Preventive Veterinary Medicine 120 (2015) 336–348

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

Reported off-leash frequency and perception of risk for gastrointestinal parasitism are not associated in owners of urban park-attending dogs: A multifactorial investigation

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ARTICLE INFO

Article history:
Received 26 September 2014
Received in revised form 19 February 2015
Accepted 29 March 2015

Keywords:
Urban park
Risk perception
Off-leash
Dog
Parasitism
Public health

ABSTRACT

Associations between park use and infections with gastrointestinal (GI) parasites in dogs (*Canis familiaris*) have been previously observed, suggesting park use may pose risks for infection in dogs, and potentially, in humans. This study was conducted to establish the overall level of perceived risk of parasitism in dogs, the frequency of unleashing dogs in parks, and to determine if dog owners' risk perceptions of parasite transmission among humans and dogs are associated with the reported frequency of unleashing dogs. From June to September 2010, 635 surveys were administered to dog owners in nine city parks in Calgary, Alberta, by the lead author to explore dog-walking behaviors in parks under differing leashing regulations. From these, a subset of 316 questionnaires were analyzed to examine associations between behavioral and dog demographic factors, risk perception and acceptability of perceived risks of dog and human parasitism, and education regarding parasitism in dogs and humans. Multivariate statistics were conducted using three separate Chi-Square Automatic Interaction Detection (CHAID) decision trees to model risk perception of dogs becoming parasitized while in the park, risk perception of zoonotic transmission, and off-leash frequency. Predictors included recreational behaviors, dog demographics, risk perception of park-based and zoonotic transmission, education regarding parasites, and leashing regulations (e.g. on-leash, off-leash, or mixed management parks). The perceived risk of park-based transmission was relatively higher than perception of zoonotic transmission and the majority of people unleashed their dogs at least some of the time. Risk perception was not associated with off-leash frequency in dogs and risk perception and off-leash frequency were associated with factors other than each other. The results suggest owners may underestimate the potential risks for parasitism related to some dog-walking behaviours, and are relevant for public and animal health.

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http://dx.doi.org/10.1016/j.prevetmed.2015.03.017
0167-5877/

1. Introduction

Dog ownership can be socially, emotionally, and physically beneficial for humans (Cutt et al., 2007; Day, 2010; Lail et al., 2011; Christian et al., 2013). In urban environments, parks are common areas for dogs (*Canis familiaris*) and owners to engage in health-promoting physical and social activities (McCormack et al., 2010; Westgarth et al., 2010; Toohey and Rock, 2011). Congregation in parks, however, also introduces the potential for gastrointestinal (GI) parasite transmission among dogs and between them and their human companions. In addition to dog-specific parasites, dogs can also carry several species of zoonotic GI parasites such as *Toxocara canis* and *Echinococcus multilocularis* that have the potential to cause disease of certain organs in humans (Conboy, 2009; Knopp et al., 2012), and *Giardia* spp. and *Cryptosporidium* spp. which can cause gastroenteritis and have the potential for zoonotic transmission (Feng and Xiao, 2011; Ryan et al., 2014). Although the lifecycles of these parasites vary, they can all be transmitted among dogs and people via fecal-oral routes (Conboy, 2009; Feng and Xiao, 2011; Knopp et al., 2012; Ryan et al., 2014). The significant accumulation of undisposed dog litter in some off-leash parks (McCormack et al., 2010; Atenstaedt and Jones, 2011), and the detection of zoonotic GI parasites in dog feces and soil from parks (Grimason et al., 1993; Habluetzel et al., 2003; Gaunt and Carr, 2011), raises questions about the specific risks for infection associated with park use and the potential impact on both animal and human health.

Few studies have focused specifically on park use as a risk for GI parasitism for dogs with the exception of Wang et al. (2012), who found a significant positive association between park attendance and *Giardia* spp. and *Cryptosporidium* spp. infection in dogs. Other studies have identified risk factors for infection with other GI pathogens, including Procter et al. (2014a,b) who investigated a broad range of behavioral and demographic risk factors for infection with antimicrobial resistant *Escherichia coli* and *Campylobacter* spp., including off-leash activity *within* park-attending dog populations. No significant association between off-leash activity and infection was detected, although data collection occurred exclusively in off-leash dog parks, which may have masked any association.

Previously, we examined dog-walking behavior within parks with different leashing regulations (hereafter 'park management'), including off-leash areas, on-leash areas, and parks with both off-leash and on-leash areas (hereafter, 'mixed-managed parks'), and found a significant positive association between GI parasitism and certain recreational behaviors, including off-leash frequency (Smith et al., 2014). And on a broader scale, Westgarth et al. (2009) investigated connectivity among dogs and owners in neighboring communities and established a high potential for contact through use of communal areas including parks, supporting the potential for parasite transmission both within and among parks. The risks associated with park behaviors raises questions about the perception and acceptance of these risks by dog owners. The present study aims to explore the relationship between unleashing dogs and the level of risk owners perceive for transmission of parasites among dogs and people.

More specifically, the purpose of this study is to: (A) determine the level of risk perceived by dog owners regarding dog and human parasitism; (B) determine the overall frequency of unleashing dogs; (C) determine if there is any association between the frequency of unleashing dogs in parks and the perception of risk of dog and human parasitism; and (D) determine other factors affecting off-leash frequency and risk perception. We hypothesized that the majority of dog owners would perceive the transmission of parasites as unlikely, and off-leash frequency would be high, overall, and that the frequency of off-leash activity would be negatively associated with risk perception of parasitism.

2. Materials and methods

2.1. Study design and study areas

We used an observational, cross-sectional study design. The study was conducted in nine urban parks in Calgary, Alberta, Canada (51°50N, 114°55′W). Parks were selected on the basis of park management and included three off-leash, three on-leash, and three mixed-managed parks. Off-leash parks included Southland (SL), Nose Creek (NC) and Edworthy (EDW); on-leash parks selected were Stanley (SP), Fish Creek Provincial (FCPP), and Weaselhead (WSH); and mixed managed sites consisted of River (RP), Bowmont (BOW), and Nosehill (NH) Parks (Fig. 1).

2.2. Research protocol and questionnaire design

Each park was visited once per week from June to September 2010. No *a priori* sample size power calculation was conducted due to the lack of data concerning number of park-attending dogs and owners of park-attending dogs. The questionnaire was conducted in English. Dog owners were approached opportunistically as they were entering or leaving the park, or while they were in the park, and asked to complete a five-minute-long oral questionnaire with assistance from the lead author. A total of 635 interviews were conducted; an average of 71 per park (standard error: ±4.1; surveys per park: min, 52; max, 84).

The questionnaire consisted of 27 questions arranged in five sections: (1) screening, (2) dog demographics and human behavior, (3) education regarding parasites, (4) risk perception and acceptability of risk, and (5) personal information. Individuals were required to answer "yes" to all screening questions in order to be eligible to participate (Table 1). The risk of the same dog owner being surveyed more than once was null, as the lead author was the sole interviewer and therefore was able to identify those dogs and dog owners that had been previously approached. Socio-demographic variables were not included in this study because they have been shown to play a minor role in predicting attitudinal characteristics (Mehmetoglu, 2007; Luo and Deng, 2008), thus other data were prioritized so as to avoid respondent fatigue.

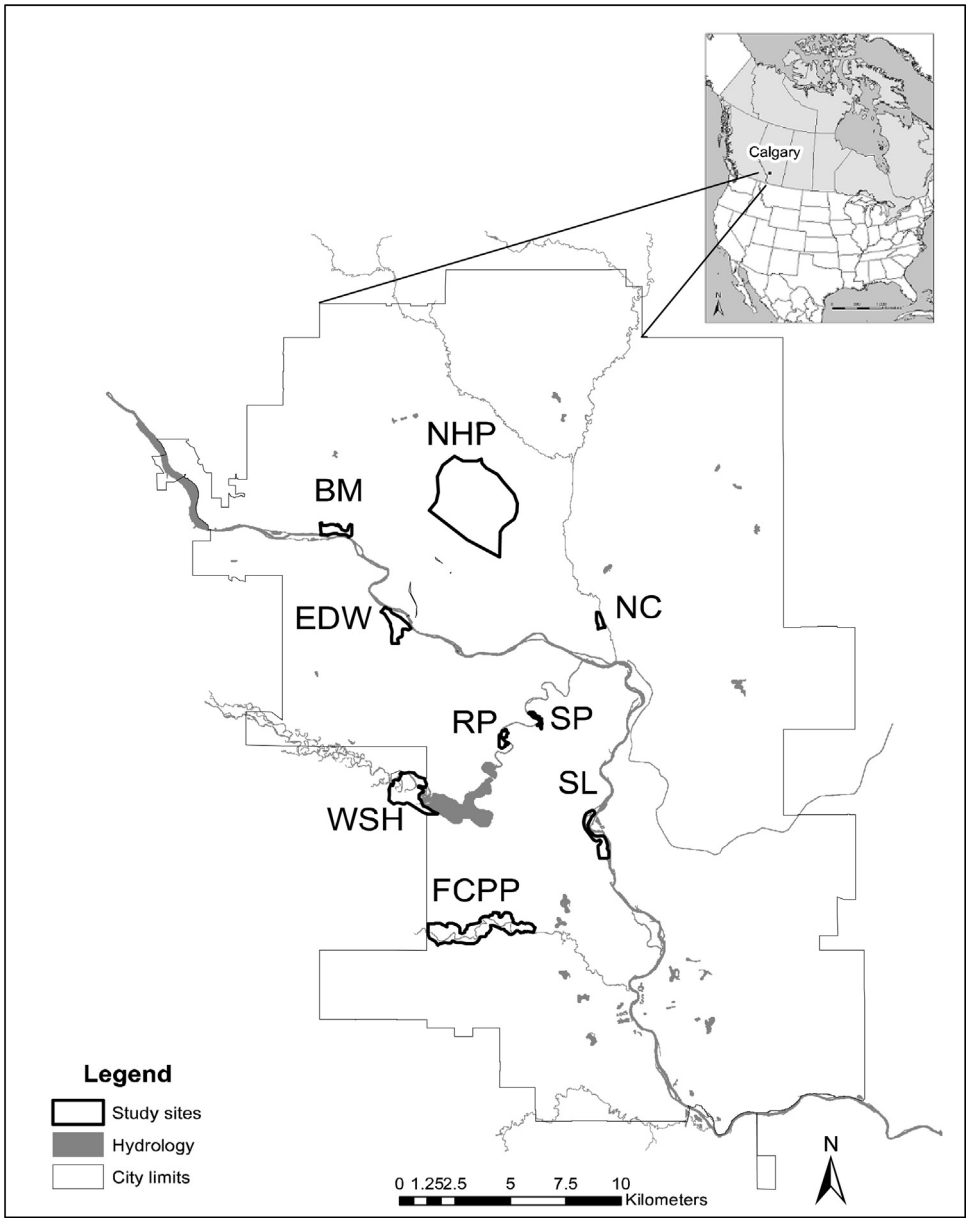

Fig. 1. Locations of nine parks used to survey dog owners' perception of risk for parasite transmission among dogs and people, and dog-walking habits in 2010, Calgary, Alberta, Canada.

Of the 635 dog-walkers who participated in the survey, 550 also supplied a fresh specimen of their dog's feces. Previously, the majority of these specimens were analyzed for the presence of helminth and select protozoa species, and the results indicated a positive association of overall GI parasitism in dogs with off-leash frequency, park-visitation frequency, and number of parks visited within 1 year (Smith et al., 2014). The present study used questionnaire data from 316 participants, all of whose dogs' feces were analyzed previously for GI parasites (see Smith et al., 2014 for a full description of sample selection criteria). This pool of data allowed for the examination of risk perception and the aforementioned activities associated to GI parasitism in dogs. In the current study, the sample included only dogs with owners whose most frequented park (MFP) was the park where the questionnaire was conducted ($n = 316$). From there, those cases matching the following criteria were prioritized hierarchically: (1) a single park focus; (2) a high visitation frequency to their MFP; (3) dogs that were 12 months of age or younger to maximize the juvenile contingent (Table 1).

Research involving human subjects was approved by the University of Calgary Conjoint Faculties Research Ethics Board (file #: 6498). Participants provided informed

Table 1
Questionnaire design including original questions and answer options.

Section	Question	Answer
1. Screening		
	Are you over the age of 18?	No/Yes
	Is this your dog?	No/Yes
	Does your dog normally defecate in this park?	No/Yes
2. Dog demographics and human behavior		
Dog demographics	What is the age of your dog?	Open
	Is your dog neutered or spayed?	No/Yes
Veterinary care history	Has your dog visited a veterinarian within the last year?	No/Yes/ Unknown
	Have you de-wormed your dog in the last 12 months (including heartworm medication)?	No/Yes/ Unknown
Walking behavior	How often do you come to this park?	Rarely 0–3/yr Occasionally <1/mnth Infrequently 1–3 days/mo Regularly 1/week Often 2–6 days/wk Everyday 1/day
	When do you come to this park?	Weekdays/Weekends/Both
	If a mixed park: management areas used	Off-leash/On-leash /Both
	How often do you let your dog off-leash in this park?	Never/Rarely/ Sometimes/Always
	Do you visit any other parks in Calgary?	No/Yes
If yes:	Which parks?	Open
	Which one of these additional parks do you visit most often (P1)?	Open
	How often do you go to this park?	Rarely 0–3/yr Occasionally <1/mnth Infrequently 1–3/mo Regularly 1/week Often 2–6/week Everyday 1/day
	When do you go to this park?	Weekdays/Weekends/Both
	What is the park management type?	Off-leash/On-leash/ Both/Unknown
	How often do you let your dog off-leash in this park?	Never/Rarely/Sometimes/Always
3. Education regarding parasites	Please comment on the following: my veterinarian talks to me about de-worming my dog	Strongly disagree Disagree Neutral Agree Strongly agree
	Please comment on the following: my veterinarian talks to me about worms that can be transferred from animals to people	Strongly disagree Disagree Neutral Agree Strongly agree
4. Risk perception and acceptability of risk	How likely, if at all, do you believe the chance is that your dog will get a parasite while in this park?	Not likely at all Very unlikely Somewhat unlikely Neither unlikely or likely Somewhat likely Very likely Definitely
	How acceptable to you, if at all, is the risk of your dog getting a parasite while in this park?	Not acceptable at all Very unacceptable Somewhat unacceptable Neither acceptable or unacceptable Somewhat acceptable Very acceptable Definitely

Table 1 (*Continued*)

Section	Question	Answer
	How likely, if at all, do you believe the chance is that your dog will transmit a parasite to you or a member of your family?	Not likely at all Very unlikely Somewhat unlikely Neither unlikely or likely Somewhat likely Very likely Definitely
	How acceptable to you, if at all, is the risk of your dog transmitting a parasite to you or a member of your family?	Not acceptable at all Very unacceptable Somewhat unacceptable Neither acceptable or unacceptable Somewhat acceptable Very acceptable Definitely
5. Personal Information		
	What is your name?	Open
	What is your postal code?	Open
	What is your email address?	Open

consent by signing a consent form outlining intended collection of dog and dog owner personal information and purpose for the data.

2.3. Data analysis

To determine the relationships among recreational behaviors, demographics, risk perception, education regarding parasites, and park management, we used Chi-Square Automatic Interaction Detection, (CHAID) classification tree analysis (Kass, 1980). CHAID selects the most significant association between independent and dependent variables using a chi-square testing approach (with reference p-value equal to 0.05 after being corrected using the Bonferroni method for multiple comparisons), identifying hierarchical subdivision within each of the subcategories and using a classification tree to represent the associations (Kass, 1980). CHAID has some advantages over more traditional methods of analysis such as multiple regression. First, CHAID displays probabilities of the response variable within groups of individuals versus regression which analyzes the response variable probability for individual units within the data (McCarty and Hastak, 2007). Moreover, CHAID is non-parametric in nature, and therefore quite robust and less sensitive to violations of assumptions than parametric techniques. CHAID can be advantageous for studies such as this one that provide information for management, and have been used for this purpose in previous studies (Semeniuk et al., 2008). This is partly because the ability to detect relationships that are not monotonic is possible with CHAID (and which regression does not directly accommodate) (McCarty and Hastak, 2007), and therefore CHAID can provide information about different subsets of park users.

Three CHAID trees were developed to describe the determinants of risk perception of parasite transmission while in parks (park-based transmission risk perception), perception of transmission to family members (zoonotic transmission risk perception), and off-leash frequency using similar predictor variables (Tables 1 and 2). We used these particular outcome variables because: (1) we were primarily interested in which demographic and behavioral factors influenced risk perceptions and; (2) out of the recreational behaviors previously found to pose risks for GI parasite infection in dogs (i.e. off-leash activity, number of attended parks, and park visitation frequency, Smith et al., 2014), off-leash activity was considered the most applicable from a management perspective. The tree was assigned a depth of ten tiers and required at least 20 cases in each root node and five cases in each terminal node. Few missing values were detected, overall, as participants were recruited by direct interception and questionnaire guidance was provided by the lead author. The following variables had missing values: 'zoonotic transmission risk perception acceptability' (9.2%; 29/316), 'deworming education' (0.3%; 1/316), and 'deworming status' (10.4%; 33/316). Missing values corresponded to the response "unknown", or to responses that were originally missing (Table 1). To avoid losing data when excluding cases that present missing values, CHAID incorporates these values as a distinct category or pools them with an existing category that closely resembles data of the missing values. Because the number of missing cases was equal to or less than 10%, we did not remove them from the analysis so as to preserve a higher power of statistical testing.

Reclassification of some variables was conducted to simplify CHAID output. For instance, 'off-leash frequency' was determined using the following procedure: original scores for reported off-leash frequency in the MFP and second most frequented park (P1) (from Table 1 within 'dog demographics and human behavior/walking behavior') were both pooled and rescored to produce three classes of overall off-leash frequency (low; moderate; high; Table 2). A similar technique was used to determine 'park visitation frequency'; however low park frequency ranks of 'rarely' and 'occasionally' in the MFPs (from Table 1 within 'dog demographics and human behavior/walking behavior') were filtered out during the sample selection process to target park-attending dogs. MFP and P1 park visitation frequencies were rescored to produce totals reflective of overall park frequency (rarely; occasionally; regularly; often; Table 2). The inclusion of only those dogs with

Table 2
Names and descriptions of the final independent variables used in CHAID analysis.

Independent variable category and name	Independent variable description
Park management:	Whether participants' most frequented park was designated as on-leash, off-leash, or was mixed-managed (both on and off-leash areas within the park)
Dog demographics:	
Dog age	Adult ≥ 12 months; Juvenile ≤ 12 months
Neuter or spay status[a]	Whether or not the dog was neutered or spayed
Deworming status	Whether or not the dog was dewormed within the previous 12 months
Veterinary care history	Whether or not dog went to the veterinarian within the previous 12 months
Walking behavior:	
Park visitation frequency	Frequency of park use (rarely ≤ 1 visit/week; occasionally = minimum 1 visit/week; regularly = 2–6 visits/week; often = everyday)
Park focus	Whether the owner attended one park, or greater than one park
Number of attended parks	Number of parks attended in total (low = 1 park; moderate = 2–3 parks; and high = 4–5 parks)
Off-leash frequency	Frequency of unleashing dog while in the park (low = rarely off-leash; moderate = sometimes or often off-leash in the most frequented park; high = often off-leash in both the most frequented and second most frequented parks)
Education regarding parasites:	
Zoonotic transmission education	Level of guidance provided by veterinarian regarding zoonotic transmission (uneducated = strongly disagree or disagree; neutral = neutral; educated = agree or strongly agree)
Deworming education	Level of occurrence of veterinarian presenting anthelmintics as an option for owners (uneducated = strongly disagree or disagree; neutral = neutral; educated = agree or strongly agree)
Risk perception and risk acceptability:	
Park-based transmission risk perception	Level of perceived risk regarding dog acquiring a parasite in the park (unlikely = not likely at all/very unlikely/somewhat unlikely; neutral = neutral; likely = somewhat likely/very likely/definitely)
Park-based transmission risk perception acceptability	Level of risk acceptability regarding dog acquiring a parasite in the park (unacceptable = not acceptable at all/very unacceptable/somewhat unacceptable; neutral = neutral; acceptable = somewhat acceptable/very acceptable/definitely)
Zoonotic transmission risk perception	Level of perceived risk regarding transmission of parasites from dog to human caregivers (unlikely = not likely at all/very unlikely/somewhat unlikely; neutral = neutral; likely = somewhat likely/very likely/definitely)
Zoonotic transmission risk perception acceptability	Level of risk acceptability regarding transmission of parasites from dog to human caregivers (unacceptable = not acceptable at all/very unacceptable/somewhat unacceptable; neutral = neutral; acceptable = somewhat acceptable/very acceptable/definitely)

[a] Neuter/spay status was used as an independent variable in the off-leash frequency CHAID only, as it was considered illogical to be a predicting factor for risk perception.

owners whose MFP was the park where the questionnaire was conducted ($n = 316$) made it possible to accurately make these calculations and ensured representation of park management (where park management was the form enforced at the MFP – Table 2).

To accommodate for the uneven distribution of some response values, certain predictor variables were pooled into three classes (see Table 2 for a description of new categories): 'zoonotic transmission education' and 'deworming education' (from Table 1 within 'education regarding parasites'); answers regarding risk perception and acceptability (from Table 1 within 'risk perception and acceptability of risk'); 'number of attended parks' (to accommodate for the use of parks other than the one in which the owners were interviewed; from Table 1 within 'dog demographics and human behavior/walking behavior').

Dog age (from Table 1 within 'dog demographics and human behavior/dog demographics') was reclassified into juvenile and adult categories (Table 2).

In addition to CHAID analysis, we calculated the overall frequency of each response category for 'zoonotic transmission education' ($n = 316$), in order to compare these results with the overall results of "zoonotic transmission risk perception" ($n = 316$).

Statistical analyses were conducted using SPSS version 20.0 (SPSS, Chicago, Illinois, USA).

3. Results

Within the filtered subsample of dog owners ($n = 316$), half of them perceived park-based transmission as unlikely, 7.9% were neutral, and 42.1% thought park-based transmission was likely to occur, overall (Fig. 2). Risk perception of zoonotic transmission was much lower: 74.7% of individuals felt zoonotic transmission was unlikely, 7.9% were neutral, and 17.4% felt it was likely ($n = 316$; Fig. 3). Approximately 38% of the participants fell into the 'uneducated' category for zoonotic transmission education; 16.8% were neutral; and 44.9% were educated. The majority of participants unleashed their dogs, at least some of the time: 83.9% ranked moderate or high, and 16.1% ranked low (Fig. 4).

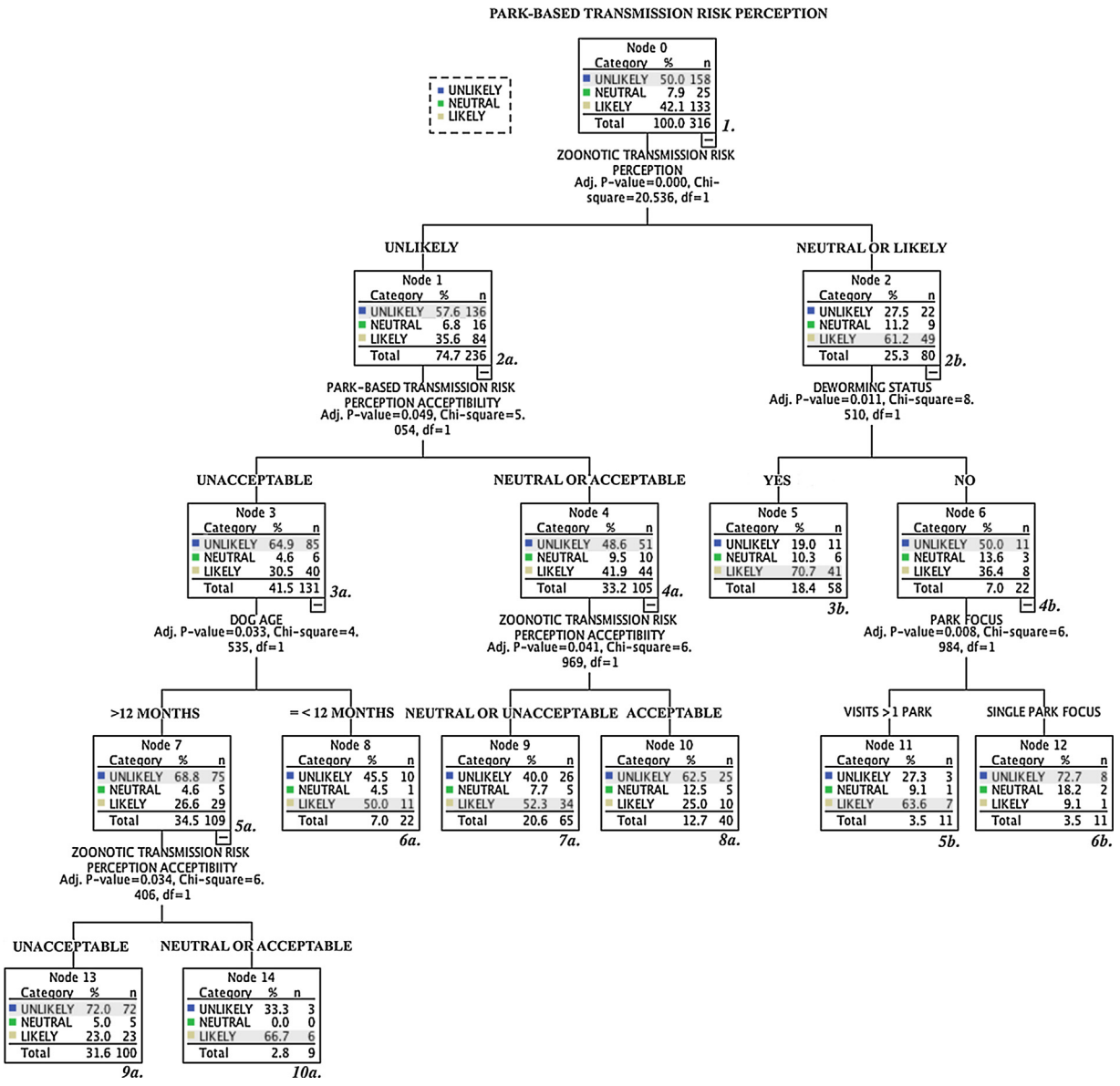

Fig. 2. CHAID decision tree representing significant associations among park-based transmission risk perception and zoonotic transmission risk perception, risk acceptability, dog-walking behaviors, education regarding parasites, dog demographics, and park management factors pertaining to park-attending dog owners and dogs in 2010 in Calgary, Alberta, Canada.

Risk perceptions of parasitism and level of reported off-leash frequency in dogs were not associated, as they were not retained in each other's classification tree models (Figs. 2–4).

3.1. CHAID profiling park-based transmission risk perception

Park-based transmission risk perception was significantly and positively associated with zoonotic transmission risk perception. Nonetheless, zoonotic transmission was perceived to be unlikely, overall (unlikely zoonotic transmission: 74.7%, $n = 236/316$, level 2a) (Fig. 2).

Respondents who perceived park-based transmission as unlikely were predominantly represented by people who had a similar perception of zoonotic transmission (57.6%, $n = 136/236$, level 2a) and who did not accept a risk of park-based transmission (64.9%, $n = 85/131$, level 3a); amongst these respondents, owning adult dogs (68.8%, $n = 75/109$, level 5a) coupled with not accepting zoonotic transmission risk (72%, $n = 72/100$, level 9a). Additionally, the majority of respondents who felt zoonotic transmission was unlikely but were instead neutral or accepted a risk of park-based transmission ($n = 105$, level 4a), were neutral or unaccepting of zoonotic transmission (62%, $n = 65/105$, level 7a). These latter respondents who found zoonotic

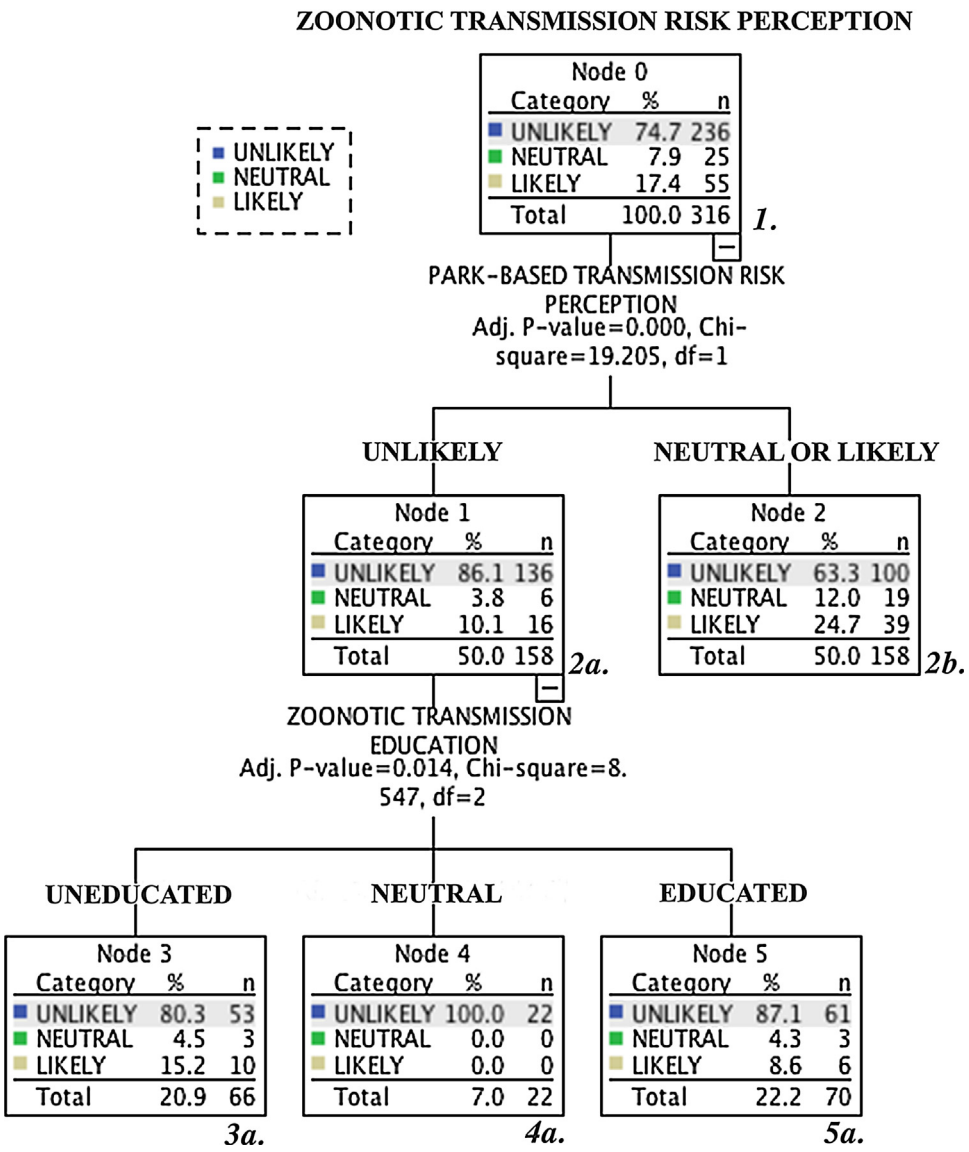

Fig. 3. CHAID decision tree representing significant associations among zoonotic transmission risk perception and park-based transmission risk perception, risk acceptability, dog-walking behaviors, education regarding parasites, dog demographics, and park management factors pertaining to park-attending dog owners and dogs in 2010 Calgary, Alberta, Canada.

transmission neutral or unacceptable perceived a higher risk of park-based transmission (unlikely park-based transmission: 40%, $n = 26/65$, level 7a) than those who accepted zoonotic transmission (unlikely park-based transmission: 62.5%, $n = 25/40$, level 8a). Those who perceived park-based transmission as unlikely and were among respondents who were neutral or responded 'likely' regarding the risk of zoonotic transmission, were characterized further by respondents who did not deworm their dog (50%, $n = 11/22$, level 4b). Participants owning dogs with negative deworming status were more inclined to perceive park-based transmission as unlikely if they attended only one park (unlikely park-based transmission: 72.7%, $n = 8/11$, level 6b) (Fig. 2).

3.2. CHAID profiling zoonotic transmission risk perception

Zoonotic transmission risk perception was associated most strongly with park-based transmission risk perception (Fig. 3). Although the majority of respondents perceived zoonotic transmission as unlikely despite their perceptions of park-based transmission risk; i.e., perception of park-based transmission was divided equally between unlikely (50%, $n = 158/316$, level 2a), and neutral or likely (50%, $n = 158/316$, level 2b), the highest proportion of people responding 'likely' to the question regarding zoonotic transmission perception (24.7%, $n = 39/158$, level 2b) gave a similar response to the question concerning

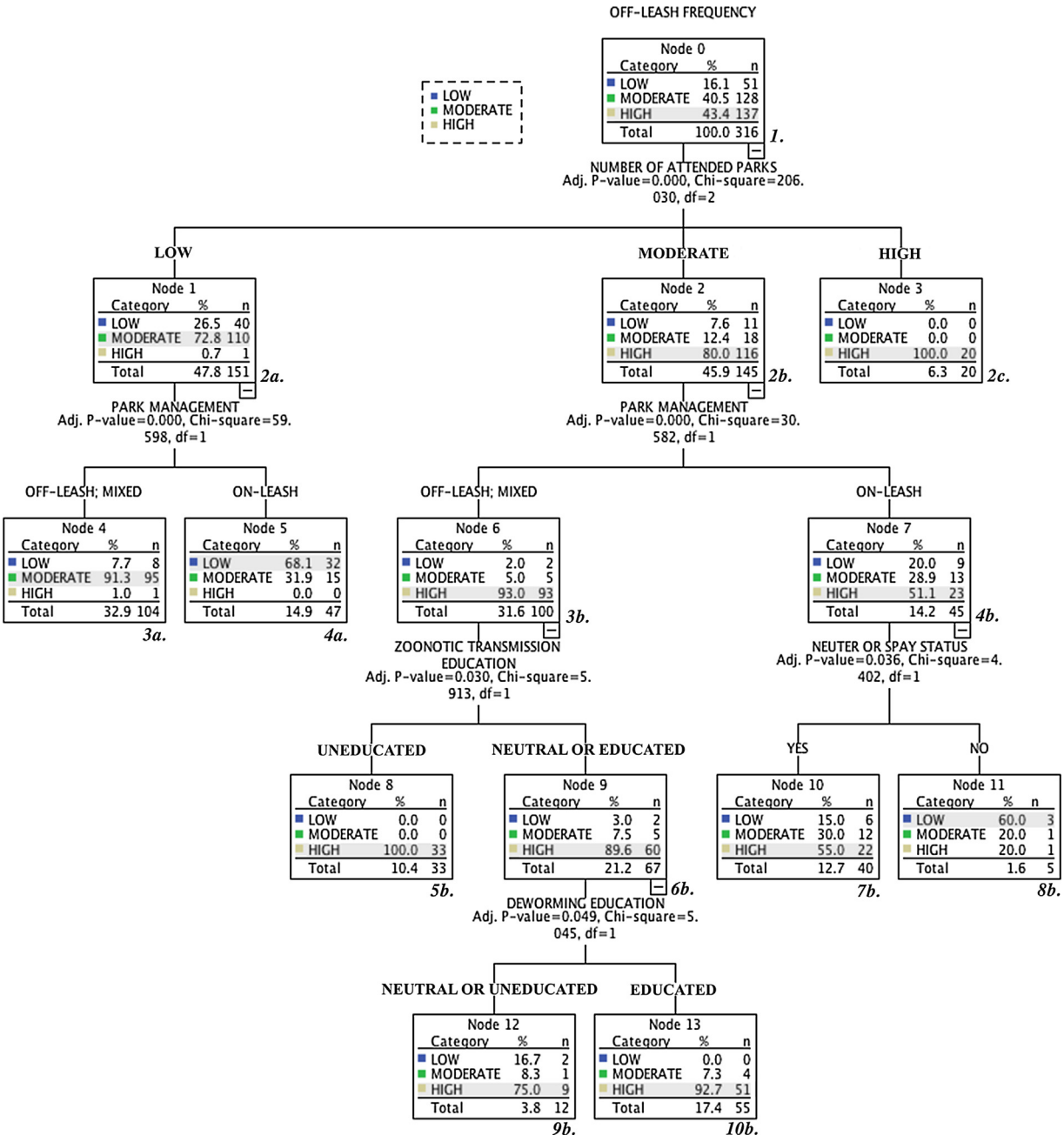

Fig. 4. CHAID decision tree classification representing significant associations among off-leash frequency and other dog-walking behaviors, risk perception, risk acceptability, education regarding parasites, dog demographics, and park management factors pertaining to park-attending dog owners and dogs in 2010 Calgary, Alberta, Canada.

park-based transmission risk perception. Of the respondents who felt park-based transmission was unlikely (n = 158, level 2a), the majority also perceived zoonotic transmission was unlikely (86.1%, n = 136/158, level 2a). Those who additionally self-identified as neutral regarding their level of education about zoonotic parasite transmission, also perceived zoonotic transmission as unlikely (100%, n = 22/22, level 4a). Zoonotic transmission was generally considered unlikely for those individuals who claimed to be educated regarding zoonotic parasite transmission (87.1%, n = 61/70, level 5a) as well as for those who claimed the opposite (80.3%, n = 53/66, level 3a) but was still slightly higher in the educated group (Fig. 3).

3.3. CHAID profiling off-leash frequency

Off-leash frequency was positively associated with the number of parks attended by dogs and owners, and consistently across forms of park management (Fig. 4). Individuals let their dogs off-leash less frequently if they

attended a single park (high off-leash: <1%, level 2a) versus those who walked their dogs in a moderate number of parks (high off-leash: 80.0%, $n = 116/145$, level 2b) or in a high number of parks (high off-leash: 100%, $n = 20/20$, level 2c).

As expected, all individuals with an off-leash or mixed-managed MFP let their dogs off-leash more often, overall, than individuals with on-leash MFPs, regardless of the number of attended parks (levels 3a, 4a, 3b, 4b).

Respondents owning dogs with a high off-leash frequency and who walked their dogs in a moderate number of parks were primarily characterized by individuals with an off-leash or mixed-managed MFP (93%, $n = 93/100$, level 3b). Of these respondents, those who self-identified as being uneducated about the risks of zoonotic transmission were most likely to allow their dogs off-leash (100%; $n = 33/33$, level 5b), although off-leash frequency was high in both groups. Similarly, of the respondents with an off-leash or mixed managed MFP but who felt neutral or educated about zoonotic transmission in combination with deworming education were also more likely to allow their dogs off-leash (92.7%; $n = 51/55$, level 10b). Dogs with an on-leash MFP were most often kept off-leash if neutered or spayed (high off-leash: 55%, $n = 22/40$, level 7b).

Similarly, individuals attending a single park with their dog(s) unleashed their animals most often if these parks were designated off-leash or mixed-managed parks (combined moderate and high off-leash: 92.3%, $n = 96/104$, level 3a) (Fig. 4).

4. Discussion

The results showed that overall, half of the participants perceived parasite transmission among park-attending dogs as unlikely, and the majority perceived this to be the case for zoonotic transmission. Meanwhile, the reported frequency of unleashing dogs (a risk factor for parasitism) was moderate to high. Perception of risk and reported frequency of off-leash activity were not associated statistically. Perception and reported off-leash frequency were significantly associated with factors other than each other. The two types of risk perception (transmission to dogs and to family members) were strongly associated with each other, and off-leash frequency was primarily associated positively with the number of attended parks, and to park management.

The apparent disconnect between risk perception and reported off-leash frequency may exist because dog owners have not considered, or are unaware, of the potential for increased exposure of unleashed dogs to sources of infection. Alternatively, the perceived health benefits of unleashing dogs for exercise and play (Rhodes et al., 2012) may supersede the perceived risks for human and dog health. The moderate to high frequency of unleashing dogs similarly suggests that the perception of parasite transmission risk associated with unleashing dogs is inconsequential.

Whereas the current study collected recreational data using a survey, Westgarth et al. (2010) compiled similar data from owners and dogs in dog-walking areas in the United Kingdom (UK) by first-hand observation, and also found that the majority of owners unleashed their dogs. In their related experiment comparing contact between a subject dog amongst other on-leash or off-leash dogs, they discovered that leashing had a significant dampening effect on the amount of contact between dogs, and they speculated that leashing could assist in preventing infectious diseases, such as in outbreak situations (Westgarth et al., 2010). Off-leash contact between dogs can have physical and social benefits of relevance to canine health, yet GI parasitism and off-leash frequency were previously found to be associated in our sample (Smith et al., 2014). In further refining our analysis of off-leash activity, we have reported here that owners who attended more than one park also reported unleashing their dogs more often than those who only walked their dogs in a single park. In addition, those who attended more than one park were less likely to abide the form of park management at their MFP. Similarly, compared to people who walked their dogs in a restricted number of sites, Westgarth et al. (2009) found that people who walked their dogs in multiple sites were more likely to unleash their dogs and to walk their dogs for longer periods of time.

Neither this study nor that of Westgarth et al. (2009) was designed to examine the rationale underlying such associations, but in both studies, the results suggest that repeated contact among individual dogs in different areas is possible. Further, through social network analysis based on questionnaire data, Westgarth et al. (2009) discovered a high degree of potential contact among dog-owning residences through typical walking routes and common dog-walking areas. Meanwhile, Degeling and Rock (2013) conducted in-depth interviews in our research setting, Calgary, AB, and found a similar result: a high degree of connectedness between residences in close proximity to one other, including shared use of the same neighborhood parks, and some overlap with larger regional parks outside the immediate neighborhood. The higher level of off-leash activity permitted by dog owners who walked in multiple areas, as reported in our study and by Westgarth et al. (2009), together with the interconnectedness of dogs and their owners who resided in similar neighborhoods (Westgarth et al., 2009; Degeling and Rock, 2013), further underscores the potential for transmission among individual dogs within urban parks.

Overall, park-based transmission was perceived to be more likely than zoonotic transmission, indicating that dog-owners felt the risk of their dogs acquiring a parasite in a park was higher than transmitting a parasite to a person. A low perceived risk of zoonotic transmission is a finding not unique to our investigation. One of the few studies to focus squarely on knowledge and attitudes regarding parasites and zoonotic diseases was recently published by Stull et al. (2012). Similar to this study, the authors administered a questionnaire to Canadian pet owners incorporating measures of perceived risks of transmission between pets and family, and they discovered a low perception of risk, overall. Furthermore, the majority of participants indicated their veterinarians were their primary source of information regarding zoonoses. Despite this, only 27% of participants who had taken their pets to the veterinarian in the previous 12 months reported that their veterinarians had raised the topic of zoonotic parasites (Stull et al., 2012). Similarly, the

results of an earlier investigation conducted by Stull et al. (2007) declared that only 44% of veterinarians surveyed reported always discussing zoonotic transmission risk with clients (Stull et al., 2007), suggesting that the overall level of concern for zoonotic parasite transmission for Canadian veterinarians is also unlikely to be very high. Although our data refer to a very specific subpopulation of owners (frequent park attendees who walked in our sampled parks), we provide supporting evidence that information about zoonotic parasite transmission is not routinely discussed with pet owners (approximately 45% of respondents reported discussing zoonotic transmission with their veterinarians, overall). It should be noted, however, that our results could also be indicative of other factors, such as: some participants with a vague recollection or understanding of past conversations with their veterinarians, or attempts by some veterinarians to balance advising clients about the risks of unleashing dogs with the benefits of this activity for the physical health and socialization of dogs.

Although zoonotic transmission was felt to be unlikely, overall, the majority of those who acknowledged this risk also perceived a high likelihood of park-based transmission, suggesting that this minority of people understand that parks could act as a potential source of infection for dogs and people. Individuals who perceived zoonotic transmission as unlikely were also more inclined to consider park-based transmission unlikely and unacceptable. This association appears logical: it is less likely that park attendance would occur at all if a higher perceived risk related to park use was considered unacceptable. Moreover, the majority of individuals who perceived zoonotic transmission as unlikely and who were tolerant of park-based transmission were not tolerant of zoonotic transmission, and considered park-based transmission likely. Conversely, the majority of individuals who considered both park-based and zoonotic transmission acceptable, perceived park-based transmission to be unlikely. Once again, our results suggest that for most participants, there is a disconnection between perceiving parks as a source of infection for dogs and for people.

Apart from zoonotic transmission risk perception and tolerance of transmission risks, other major indicators of park-based transmission risk perception included deworming status, park focus, and dog age. Owners who perceived both park-based and zoonotic transmission risks were more likely to deworm their dogs. Owners who had treated their dogs previously with anthelmintics may have been more aware of the risks than owners who had not. A small subset of owners regularly visiting more than one park and who did not deworm their dogs, indicated a higher perceived likelihood of park-based transmission than those only visiting one park. This suggests that some owners may be perceiving an increased potential for coming into contact with greater numbers of dogs and other infection sources when the number of attended parks increases: a perception supported by contact network analysis conducted by others (Westgarth et al., 2009). Similarly, some owners may be correctly informed with respect to a higher rate of infection with some parasites in young versus adult dogs (Bugg et al., 1999; Fontanarrosa et al., 2006; Joffe et al., 2011). Although these individuals considered zoonotic transmission to be unlikely and park-based transmission unacceptable, owners of juvenile dogs still acknowledged a higher likelihood of park-based transmission than owners of adult dogs.

The overall low perceived risk of zoonotic and park-based transmission, high off-leash frequency, and apparent divergence between low risk perception and high frequency of unleashing dogs found in this study, may increase the risk of GI transmission within and between parks given the previously established risks for GI parasitism in dogs associated with park use (Wang et al., 2012; Smith et al., 2014) and high potential for connectedness among urban parks (Westgarth et al., 2009). The CHAID output indicated certain subsets of the population that could be particularly responsible for disease transmission among park-attending dogs i.e. those individuals attending multiple parks, who typically unleash their dogs, and disobey park management rules. Targeting these dog owners for management and disease mitigation initiatives is recommended. Despite the potential transmission risks, however, using parks responsibly should be endorsed for the social and physical health benefits they provide for dogs and people. Incorporating more fenced off-leash areas into currently on-leash designated parks may help to improve compliance with leashing regulations. The opportunity to use officially designated off-leash areas within urban parks (particularly heavily used parks), may override the desire to unleash dogs in areas where this is not permitted. Engaging veterinarians in educating owners regarding the current status of regional GI parasite prevalence, risk factors for parasitism, and the importance of relaying information about responsible park use and deworming is fundamental. Park management should continue to allow for unleashing dogs in designated areas, but focus on implementing responsible owner policies (Rock et al., 2014) to reduce hazards for animal health such as the burden of dog feces accessible to off-leash dogs. In designing communication strategies and allocating public resources toward park maintenance, social science methodologies and theories of risk perception and norms should be considered to maximize the potential for behavioral change (Keizer et al., 2008; Quine et al., 2011; Goodwin et al., 2012). For example, understanding why people justify leaving behind their dogs' litter and the characteristics of those who do and do not remove their dogs' litter would be helpful in the design of appropriate interventions to redress these and other behaviors (Webley and Siviter, 2000; Wells, 2006; Atenstaedt and Jones, 2011).

Potential limitations to this study include our subsample selection process that used several criteria principally designed to include those participants who primarily attended one of the study sites and to maximize the number of frequent park users with high park fidelity. Although not all samples fulfilled all criteria, this selection process introduces selection bias and may inhibit internal validity to park-attending dogs. However, our intention was not to represent all park-attending dogs, but to determine perceptions and behaviors of individuals with park-attending dogs at a potential higher risk of parasitism. We aimed to represent these individuals across multiple park locales and forms of bylaw and provincial

management, all in order to inform the management of high-risk behaviors. Also, this study is cross-sectional and therefore a cause–effect relationship cannot be established. However, our greater intention was to determine the dynamic relationships existing among variables rather than to determine cause–effect relationships. Even so, several of the observed independent–dependent variable associations in this study would be unlikely to occur in the reverse. For example, park management is more likely to drive whether or not people unleash their dogs than occurrence of the opposite relationship. Other limitations to this study include lack of human demographic data (including human age and gender as potential confounders), and an uncomprehensive exploration of participants' reasons for their risk perception. Lastly, our study focused on the relationships among previously established risk factors for GI parasitism in dogs from helminths and protozoa (Smith et al., 2014). Participants in the current study were asked about their perception of parasite transmission risk in general (i.e. we did not specify particular types of parasites), but we discussed the implications of these perceptions with respect to enteric helminths and protozoa, overall. We did this because the sample used in the current study was similar to that used in the aforementioned study regarding risk factors for parasitism with helminths and protozoa in dogs (Smith et al., 2014). There may be broader implications for dog and human health associated with some ectoparasites and other endoparasites. Examples include other enteric pathogenic microorganisms, such as certain potentially zoonotic bacteria and viruses (e.g. *Salmonella* spp.). Future research in these areas is recommended.

5. Conclusions

Despite the potential for parasite transmission among park-attending dogs and humans, the perception of transmission is disconnected from behaviors that may increase this risk (e.g. unleashing dogs). However, some of these behaviors such as walking dogs off-leash, have important health and social outcomes, thus retaining parks as areas of recreation for dog and human companions is recommended. Education about responsible park use is suggested to increase awareness and affect perceptions about parasite transmission, so as to reduce risk. Expanding veterinary public health to encompass risk perceptions of disease transmission, as well as effective risk communication based on social science theory is recommended to identify management and education strategies and to successfully translate knowledge.

Conflict of interest

None.

Acknowledgments

We would like to thank Alistair Bath and Cormack Gates for assisting with project design and providing guidance in their areas of expertise. This study was funded primarily by the National Sciences and Engineering Research Council of Canada (Application number PGSM-358333-2008 to AS), an Alberta Innovates – Health Solutions Health Research Studentship (201001195 and 201001196 to AS), and the University of Calgary, Faculty of Veterinary Medicine (RT756475 to AM). We also acknowledge funding from Animal & Bylaw Services, City of Calgary (RT707431 to AM), an Alberta Innovates – Health Solutions Population Health Investigator Award (AHFMR-200600378 to MR) and a Canadian Institutes of Health Research New Investigator Award (MSH-83745 to MR).

References

Atenstaedt, R.L., Jones, S., 2011. Interventions to prevent dog fouling: a systematic review of the evidence. Public Health 125, 90–92.
Bugg, R.J., Robertson, I.D., Elliot, A.D., Thompson, R.C., 1999. Gastrointestinal parasites of urban dogs in Perth Western Australia. Vet. J. 157, 295–301.
Christian, H.E., Westgarth, C., Bauman, A., Richards, E.A., Rhodes, R.E., Evenson, K.R., Mayer, J.A., Thorpe Jr., R.J., 2013. Dog ownership and physical activity: a review of the evidence. J. Phys. Activ. Health 10, 750–759.
Conboy, G., 2009. Cestodes of dogs and cats in North America. Vet. Clin. North Am. Small Anim. Pract. 39, 1075–1090.
Cutt, H., Giles-Corti, B., Knuiman, M., Burke, V., 2007. Dog ownership, health and physical activity: a critical review of the literature. Health Place 13, 261–272.
Day, M.J., 2010. One Health: the small animal dimension. Vet. Rec. 167, 847–849.
Degeling, C., Rock, M., 2013. 'It was not just a walking experience': reflections on the role of care in dog-walking. Health. Promot. Int. 28, 397–406.
Feng, Y., Xiao, L., 2011. Zoonotic potential and molecular epidemiology of *Giardia* species and giardiasis. Clin. Microbiol. Rev. 24, 110–140.
Fontanarrosa, M.F., Vezzani, D., Basabe, J., Eiras, D.F., 2006. An epidemiological study of gastrointestinal parasites of dogs from Southern Greater Buenos Aires (Argentina): age, gender, breed, mixed infections, and seasonal and spatial patterns. Vet. Parasitol. 136, 283–295.
Gaunt, M.C., Carr, A.P., 2011. A survey of intestinal parasites in dogs from Saskatoon, Saskatchewan. Can. Vet. J. 52, 497–500.
Goodwin, R., Schley, D., Lai, K.M., Ceddia, G.M., Barnett, J., Cook, N., 2012. Interdisciplinary approaches to zoonotic disease. Infect. Dis. Rep. 4, 146–151.
Grimason, A., Smith, H., Parker, J., Jackson, M., Smith, P., Girdwood, R., 1993. Occurrence of *Giardia* spp. cysts and *Cryptosporidium* spp. oocysts in faeces from public health parks in the west of Scotland. Epidemiol. Infect. 110, 641–645.
Habluetzel, A., Traldi, G., Ruggieri, S., Attili, A.R., Scuppa, P., Marchetti, R., Menghini, G., Esposito, F., 2003. An estimation of *Toxocara canis* prevalence in dogs, environmental egg contamination and risk of human infection in the Marche region of Italy. Vet. Parasitol. 113, 243–252.
Joffe, D., Van Niekerk, D., Gagne, F., Gilleard, J., Kutz, S., Lobingier, R., 2011. The prevalence of intestinal parasites in dogs and cats in Calgary, Alberta. Can. Vet. J. 52, 1323–1328.
Kass, G., 1980. An exploratory technique for investigating large quantities of categorical data. J. Appl. Stat. 29, 119–127.
Keizer, K., Lindenberg, S., Steg, L., 2008. The spreading of disorder. Science 322, 1681–1685.
Knopp, S., Steinmann, P., Keiser, J., Utzinger, J., 2012. Nematode infections: soil-transmitted helminths and trichinella. Infect. Dis. Clin. North Am. 26, 341–358.
Lail, P., McCormack, G.R., Rock, M., 2011. Does dog-ownership influence seasonal patterns of neighbourhood-based walking among adults? A longitudinal study. BMC Public Health 11, 1–7.
Luo, Y.J., Deng, J.Y., 2008. The new environmental paradigm and nature-based tourism motivation. J. Travel. Res. 46, 392–402.
McCarty, J.A., Hastak, M., 2007. Segmentation approaches in data-mining: a comparison of RFM, CHAID, and logistic regression. J. Bus. Res. 60, 656–662.
McCormack, G.R., Rock, M., Toohey, A.M., Hignell, D., 2010. Characteristics of urban parks associated with park use and physical activity: a review of qualitative research. Health Place 16, 712–726.
Mehmetoglu, M., 2007. Typologising nature-based tourists by activity – theoretical and practical implications. Tourism Manage 28, 651–660.

Procter, T.D., Pearl, D.L., Finley, R.L., Leonard, E.K., Janecko, N., Reid-Smith, R.J., Weese, J.S., Peregrine, A.S., Sargeant, J.M., 2014a. A cross-sectional study examining *Campylobacter* and other zoonotic enteric pathogens in dogs that frequent dog parks in three cities in south-western Ontario and risk factors for shedding of *Campylobacter* spp. Zoonoses Public Health 61, 208–218.

Procter, T.D., Pearl, D.L., Finley, R.L., Leonard, E.K., Janecko, N., Reid-Smith, R.J., Weese, J.S., Peregrine, A.S., Sargeant, J.M., 2014b. A cross-sectional study examining the prevalence and risk factors for anti-microbial-resistant generic *Escherichia coli* in domestic dogs that frequent dog parks in three cities in south-western Ontario, Canada. Zoonoses Public Health 61, 250–259.

Quine, C.P., Barnett, J., Dobson, A.D., Marcu, A., Marzano, M., Moseley, D., O'Brien, L., Randolph, S.E., Taylor, J.L., Uzzell, D., 2011. Frameworks for risk communication and disease management: the case of Lyme disease and countryside users. Philos. Trans. R. Soc. Lond. B Biol. Sci. 366, 2010–2022.

Rhodes, R.E., Murray, H., Temple, V.A., Tuokko, H., Higgins, J.W., 2012. Pilot study of a dog walking randomized intervention: effects of a focus on canine exercise. Prev. Med. 54, 309–312.

Rock, M.J., Adams, C.L., Degeling, C., Massolo, A., McCormack, G.R., 2014. Policies on pets for healthy cities: a conceptual framework. Health. Promot. Int., http://dx.doi.org/10.1093/heapro/dau017.

Ryan, U., Fayer, R., Xiao, L., 2014. Cryptosporidium species in humans and animals: current understanding and research needs. Parasitology 141, 1667–1685.

Semeniuk, C.A.D., Haider, W., Beardmore, B., Rothley, K.D., 2008. A multi-attribute trade-off approach for advancing the management of marine wildlife tourism: a quantitative assessment of heterogeneous visitor preferences. Aquat. Conserv. 19, 194–208.

Smith, A.F., Semeniuk, C.A., Kutz, S.J., Massolo, A., 2014. Dog-walking behaviours affect gastrointestinal parasitism in park-attending dogs. Parasite. Vect. 7, 429.

Stull, J.W., Carr, A.P., Chomel, B.B., Berghaus, R.D., Hird, D.W., 2007. Small animal deworming protocols, client education, and veterinarian perception of zoonotic parasites in western Canada. Can. Vet. J. 48, 269–276.

Stull, J.W., Peregrine, A.S., Sargeant, J.M., Weese, J.S., 2012. Household knowledge, attitudes and practices related to pet contact and associated zoonoses in Ontario, Canada. BMC Public Health 12, 553.

Toohey, A., Rock, M., 2011. Unleashing their potential: a critical realist scoping review of the influence of dogs on physical activity for dog-owners and non-owners. Int. J. Behav. Nutr. Phys. Act. 8, 1–9.

Wang, A., Ruch-Gallie, R., Scorza, V., Lin, P., Lappin, M.R., 2012. Prevalence of *Giardia* and *Cryptosporidium* species in dog park attending dogs compared to non-dog park attending dogs in one region of Colorado. Vet. Parasitol. 184, 335–340.

Webley, P., Siviter, C., 2000. Why do some owners allow their dogs to foul the pavement? The social psychology of a minor rule infraction. J. Appl. Soc. Psychol. 30, 1371–1380.

Wells, D.L., 2006. Factors influencing owners' reactions to their dogs' fouling. Environ. Behav. 38, 707–714.

Westgarth, C., Christley, R., Pinchbeck, G., Gaskell, R., Dawson, S., Bradshaw, J., 2010. Dog behaviour on walks and the effect of the use of a leash. Appl. Anim. Behav. Sci. 125, 38–46.

Westgarth, C., Gaskell, R.M., Pinchbeck, G.L., Bradshaw, J.W., Dawson, S., Christley, R.M., 2009. Walking the dog: exploration of the contact networks between dogs in a community. Epidemiol. Infect. 137, 1169–1178.