to be euthanized and continue to evaluate which programs are most effective at reducing non-live outcomes in animal shelters.

This study also observed statistically significant decreases in intake by owner-intended euthanasia and for the "no reason given" category. There has been limited examination of the issue of owner-intended euthanasia, so ongoing assessment of this trend should be studied in future research (40). The "no reason given" category represented a large percentage (22%) of the data available by intake subtype. The significant decrease in this subtype likely indicates a promising improvement in organizations' ability to collect more detailed data. Understanding the factors contributing to this increase in reporting of specific intake subtype data is important to advance the national efforts to compile data from a greater percentage of organizations across the United States.

Although the decreases observed in RTO rates for both dogs and cats were not statistically significant, the considerable differences in RTO as a percentage of intake by species are worth highlighting. While RTO as a percentage of intake increased over the study period by 13% for both all animals and dogs, there was no significant increase, there was no significant increase in RTO as a percentage of intake for cats. By contrast, RTF as a percentage of intake significantly increased over the study period by 65% for cats and 696% for dogs. It is worth nothing that the RTF data for dogs are likely erroneous, almost certainly representing pet dogs returned directly to their owners "in the field" by enforcement staff without bringing the dogs to the shelter. The observed increases in canine RTO and feline RTF rates, each as a percentage of intake, may be a reflection of more organizations returning lost animals to the community where they were found, rather than keeping them in shelter care to be reclaimed through the traditional RTO process. This innovation in lost/found programs for both cats and dogs was implemented within the shift toward community-support sheltering models and effort to reduce shelter intake during the COVID-19 pandemic and was further justified by previous studies that documented RTO rates of 7% or less for cats (8, 41, 42), compared to 15–35% for dogs (8, 41, 43–45). Future research is still needed on the best practices for continuing to increase live outcomes for lost/found animals and community cats and dogs.

While not statistically significant, the decreasing trends in community-based intake should be monitored on a national basis as a promising indicator of how a collaborative animal welfare system, growing emphasis on surrender prevention, and increasing access to pet support services might be making a positive impact on animal welfare outcomes. Transfers are another important strategy for optimizing the shelter system's capacity on the local, regional, and national level that should be monitored in future research. Over the study period, transfers as a percentage of intake increased by 27% for all animals and by 26% for cats, with no change for dogs. Transfers can help facilitate live outcomes for animals, particularly when the organization receiving the transfer has a higher degree of specialization in addressing the medical or behavioral challenge of the animal or has access to a larger population of potential adopters. Future research should monitor efforts to standardize health and safety protocols for transfer partnerships, including best practices such as mandatory quarantine or medical treatment prior to or post-transport. Further, transfers across state lines should be studied at the state or regional level to understand the extent to which this source of intake may impact the community's risk of disease (46–49).

A number of studies have documented trends in animal shelter intake and outcomes on the individual organization or state level (44, 45, 50–53). This study addresses a critical gap in the field to summarize emerging trends in how cats and dogs are being served in animal shelters at the broader national level within the U.S. (54–56). The findings illustrate a comprehensive picture of the changing dynamics of animal shelter intake and outcomes for cats and dogs at the national level that likely impacts the trends observed at the state and regional levels (50, 51). By breaking down the results by intake and outcome type, these data provide insights into pet support services needs across the U.S. and the overall capacity of the national sheltering system to meet those needs. These findings can be used to inform pet support service program development and overall resource allocation in the animal welfare field.

Limitations

The findings of this study have several limitations. The methods used in recording, compiling, and analyzing data from a national sample of sheltering organizations are not without their shortcomings. One potential limitation is that all shelter data included in the study are self-reported by each organization and assumed to be as accurate as can be reasonably expected. The best estimates identify 4,400 animal shelters across the United States (15). The sample of organizations included in this study (n = 1,373) consisted of those organizations who voluntarily submitted data to SAC or BFAS, or otherwise had data publicly available on their websites. In contrast, more than 3,300 animal shelters are included in the 2020 dataset. Future studies examining longitudinal trends will benefit from the larger sample sizes available for more recent years. The relatively low proportion of organizations with publicly available data relative to the number of known organizations represents a potential limitation for this study, while also representing an important future direction for research in this field. It is also worth mentioning that the organizations that report to BFAS through the SAC coalition may have unique characteristics compared to organization that do not report to SAC, which should be considered when interpreting trends using data from this source. Shelters that report their data on this publicly available platform are likely to have higher live release rates, a larger number of animals served annually, and so forth, with leadership who are committed to values around community engagement and transparency of data collection. Organizations that do not report to SAC likely have limited resources available to them (e.g., access to data collection software, dedicated staff time) to report these data on an annual basis. Further limitations of the sample include that Best Friends Network partners are over-represented in the sample of consistently reporting organizations over the study period of 2016–2020 (52% of the sample, compared to 35% of the 4,400 shelters identified). Network partners are organizations with which BFAS has a working relationship, the benefits of which include access to training, various resources, and grant funding. These organizations could have had greater access to information on best practices for decreasing intake and euthanasia; therefore, the efforts to increase representation of organizations with more limited funding or support from national organizations is an important effort for assessing the ongoing needs and challenges in the field. Another limitation of note is that it is likely that there were several pandemic-related factors that are outside the control of animal sheltering organizations (e.g., stay-at-home orders, increases in mental health concerns, and economic barriers due to unemployment or underemployment) that contributed to the trends that were observed in the 2020 timepoint of the dataset. Due to the exploratory nature of this study and the uncertain nature of the post-COVID-19 reality in animal sheltering organizations, these findings should be used to assist in hypothesis generation for future studies rather than drawing definitive conclusions about the trends in national level shelter metrics. Finally, there are likely a number of key factors (e.g., regional heterogeneity, species, facility-type, and total number of animals served) informing the observed trends and assessing the influence of these organizational characteristics on the trends in both intake and outcomes.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available. Requests to access the datasets should be directed to: kevin.morris@du.edu.

AUTHOR CONTRIBUTIONS

PW, JR, SMH, and KM conceived the study design. JD and SH compiled and analyzed the original dataset. JR performed the statistical analysis. JR, JD, SH, PW, SMH, and KM contributed to the drafting of the manuscript. All authors contributed to the article and approved the submitted version.

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The Impact of Incorporating Multiple Best Practices on Live Outcomes for a Municipal Animal Shelter in Memphis, TN

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Modern animal shelters are encouraged to adopt "best practices" intended to promote life-saving for the animals that enter their systems. While these best practices have been defined and widely promoted within the profession, few studies have tracked how making the recommended changes affects live release rates (LRR) and other shelter metrics. In 2017, the municipal animal shelter in Memphis, TN (Memphis Animal Services) implemented five new strategies and analyzed their resultant life-saving data. The interventions included managed strategic shelter intake, pet owner safety net, community cat return to field, transition of field services from punitive to assistive, and streamlined adoption and transfer protocols. The median LRR for cats prior to 2017 was 35% (IQR 22, 36). After the intervention, the LRR increased to a median of 92% (IQR 92, 94). The correlation between intake and euthanasia for cats prior to the intervention was significant ($P < 0.001$) and very strong ($r = 0.982$), while after there was no relationship (−0.165) and it was not significant ($P = 0.791$). The median LRR for dogs prior to 2017 was 25% (IQR 19, 48). After the intervention, the LRR increased to a median of 87% (IQR 86, 88). The correlation between intake and euthanasia for dogs prior to the intervention was significant ($P < 0.001$) and very strong ($r = 0.991$), while after there was a moderate relationship (−0.643) that was not significant ($P = 0.242$). The median LRR for kittens prior to 2017 was 34% (IQR 23, 38), which increased ($P = 0.001$) to 92% (IQR 91, 92) after intervention. The percent of kittens entering the shelter with an outcome of euthanasia decreased ($P < 0.001$), from a median of 59% (IQR 54, 73) to a median of 3% (IQR 1, 3). The median return to owner (RTO) rate for dogs increased ($P = 0.007$) from 10% (IQR 9, 11) to 13% (IQR 13, 13). Implementation of these best practices accelerated Memphis Animal Services' progress toward a live release rate of at least 90%, particularly for cats, dramatically decreased kitten euthanasia, increased the RTO rate for dogs and severed the historical correlation between euthanasia and intake.

Keywords: managed intake, safety net program, live outcome, field services, Shelter-Neuter-Return, community cat, return to field, live release rate (LRR)

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INTRODUCTION

Animal shelters in the United States were historically created with the primary objective of protecting human health, particularly from rabies. Shelter facilities and protocols, particularly those operated by municipalities, were designed to accommodate stray animals (those that have strayed from home and become lost or that have been abandoned) for a brief holding period followed by euthanasia for unclaimed animals ("catch and kill"). Historically, many municipal shelters operated as an "open admission" system, meaning all owner surrendered and stray pets were admitted to the shelter with no attempt at mitigation. If the shelter was full or over capacity, euthanasia was used as a tool for population management to make space for new incoming animals (1).

In the 1970s, an estimated 20 million animals entered shelters and 13.5 million were euthanized (2). Since then, societal views regarding animals have evolved and canine rabies variant has been eradicated from the United States due to vaccination and animal control measures (3, 4). Communities subsequently desire live outcomes for shelter animals and modern animal shelters are able to focus on other goals such as life saving. However, finding the resources to provide live outcomes for most animals admitted to the shelter can be challenging for shelters evolving from a catch and kill model to one that supports the goals of a modern animal shelter. These goals include providing live outcomes for pets who do not have owners or must be rehomed (5) and reuniting lost pets with their owners (6). The rate of live outcomes, also known as live release rate, is often used as a benchmark, with a rate of 90% or greater generally targeted, as it suggests that animals are not euthanized for population management (7). It is also important that modern animal shelters provide a high standard of animal welfare for animals within the shelter's care and engage constructively and collaboratively with their community (8).

Returning lost pets to their owner is another primary goal of a modern shelter. Return to owner (RTO) rates are highly variable between communities, although it is very consistent that the cat RTO rate is approximately an order of magnitude less than dogs within a given community (7). This finding may be due to the differing ways in which lost cats and dogs are reunited with their owners, with the greatest proportion of dogs being reunited via a shelter, and the greatest proportion of cats finding their way home on their own (9, 10). The nationwide average RTO rate is estimated to be 19% for dogs (11). RTO rates are calculated by dividing the number of pets reclaimed by their owner by the number of stray pets entering the shelter (12).

Cats are generally not well-served by traditional shelter practices. This problem is due to a relatively large number of cats entering the shelter, differences in the way that cats as compared to dogs are acquired as pets, and the fact that community cats can sustain themselves. Community cats are those that are free-roaming (not confined in a house or other type of enclosure) and may be socialized or unsocialized (untamed or feral). Although cats are slightly less than half of shelter intake, it is estimated that they are euthanized for population management at a ratio of more than 2:1 as compared to dogs (7). Historically, intake and euthanasia were tightly coupled, with a correlation of 0.964 found consistently across multiple states with variable levels of per-capita intake during the period of 2003 to 2007 (13). While pet acquisition statistics vary between sources, cats are consistently acquired directly more frequently as strays as compared to dogs (2). Community cats, whether social or not, are commonly able to maintain themselves either by scavenging or *via* support from human caretakers resulting in a large population of cats perceived as stray, particularly kittens. Even for cats that are maintained by caretakers or loosely owned, many caretakers or semi-owners would be unlikely to look for their cat in a shelter if they were to go missing for a few days (14). This fact has consistently resulted in a return to owner rate for cats entering a shelter categorized as stray of <3.5% annually as compared to 22% of dogs (7).

Several innovative strategies aimed at the efficient use of shelter resources to meet the modern goals for animal shelters and implemented at various shelters have been promoted as "best practices" within the profession (8). Strategies such as managed strategic intake, pet owner safety net programs, community cat return to field, transition of field services from punitive to supportive, and streamlined adoption and transfer show great promise but have not been fully analyzed within the scientific literature.

Managed strategic intake regulates or schedules non-urgent intake to the shelter so that all viable alternatives to shelter intake are exhausted before an animal enters the shelter. Shelter space is a crucial resource and by using it only for pets with no other options, more pets and people can be helped. When shelter space is reserved for those pets with no other alternatives and there are fewer pets in the shelter to care for, the staff is better able to serve and provide for the pets that do enter. Managed intake helps shelters to plan for appropriate staffing and ensure that there is the capacity to serve the animals that enter the shelter. It also involves researching and providing resources outside of the shelter to pet owners who are experiencing challenges keeping their pet in their home (8, 15, 16).

Safety net programs are designed to assist pet owners in need or help pet owners rehome their pets directly in lieu of shelter intake (17). The shelter provides direct or referral services to help pet owners avoid the need to surrender their pet or to support them in adopting their pet to another home without a stay in the shelter (8).

Return to field (RTF) or Shelter-Neuter-Return programs provide a live outcome for healthy community cats categorized as stray with good body condition. These cats are sterilized, vaccinated, and returned to the location where they were found (8). RTF is similar to Trap-Neuter-Return (TNR), with the main difference being that the cats in RTF programs have undergone intake to the shelter as a stray, as compared to TNR where cats are trapped for the specific purpose of sterilization and the procedures provided as a clinical service. However, RTF programs have been shown to increase the live release rate for cats while decreasing the amount of time that they spend in the shelter (18, 19).

Traditionally animal control services have operated with a punitive enforcement-minded approach and primary duties have included issuing citations for animal-related infractions, transporting non-aggressive, healthy, free-roaming animals to

the shelter for intake, and seizing animals. However, this approach is not conducive to the goals of a modern shelter, particularly reuniting lost pets with their owner and engaging collaboratively with the community. Emerging data in Dallas (12), El Paso and Austin, Texas, have demonstrated that animals picked up by an animal control officer (ACO) are typically found very close to their home, suggesting that animals may be more likely to be reunited with their family if efforts are made to locate the owner prior to transporting them to the shelter. Transforming field services into an assistive rather than punitive role also encourages constructive interaction with the community, helping to build trust and a collaborative relationship with the shelter.

Two common live outcomes for many shelters are adoption and transfer to another shelter or rescue organization with different resources or demand for animals. However, there has traditionally often been barriers to adoption such as long adoption applications with very specific requirements for housing (20). Transfer fees charged to organizations accepting transfers have been levied in an attempt to recoup the costs of impounding an animal or loss of potential adoption income, resulting in barriers to the transfer out of animals.

Background

In January 2016, the new mayor elected in the city of Memphis, Tennessee was given a clear mandate by the community to commit Memphis Animal Services (MAS), the local government shelter operated by the city of Memphis, to a focus on life-saving (21). Between 2008 and 2015, MAS had a historical live release rate ranging from 9 to 65% (22). Several categories of animals, such as community cats and neonates, were euthanized on intake despite most being healthy on presentation.

Those historical policies were coupled with other barriers to live outcome, including the requirement for an ACO to do a home visit and fence check for the adoption of a pit bull-type dog as well as background checks for those interested adopters. Although the shelter worked with non-profit rescue groups interested in transferring and saving animals, the $50 charge per pet posed a financial barrier to those groups.

At the time, MAS was under the Parks and Neighborhoods department with several layers of decision-makers between the shelter administrator and the mayor. The new mayoral team decided to create an independent department and reclassify the shelter administrator position to a director position answering directly to the Chief Operating Officer under the mayor.

Soon after the mayoral election, a new director was hired and Target Zero, a charitable initiative offering pro bono shelter and community assessments nationally between 2013 and 2017, was invited to complete a shelter assessment. The Target Zero team (which included one of the authors, SP) provided a report to benchmark national best practices compared to current MAS protocols. They created a plan for a progressive animal welfare system that would increase lifesaving, increase animal welfare, and fulfill the goals of a modern animal shelter. This plan included the implementation of managed strategic shelter intake and a safety net program with the goal of only admitting animals that require and are benefited by intake to the shelter. The new administration also embraced simplifying the adoption process and eliminating unnecessary adoption barriers like home visits and fence checks.

The purpose of this study was to document the impact of these key best practices on lifesaving, animal welfare, and modern sheltering goals.

METHODS

Description of Interventions

Managed Strategic Shelter Intake

The Target Zero consultation included an examination of statutes and contracts that determined that the shelter was not legally required or mandated to accept owner surrendered pets. The managed strategic shelter intake program began in 2017, with the first step being the requirement of an appointment for non-emergent owner surrenders. Emergency cases could still be admitted without delay if necessary.

Pet Owner Safety Net

Initially, there was no budget for a formal Safety Net assistance program to directly provide resources to the public, so leadership focused on linking pet owners to information and other resources available outside the shelter. A Skip the Shelter brochure was created that listed rescue partners, pet-friendly housing options, low-cost spay/neuter programs, and information about Care Credit for those needing veterinary care at a private clinic (**Supplementary Addendum 1**). Prior to 2017, neonates were typically euthanized upon intake because there were no resources to care for them in the shelter. As part of the Safety Net Program, MAS educated the community about neonatal kittens. Educational information was provided on the website to direct finders of neonatal kittens to leave them in place or to return nursing kittens where they found them when not at risk. Finders of kittens requiring a foster home were provided educational materials regarding caring for underage kittens and supplies (**Supplementary Addendum 2**).

In 2020 the shelter expanded the Safety Net program to include a Pet Resource Center (PRC) to use shelter-provided resources to assist pet owners in need as well as address other types of shelter intake. The PRC became an integral part of the MAS budget, with coverage for the two full-time Pet Resource Specialist positions as well as subsidies to help pet owners and finders. The PRC is additionally supported by grants and donations. Leadership determined the subsidy amount of $300 that PRC resources specialists may approve to prevent a surrender based on the estimated cost of $309 to admit a pet to the shelter. This amount was calculated by dividing the average annual intake into the overall operating expenses less field operations. Financial assistance may cover veterinary care, a temporary stay at a boarding facility, pet deposits for housing, fixing fences, behavior training, pet food, free spay/neuter or whatever intervention may help the owner keep their pet. Shelterluv[1] software is used to track the work of the specialists using their free field and community services platform.

[1]ShelterLuv, ShelterLuv, Inc., Palo Alto, CA.

Community Cat Return to Field

Prior to 2017, MAS euthanized most community cats on intake like many traditional municipal shelters at the time. It was calculated that sterilizing and returning healthy stray cats the following day to the location they were found cost <$150 as compared to the $309 per pet calculated for a typical intake. Implementing an effective community cat program began with training the staff and providing the tools they needed to explain the program to the public. One of those tools was a brochure that included Frequently Asked Questions and information was also added to the website (**Supplementary Addendum 2**). Staff were trained to have a conversation with constituents calling about or bringing a community cat to the shelter for the purpose of intake to explain how sterilization mitigated unwanted behaviors associated with mating, and to determine whether other resources were required to address concerns. Stray cats and kittens were evaluated on intake for the best pathway for the cat and shelter capacity. Kittens and socialized adult cats were put on an adoption track if shelter capacity allowed, if the kitten was too young for sterilization surgery, or if the cat could not be returned to its originating location. Constituents were asked if they were willing to return their community cat the day after the surgery. If the finder was unwilling or unavailable to do so ACOs returned the community cats.

Field Services Transition

Redefining the role of field services was an important step to meeting the goals of a modern shelter. The only pathway for assistance at the time was to admit an animal to the shelter. With the traditional approach, Animal Control Officers apprehended a dog at large and transported them to the shelter for admission and a stray hold period. Given MAS' catchment, this protocol meant that dogs might be transported up to an hour away from their home to the shelter. It is likely that many owners would not know about the shelter or that their missing dog would have been taken there. If an owner came forward, they were subject to citations, fines, or boarding fees prior to reclaiming. However, dogs at large who are not a public safety threat are a prime example of an animal that may not be best served by intake to a shelter.

Since 2019, MAS protocols have specified that ACOs must make all reasonable efforts to reunite dogs in the field and are instructed to spend time in the neighborhood, speak to neighbors, knock on doors, and speak to children playing outside to find the owner. If an owner is located the dog is returned without undergoing intake to the shelter. An informational door hanger is left on the house or houses where the ACO suspects the dog lives if the ACO must transport the dog to the shelter.

In 2020, the protocol for field services was revised to route field service calls through a specialist with the PRC before an ACO responds in-person to a dog at large call. The specialist discusses the possibility of the finder fostering the dog (Found Foster Program) and partnering in the efforts to locate the owner by checking for identification, placing flyers in the neighborhood, walking the dog in the area where they were found, and speaking to neighbors.

Streamlined Adoption and Transfer

Adoption and rescue transfer practices were streamlined. The requirement for a background check and an ACO home visit and fence check for the adoption of a pit bull-type dog was removed. The $50 charge per pet transferred to rescue was eliminated and staff created a more welcoming environment for the public and rescue groups.

Statistical Methods

Descriptive statistics were used to summarize the shelter data, with the mean and standard deviation (SD) used for normally distributed data and the median and interquartile range (IQR), reported as (Q1, Q3) to describe the skew of the data, used for non-normally distributed data. Linear regression was used to determine the rate of change over time. T-tests were used to compare normally distributed data and Wilcoxon rank-sum tests non-normally distributed data before and after the intervention in 2017. Interrupted time series were used to compare trends before and after the intervention. The final disposition based live release rate was calculated as (live outcomes/all outcomes × 100) (23).

RESULTS

Live Outcomes for Animals Entering the Shelter

The median live release rate for cats prior to 2017 was 35% (IQR 22, 36). The live release rate was found to increase by 6% each year from 2008 to 2017 ($P < 0.001$), reaching a maximum of 62% in 2016—(**Figure 1A**). After the intervention in 2017, the live release rate increased to a median of 92% (IQR 92, 94)%. The correlation between intake and euthanasia for cats prior to the intervention was significant ($P < 0.001$) and very strong ($r = 0.982$), while after there was no relationship (−0.165) and it was not significant ($P = 0.791$).

The median live release rate for dogs prior to 2017 was 25% (IQR 19, 48). The overall increase in live release rate followed a sigmoid pattern (**Figure 1B**), with the live release rate relatively flat from 2008 to 2010, then rapidly increasing from 2011 to 2016, before leveling out just below 90% for 2017 through 2021. Linear regression of the linear portion of the sigmoid curve from 2011 to 2017 found an increase of 11% per year ($P < 0.001$). After the intervention, the live release rate increased to a median of 87% (IQR 86, 88). The correlation between intake and euthanasia for dogs prior to the intervention was significant ($P < 0.001$) and very strong ($r = 0.991$), while after there was a moderate relationship (−0.643) that was not significant ($P = 0.242$).

After the intervention the LRR was no longer correlated to intake, particularly for cats (**Figure 2**). Prior to 2017, intake and live release rate were tightly correlated. For cats, there was a linear relationship, with live release rate increasing by 4% for each fewer 100 cats entering the shelter ($P < 0.001$). For dogs, there was a sigmoid relationship, with the live release rate consistently low for intake >12,000, and an increase of 1% for each fewer 100

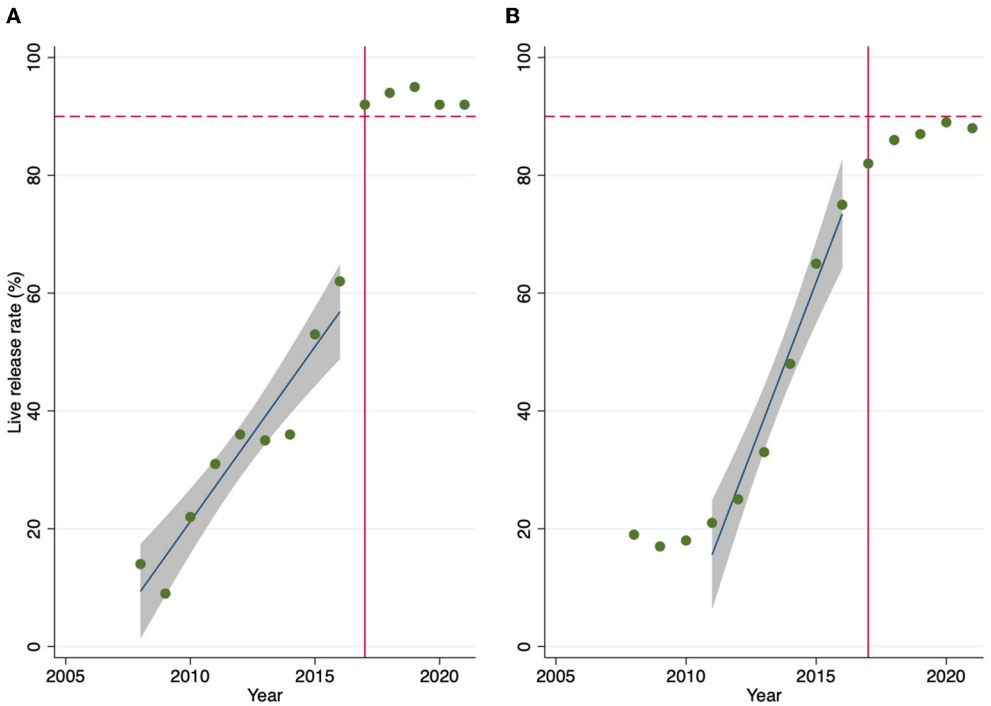

FIGURE 1 | Live release rate for cats **(A)** and dogs **(B)** by year overlaid by best fit line and 95% confidence interval for years 2008 to 2016 for cats and 2011 to 2016 (the linear portion of the sigmoid curve) for dogs. Dotted red line at the 90% target live release rate and solid red line at the intervention year.

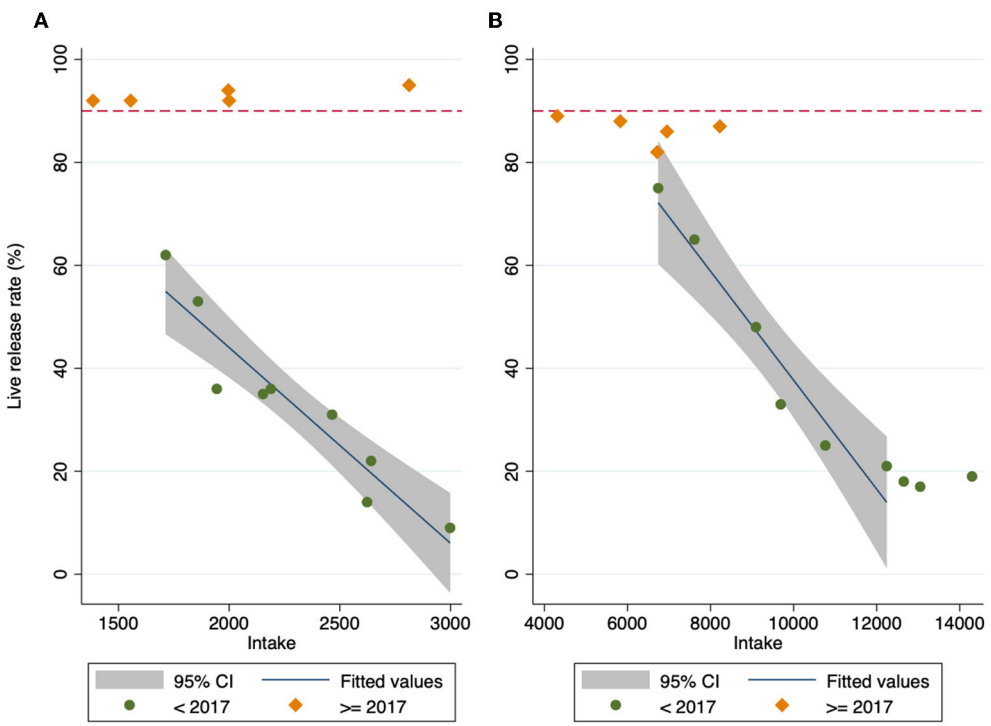

FIGURE 2 | Live release rate for cats **(A)** and dogs **(B)** by the number entering the shelter. Intake prior to the intervention year (2017) in green, and intake from 2017 onward in orange. Dotted line at 90%. The best fit line for cats shows a linear relationship between intake and live release rate prior to 2017, while there is no relationship between intake and live release rate after. The best fit line for dogs showed a curvilinear relationship between intake and live release rate prior to the intervention year, while there is no relationship between intake and live release rate after the intervention year.

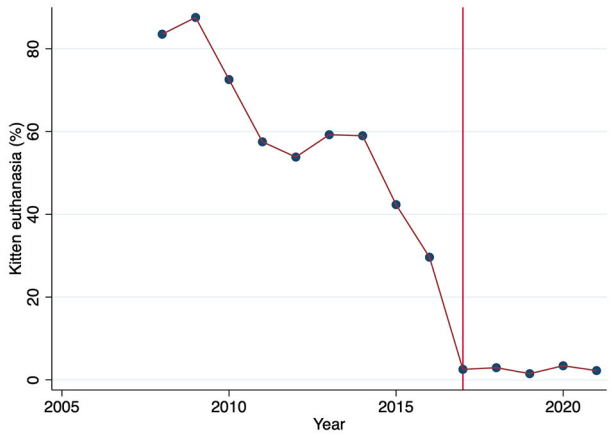

FIGURE 3 | Percent of kittens entering the shelter <5 months of age euthanized by year. Solid line at intervention year.

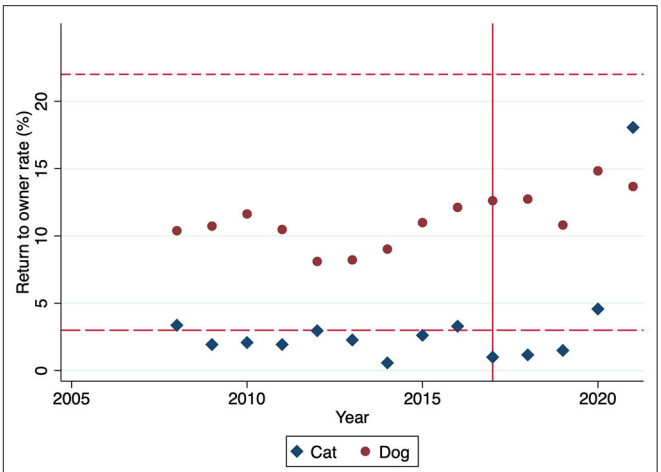

FIGURE 4 | Return to owner rate by year for cats (blue diamond) and dogs (red dot). Solid line at 2017, the year the community case study began. Short dashed line at the national average dog return to owner rate (22%), and long dashed line at the national average cat return to owner rate (3%).

dogs entering the shelter ($P = 0.001$) in the linear portion of the sigmoid curve. After the intervention, there was no significant relationship between intake and live release rate for cats ($P = 0.565$) or dogs ($P = 0.460$).

Managed Strategic Intake

Cat intake prior to 2017 was a median of 2,188 (IQR 1,944, 2,623), with a decrease ($P = 0.001$) of 138 cats per year (**Supplementary Addendum 3a**). There was no significant change in intake after the intervention ($P = 0.868$).

Dog intake prior to 2017 was a median of 10,764 (IQR 9,093, 12,651), with a decrease ($P < 0.001$) of 937 dogs per year (**Supplementary Addendum 3c**). There was no significant change in intake after the intervention ($P = 0.394$).

Pet Owner Safety Net

The composition of cat intake type prior to 2017 was a mean of 46% (SD 5) stray and 50% (SD 5) owner surrender, with the 4% remaining (enforcement for cruelty confiscation, bite or rabies quarantine, or born in care) classified as "other" (**Supplementary Addendum 3b**). After the intervention, the stray intake was a mean of 49% (SD 3), owner surrender was 29% (SD 5), and other (enforcement for cruelty confiscation, bite or rabies quarantine, or born in care) 22% (SD 3). The percent of owner surrenders decreased after the intervention [$t_{(12)} = 8.1$, $P < 0.001$], but not stray (P = 0.806) or other ($P = 0.063$).

The composition of dog intake type prior to 2017 was a mean of 63% (SD 4) stray and 28% (SD 3) owner surrender, with the remaining 8% (enforcement for cruelty confiscation, bite or rabies quarantine, or born in care) classified as "other" (**Supplementary Addendum 3d**). After the intervention, the stray intake was a mean of 69% (SD 3), owner surrender was 17% (SD 2), and other 14% (SD 3). The percent of owner surrender decreased after the intervention $t_{(12)} = 7.3$, $P < 0.001$, while stray and other intake increased, $t_{(12)} = -2.6$, $P = 0.024$, and $t_{(12)} = -2.5$, $P = 0.029$, respectively.

In 2021, the only year for which a full year of data from the fully operational PRC are available, the PRC handled 4,394 calls. Of these calls, 1,419 (32%) were for rehoming support, 1,223 (28%) were for assistance with pet food or supplies, 860 (20%) for assistance with medical care, 38 (1%) for assistance with behavior, and 854 (19%) other pet retention.

Community Cat Return to Field

The number of cats returned to field per year after the intervention ranged from 26 to 207, with a median of 101 (IQR 79, 112). An estimated 25% of the constituents agreed to provide transportation for the cats the day after surgery. Prior to the intervention in 2017, the median percent of kittens aged <5 months was 52% of all cats entering the shelter (IQR 51, 53l). After the intervention, the percent of kittens increased ($P = 0.001$) to a median of 61% (IQR 61, 64). However, the percent of kittens entering the shelter with an outcome of euthanasia (**Figure 3**) decreased ($P < 0.001$), from a median of 59% (IQR 54, 73) to a median of 3% (IQR 1, 3). A median of 686 (IQR 548, 960) kittens were euthanized per year prior to intervention, and 27 (IQR 26, 28) per year after. This resulted in the median LRR for kittens increasing ($P = 0.001$) from a median of 34% (IQR 23, 38) prior to 2017 to a median of 92% (IQR 91, 92) after intervention. Death in shelter for kittens increased ($P= 0.001$) after the intervention from a mean of 2% (SD 1) to a mean of 4% (SD 1). A median of 23 (IQR 17, 30) kittens died in shelter per year prior to intervention, and 42 (IQR 41, 70) after. Death in shelter for adults was 1% (SD 0) before and 1% (SD 1) after intervention and was not different ($P = 0.085$).

Field Services Transition

Between 2008 and 2016, the RTO rate for cats (**Figure 4**) was a median of 2% (IQR 2, 3). After the intervention, the RTO rate for cats was a median of 2% (IQR 1, 5). The RTO rate for cats was

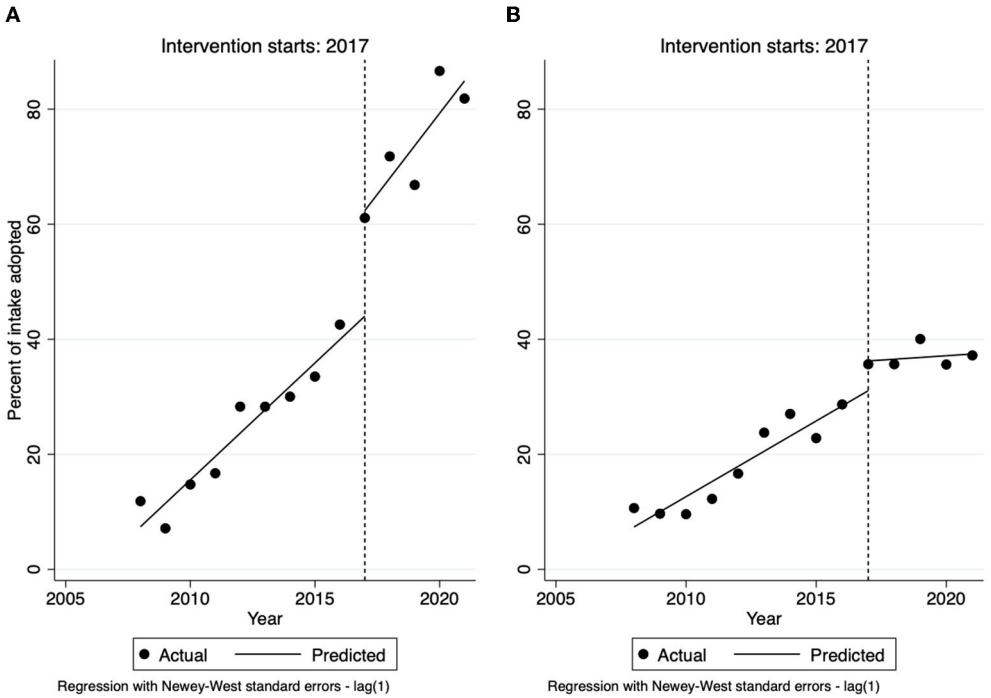

FIGURE 5 | Interrupted time series analysis of the percent of intake of cats **(A)** and dogs **(B)** with an outcome of adoption. Line at intervention year (2017).

not different after the intervention ($P = 0.898$), and the median RTO rate was below the national average of 3% for cats for all but 1 year (7).

For dogs between 2008 and 2016, the median RTO rate (**Figure 4**) was 10% (IQR 9, 11). From 2017 to 2021, the RTO rate for dogs increased ($P = 0.007$) to 13% (IQR 13, 13). Median RTO rate for dogs was below the national average of 22% at all time points (7). There were 161 dogs reunited in the field with their owner that were not reflected in intake or RTO numbers in 2021. For comparison, in 2021 there were 518 dogs admitted to the shelter with an outcome of RTO. An internal analysis using ArcGIS Pro conducted by MAS of addresses for 328 dogs with an intake type of stray, outcome type of return to owner, and mappable found and reclaimed addresses between July 2020 and December 2021 found that the median distance from the owner's home address to the stray pick-up location was only 0.5 miles for dogs reclaimed from MAS (range 0 to 18.3 miles).

In an analysis of the 9,991 field service calls received in 2019 and 2020, 5,425 (54%) were for stray roam, 2,422 (24%) were for stray aggressive, 1,302 (13%) were for bite/dangerous, and 842 (8%) for welfare investigation.

Streamlined Adoption and Transfer

The percent of cats entering the shelter that had an outcome of adoption prior to 2017 was a median of 28% (IQR 15, 30). After the intervention, the percent with an outcome of adoption increased ($P = 0.001$) to a median of 72% (IQR 67, 73). The percent of adoption outcomes had linearly increased 4% per year prior to 2017 ($P < 0.001$), but an interrupted time-series analysis (**Figure 5A**) demonstrated that there was a 20% increase in the percent of adoptions immediately after the intervention ($P < 0.001$), after which adoptions continued to increase 4% per year ($P = 0.032$). The percent transferred increased from a median of 6% (IQR 5, 13) to 13% (IQR 11, 15), although this was not significant ($P = 0.298$).

The percent of dogs entering the shelter that had an outcome of adoption prior to 2017 was a median of 17% (IQR 11, 24). After the intervention, the percent with an outcome of adoption increased ($P = 0.001$) to a median of 36% (IQR 36, 36). Interrupted time series analysis of percent of dog adoption (**Figure 5B**) showed that adoptions were increasing at 3% per year prior to 2017 ($P < 0.001$), there was an increase of 6% immediately the intervention ($P = 0.034$), and then adoptions decreased by 3% per year after 2017 ($P = 0.001$). The percent transferred increased ($P = 0.004$) from a median of 3% (IQR 1, 15) to 39% (IQR 38, 41).

DISCUSSION

Implementation of best practices helped MAS to eliminate the long-standing correlation between intake and euthanasia, resulting in a live release rate of over 90% for cats and nearly 90% for dogs even though overall intake did not decrease after the intervention. The improvement in community trust may increase intake if community members are no longer fearful that healthy pets will be euthanized (24). While there were

positive trends in measures such as the live release rate prior to the intervention, implementation of best practices dramatically accelerated progress toward the goal of at least 90% live release rate. The implementation of best practices was made easier by the movement of MAS from the Parks and Neighborhoods department to an independent department and reclassifying the shelter director position as a director position as this change removed several layers of decision-makers between the shelter administrator and the mayor.

Managed Strategic Intake

MAS leadership found that the service of intaking owned pets was not required by statute or contract and determined that accepting an owner surrender, particularly when an owner just needed temporary assistance, was not in the best interest of the shelter, the pet, or the pet owner. Persons surrendering animals due to temporary hardships are likely to acquire another pet when they were able to (25) but, in the meantime, the responsibility of keeping a surrendered pet healthy and finding a live outcome falls to the shelter. While there was initial concern from animal advocates that people would abandon their pets if they were not admitted to the shelter without delay, the shelter administration determined that non-emergent immediate owner surrender was not in line with the established goals of lifesaving, public safety, and animal welfare, was not fiscally responsible and did not create sustainable resolution. No increase in abandonment was noted by the shelter administration, an experience similar to other shelters implementing managed intake (26). The change to managed intake also provided a platform for a proactive conversation about the perceived need to surrender the pet to the shelter and offered an opportunity for interventions such as the pet owner safety net.

Pet Owner Safety Net

There was a decrease in owner surrendered dogs and cats after the implementation of the safety net program. For cats, this decrease was the only significant change in the composition of intake type. The proportion of cats younger than 5 months increased, likely due to a decrease in adult owner surrenders. For dogs, there was an increase in both stray and "other" intake. It is unknown whether this increase in stray intake for dogs was related to the decrease in owner surrender, for example if owners claimed that their dog was stray or abandoned their dog.

Community Cat Return to Field

Despite relatively small numbers the community cat program was impactful in several ways. First, it reserved vital resources such as shelter space and human capital for cats who had no other options by providing a live outcome within a very short period at the shelter for cats that could be returned. Secondly, it returned cats to the location they were found so that lost owned cats would have a greater chance of being reunited with their family, unowned cats would have a chance to be directly adopted into a new home by the finder of a stray cat, and unsocial community cats were returned to their outdoor home. A key aspect of this program was the recruitment of finders to return the cats to their original location the day after surgery as it reduced the workload for the staff. Another important benefit for the ACOs and other staff was the reduction in the number of healthy cats they were assigned to euthanize.

The percent of kittens with an outcome of death in shelter increased from 2 to 4%, likely due to kittens <8 weeks of age, that are more likely to die in care, no longer being euthanized on intake. Recent studies of shelter mortality for kittens younger than 8 or 9 weeks have found rates of 12.6% (95% CI 10.8, 14.4) (27) and 2.5% (95% CI 0.8, 5.7) (28), respectively. The rate of 1% did not change for adult cats, supporting that this increase may be due to increased mortality for very young kittens. In absolute numbers the median number of kittens that died or were euthanized per year prior to intervention was 875 as compared to 66 after; while there is always a concern regarding animal welfare when death in shelter increases, the increase here is consistent with mortality rates observed in other shelters with programs that support young kittens and does not support the argument that over 800 kittens per year would have been better off euthanized.

Field Services Transition

The animal services field team is a key shelter resource. Since a large percentage of calls for service do not involve public or animal safety issues, there is opportunity to deploy the PRC team to intervene and find alternatives to shelter intake. This change would conserve shelter resources and allow the field team to focus on true safety issues. Future goals for the Pet Resource Center include dedicated staff responding in person to calls for a dog at large when the finder is unable to foster, prioritizing ACO time for true public and animal safety cases and making the best use of shelter resources. This approach would parallel the evolution seen with emergency services for people in Memphis. Dispatch personnel for 911 are trained to prioritize calls for a medical team vs. a call that can be handled by a nurse practitioner, and determine which calls are not emergent and can wait for assistance.

The shift in mindset from enforcement to assistance proved to be one of the most challenging changes to implement at the shelter since ACOs had always believed they were doing what was in the best interest of the dog at large and the community. During the initial transition from a punitive, enforcement-minded field and shelter team to one of inclusivity, compassion, and providing direct assistance, staff who were not willing to adapt were transitioned to other opportunities.

The RTO rate for MAS for cats was lower than the national average for most years. The last 2 years of data showed an artifactual increase in the RTO rate that was due to the denominator of stray intake dramatically decreasing due to a change in the intake type for kittens from stray to wildlife. The RTO rate for dogs was significantly lower than the national average for all years and there were fluctuations both before and after the intervention. The RTO rate after the intervention may have been artifactually lower due to the return of stray dogs in the field by ACOs prior to shelter intake and possibly the effect of dogs that were misclassified as stray by an owner wishing to surrender.

Streamlined Adoption and Transfer

The percent of adoption outcomes increased for both cats and dogs. For cats, this increase in adoption outcomes was likely due to the elimination of euthanasia of underage kittens, most of which had an outcome of adoption after the intervention. For dogs, adoptions initially increased after the intervention, which may have been due to the elimination of requirements such as a home check for Pitbull type dogs and a streamlined adoption process. The slight decrease in adoption over time after the intervention may be due to competition from transfer, which increased dramatically. The increase in transfer may be due to the elimination of the transfer out fee.

LIMITATIONS

Consistent with national trends (7), there was a large decrease in intake and changes to shelter operations during 2020 that complicated trend analysis. Only 5 years of data were available after the intervention, complicating statistical analysis through bias toward the null. There was a transition in shelter software in 2020 that changed how some animal types, particularly the intake type of neonatal kittens, were classified. It was not possible to determine whether animals classified as stray were actually owner surrender or abandoned. Multiple programs were implemented and refined over different time periods, making it impossible to quantify the impact of individual interventions. Secular trends such as increases in live release were already present and may not have been fully statistically controlled. However, despite these limitations, the dramatic decoupling of euthanasia from intake demonstrates that there was truly a difference after intervention beyond the continuation of secular trends.

Future research should attempt to look at longer periods of time (at least 7 years) and would ideally control the implementation of programs so that the individual impact of different programs can be determined. More data is required to determine the impact of pet owner safety nets on pet retention. There should also be an effort to determine whether making owner surrender less convenient, whether through scheduled appointments or other interventions that owners perceive as barriers, results in an increase in stray intake at other locations and if so whether some portion of the stray animals are truly owner surrender or abandoned.

CONCLUSION

Implementation of these best practices accelerated MAS' progress toward a live release rate over 90%, dramatically decreased kitten euthanasia, increased the RTO rate for dogs and severed the historical correlation between euthanasia and intake.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://www.memphistn.gov/animal-services/shelter-statistics/.

AUTHOR CONTRIBUTIONS

SP: conceptualization, writing—original draft, supervision, and project administration. AP: resources and writing—original draft. RK: formal analysis, data curation, writing—original draft, and visualization. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fvets.2022.786866/full#supplementary-material

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The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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