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Risk factors for dog bites occurring during and outside of play: Are they different?

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Abstract

The aim of this study was to determine whether the effects of selected human-canine interaction/environmental factors on bites occurring when the victim was and was not playing with the dog differed from each other. A veterinary clinic-based retrospective cohort study was conducted in Kingston, Jamaica (709), and San Francisco, USA (513) to compare the effects of selected exposures on non-play bites (161) relative to bites preceded by play with the dog (110) as reported by veterinary clients. Additionally, 951 non-biting dogs were used for a risk factor analysis of bites occurring during play. Using directed acyclic graphs and the change-in-estimate procedure to select and adjust for confounders, modified Poisson regression was used to estimate a) the ratios of proportions of non-play bites out of all bites comparing exposed to unexposed dogs (proportionate bite ratios) and b) risk ratios for bites occurring during play for each factor of interest.

Proportionate bite ratios ranged from 0.84 to 1.29, with most 95% confidence intervals including one, thus implying a lack of specificity of effects of the examined factors on non-play bites relative to bites occurring during play with the dog. Consistent with this lack of specificity, risk ratios for bites occurring during play were similar in magnitude and direction to risk ratios previously published for non-play bites using the same non-biting dogs as a reference group. No country-specific differences in proportionate bite ratios were detected.

Each human-canine environmental factor showed similar levels of association with both types of bites. One possible explanation is that both types of bites have a common causal pathway leading from each factor up to the point of human-canine contact. If the human-canine contact then leads to either play or non-play interactions with

dogs and subsequently to both types of bites, the presence of such a common pathway would make the factor non-specific to either type of bite. As some of the examined factors are associated with increased frequencies of both types of bites, this could explain high percentages of bites occurring during play with the dog reported in case series of dog bites. If so, dog bite prevention strategies targeting these factors will simultaneously reduce the incidence of both types of bites.

Key words: dog, non-play bite, bites during play, human-canine contact, risk factor

1. Introduction

Research on dog bites has revealed that they can result in disfiguring and psychologically scarring injuries (Mathews and Lattal, 1994; De Keuster et al., 2006; Kesting et al., 2006; Morgan and Palmer, 2007) sometimes ending in death (Sacks et al., 2000). These injuries financially burden the public health system (Weiss et al., 1998), often hurt owner-dog relationships (Reisner et al., 1994; Hart, 1995; Burt, 1997), and have a negative impact on society's view of dog rearing (Serpell, 1995; Hunthausen, 1997).

Research focusing on the circumstances of dog bites mentions that some bites occur during play (Parrish et al., 1959; Thompson, 1997; Guy et al., 2001; Ozanne-Smith et al., 2001; Horisberger et al., 2004), which is both a type and a trigger of aggression (Beaver, 1983; Wright and Nesselrote, 1987; Landsberg et al., 1997). Overall, various studies report between 5 and 29% of dog bites occurring either as a sequel to or during play with the dog (Beck et al., 1975; Szpakowski et al., 1989; Shewell and Nancarrow, 1991; Ashby, 1996; Guy et al., 2001; Maragliano et al., 2007; O'Sullivan et al., 2008). One possible explanation for the high percentages of bites occurring during play among reported dog bites is that certain exposures might be risk factors both for bites occurring during play as well as for bites occurring outside of the context of play. Nevertheless, systematic study of bites occurring while the victim is playing with the dog has largely been neglected. Distinguishing between the two types of bites in studies will help to uncover the specificity, or lack thereof, of underlying associations with potential risk factors, help to clarify aspects of the causal web of dog bites and thus provide a basis for intervention aimed at reducing total dog bite incidence. It should also help explain the high proportion of bites occurring during play among the total numbers of bites.

To determine whether the effects of selected human-dog environmental factors on the risk of non-play bites differed from their effects on the risk of bites occurring during play with the dog, a veterinary clinic-based retrospective cohort study was conducted in both San Francisco (SF), USA, and Kingston, Jamaica, directly comparing both types of bites as reported by clients. The premise was that if a particular factor specifically causes (or prevents) non-play bites but not bites occurring during play with the dog, then there should be proportionately more (or fewer) non-play biters among all biting dogs exposed to that factor when compared to those unexposed to the factor. This translates to the ratio of proportions of non-play biters among exposed and unexposed biters being greater (or less) than one. Correspondingly, the associated 95% confidence intervals should predominantly include values greater (or less) than one. Additionally, the greater (lesser) the specificity of the effects, the further (closer) will be the 95% confidence limits from (to) one.

Though little has been published on cross-cultural differences in dog keeping worldwide (Wan et al., 2009), previous research points to different cultural attitudes to dogs between the United States and the Caribbean (Fielding and Mather, 2001; Davis et al., 2007; Fielding, 2008). The goal of the bi-national component of the study was to assess whether the effects of the factors being studied differed in these two countries.

2. Materials and methods

2.1. Study protocol

The protocol for this study constitutes a part of a large cohort study on human-animal interactions as risk factors for dog bites approved by the Human Subjects Review

Committee at the University of California, Davis, USA. The methods used are identical to those previously described in detail elsewhere (Messam et al., 2008) and thus only a brief description is provided here.

2.2. Study participants and study sites

Study participants were clients in the waiting rooms of eight veterinary clinics in Kingston, Jamaica, from May 30, to August 9, 2003, and from three veterinary clinics in San Francisco (SF), USA, from October 20, 2003 to January 10, 2004. Persons were eligible to participate if they had owned the dog for ≥ 24 hours, were living seven days a week in the same home as the dog, had the dog at the clinic during the interview, and were at least 18 years old. Data was collected by interviewer-administered questionnaire and canine information pertained to only the dog present at the time of the interview. Identical data collection protocols were observed in both countries.

2.3. Outcome Determination

A dog bite was defined as sudden pressure from a dog's teeth to a part of a person's body and/or clothing. Outcome categories were determined based on responses to the following questions: a) "During play, in the last two years, did the dog ever hold onto or catch a part of any person's body with its teeth and cause a wound?"; b) "Not during play, in the last two years, did the dog ever hold onto or catch a part of any person's body with its teeth and cause a wound?"; and c) "Not during play, in the last two years, did the dog ever hold onto or catch a part of any person's body or clothes with its teeth but not cause a wound?" The outcome was a bite occurring during play with the dog if the respondent

answered “yes” to (a) but “no” to both (b) and (c), and a non-play bite if the respondent answered “yes” to (b) and/or (c) but “no” to (a). The dog was considered a non-biter if the respondent answered “no” to all three questions. If the respondent answered in the affirmative to (a) and (b), (a) and (c) or to all three, the event that occurred earliest was chosen as the outcome. Using two questions in parallel to determine outcome status for non-play bites increased the sensitivity of detecting instances when a dog attacked and made contact with a person with its teeth. In defining bites occurring during play, outcomes included those circumstances in which the victim was playing with the dog but were restricted to those resulting in wounds to exclude cases of playful mouthing where a dog might grasp a person’s body without applying sudden pressure. The use of the term “play bites” has been avoided in preference to “bites occurring during play with the dog” as it was not ascertained whether the dog was playing at the time of the bite. The type of bite, where only the human is playing, is hereafter referred to as a “play” bite to distinguish it from a situation in which the dog was also known to be playing (Fig. 1)

2.4. Exposure assessment

Exposures for this analysis were identical to those previously examined for their effect on the risk of non-play bites (Messam et al., 2008) (Fig.1). Based on their hypothesized role in leading to dog bites, they were placed into three categories. First, certain exposures were thought to exert their effects only prior to the initiation of human-canine contact (Fig. 1, box A) and thought to determine contact. Second, other exposures were thought to exert their effects only subsequent to the initiation of human-canine contact (Fig. 1, box B) and third, some exposures were thought to exert their effects both

prior and subsequent to the initiation of human-canine contact (Fig. 1, box C). Because the essential etiological distinction between both types of bites hinges on whether or not the event occurred while the victim was playing with the dog, it was assumed that the causal pathway from an exposure acting prior to human-canine contact would be the same for both types of bites up to the point of the human-canine contact, and then after contact, diverge before play with the dog occurred. Human-canine contact is used in this context to mean any habitual or intermittent human-canine interaction facilitated by occupation of the same space and time and need not involve tactile contact. For example, a playful interaction may start by touching the dog, a play bow by the dog, or a verbal stimulus from the person that elicits a play bow. (Play with the dog may also be a component of certain types of contact.).

2.5. Data Analysis

During data collection, 41 persons (11 in Kingston and 30 in San Francisco) elected not to participate. In total, 1235 (718 in Kingston, and 517 in SF) interviews were conducted. During data entry, thirteen questionnaires were found to be ineligible and thus data from 1222 participants (110 biters during play, 161 non play biters and 951 non-biters) were used for final data analysis.

Modified Poisson regression (Zou, 2004) in SAS version 8.2 was used to estimate proportionate bite ratios for non-play bites and associated 95% CIs (Spiegelman and Hertzmark, 2005). The proportionate bite ratio for non-play bites is given by:

$PBR_{NP} = PB_{NP}^{E+} / PB_{NP}^{E-}$, where PB_{NP}^{E+} and PB_{NP}^{E-} were the proportions of non-play biters

among all biting dogs for exposed and unexposed categories, respectively, of the factor.

Functional forms of continuous variables were determined using fractional polynomials (Royston and Altman, 1994) and directed acyclic graphs (DAGs) were used to create a subset of potential confounders to control for each exposure of interest (Greenland et al., 1999) (Table 1). The owner's age, gender and method of response were included in each of these subsets and for each exposure of interest, identical subsets to those previously reported for analyses of non-play bites were used (Messam et al., 2008). Initially, to detect differences in PBR_{NP} attributable to city of residence, interaction terms consisting of the factor of interest with country were added to each model. These terms were retained if the corresponding regression coefficients were statistically significant ($p < 0.05$). Finally, a set of confounders for each factor of interest was selected from its respective DAG via forward selection using the change-in-estimate method (Greenland, 1989) with a $\geq 10\%$ change in the estimated PBR_{NP} required for retention in the model.

Finally, the above mentioned procedures were repeated in order to estimate risk ratios (RR) and 95% CIs for bites occurring during play with the dog and informally compare them to results previously reported for non-play bites with the same non-biting dogs as a reference group (Messam et al., 2008).

3. Results

3.1. Study Population Characteristics

Distributions of the exposures of interest with respect to biters and non-biters by country are presented in Tables 2 to 4. Forty percent of all biters, bit while being played with by the victim, with the proportion in SF (43%) slightly greater than in Kingston (37%). Most respondents were female (58%), especially among Kingstonians (62%) and owners of non-

play biters (63%). Eighty percent of owners of non-play biters and 72% of owners of dogs that bit while being played with answered questions without assistance from a spouse, child or other accompanying person and similar proportions of owners of dogs that bit during (89%) and outside of play (83%) witnessed the respective biting incidents. Dogs that bit during play with the victim, were younger than non-play biters with inter-quartile ranges of ages of 10 weeks to 1 year and 11 months to 6.5 years, respectively. Fifty-eight percent of both types of biters were acquired for companionship and not protection and approximately 25% of both types of biters lived in a home with a child 5 to 15 years old. Of the victims for which relevant information was collected, 70% (91% of those bitten during play vs. 57% of those bitten outside of play) were family members and/or lived in the same home as the dog. Overall, 42% of victims were family members and/or lived with the dog, while 18% were not, and most persons in this latter category were familiar with both dog and owner. The relationships of the remaining 40% of victims with the dog was not specified.

Twelve percent of biters in Kingston were born at their current home compared to 1% in SF, and more biters in Kingston (97%) had access to yard space than in SF (59%). In SF, more biters were neutered (56% compared to 7% in Kingston) and fewer (1%) were acquired for protection than in Kingston (17%).

3.2. Proportionate bite ratios for non-play bites

No interaction with country of residence was found for any of the factors examined, and thus PBR_{NP} estimates based on the pooled data from both countries are reported.

Estimates of PBR_{NP} for non-play bites were close to one (ranging from 0.84 to 1.29) and

associated 95% CIs tended to be narrow (Tables 5 and 6, Fig. 2 (a) to (c)). Ninety five percent confidence intervals for effects of the exposures thought to act i) prior to contact and ii) the exposures thought to act both prior to and subsequent to contact all included 1 (Tables 5 and 6, Fig. 2 (a) to (c)). For example, having yard space was associated with a 3% increase in the proportion of non-play bites ($PBR_{NP} = 1.03$; 95% CI: 0.93 to 1.14), showing that the data is compatible with both increases and decreases in the proportion of non-play bites as well.

Proportionate bite ratios with 95% CIs excluding one were found only for exposures thought to act exclusively subsequent to contact. For instance, the proportion of non-play bites among dogs that were always removed after growling in the presence of visitors and strangers to the home compared to the proportion of non-play biters among dogs that had never growled in the presence of visitors and strangers was $PBR_{NP} = 1.29$ (95% CI: 1.17 to 1.42). Using the same comparison group, the PBR_{NP} was 1.26 (95% CI: 1.16 to 1.37) for dogs that were either never or only sometimes removed after growling in the presence of visitors and strangers to the home.

3.3. Risk factors for bites occurring during play with the dog.

The magnitudes and directions of the RRs for bites occurring during play were similar to the RRs previously reported for the same exposures on non-play bites (Messam et al., 2008). There was also substantial overlap of their respective 95% CIs with the major difference being in the precision of the estimates (Tables 5 and 6).

4. Discussion

With few exceptions (Beck et al., 1975; Messam et al., 2008), bites occurring during and outside of play are routinely pooled together for analysis. To our knowledge, this is the first report of data collected with the express purpose of distinguishing between both types of bites. Previously, in case series conducted in urban areas, Ashby (1996) (5%), Beck (1975) (9.6%), Shewell and Nancarrow (1991) (12%), Szpakowski (1989) (12.5%), Guy (2001) (28.6%) and Horisberger (2004) (14%), reported lower percentages of dog bites occurring (among total reported bites) while the victim played with the dog than the 40% reported in this study. This difference is difficult to explain as published reports yield little information on exactly how bites occurring during play with the dog are distinguished from bites occurring outside of the context of play. Others, Georges and Adesiyun (2008) (32%) and Parrish (1959) (33%) reported estimates more similar to this study's, but combined petting and playing with the dog into one exposure category. Thus, apart from differences in study populations, differences in case definitions are likely to explain these differences in estimates.

While owners should be capable of accurately identifying and reporting human play, it has been suggested that they are unreliable in distinguishing between play and non-play signals in the dog (Moss and Wright, 1987; Mathews and Lattal, 1994; Maragliano et al., 2007; Reisner and Shofer, 2008; Tami and Gallagher, 2009). This might particularly be true if the dog's behaviour changes during the interaction. Thus, apart from indicating a situation in which a true play bite occurred, i.e., while both dog and victim were playing (Fig. 1), a dog bite "during play with the dog" might have other interpretations: at the time of the bite, unbeknownst to the respondent, the dog may not have been playing. This may

have been the case for the duration of the entire person-dog interaction or just during its latter stages. Alternately, the respondent might have known that the dog was not playing but may have misrepresented (intentionally or otherwise) the dog's actions to minimize the circumstances of the bite. This is consistent with a tendency among some owners to "display a dog positivity bias" (Rajecki et al., 1998) and excuse perceived dog misbehaviour (Sanders, 1990; Rajecki et al., 1999).

The low proportionate bite ratio estimates for non-play bites, coupled with 95% confidence limits close to the null (Tables 5 and 6 Fig. 2 (a) to (c)), suggest that the selected human-dog environmental exposures are associated with very slight changes in the proportions of bites occurring either during or outside of the context of play with the dog. Consequently they are not specific to either of the two types of bites. In addition, this lack of specificity of effects is consistent in both countries, though for some factors, low numbers of exposed dogs in either of the countries might have contributed to a lack of power to detect interactions. Considering that some of the exposures examined in this analysis are both positively associated with bites occurring during play and previously have been identified as positively associated with non-play bites (Tables 5 and 6) (Messam et al., 2008), this lack of specificity of effects would explain high proportions of bites during play in case series of dog bites.

Growling in the presence of visitors/strangers to the home showed some specificity of effects on non-play bites compared to bites occurring during play. Because aggression in dogs is often preceded by growling (Messent, 1983; Wright and Nesselrote, 1987; Bradshaw, 1995; AVMA, 2001; Rooney et al., 2001), this finding is not surprising.

However, the low specificity may have resulted from some growls having occurred while the dog was playing as opposed to being signs of aggravation.

This study has primarily focussed on environmental factors which in exerting their effects prior to human-canine contact (Fig. 1, Groups A and C) are not immediate causes of dog bites. Nevertheless, they provide the environmental context for different types of dog bites to occur by determining the type of human-canine contact which precedes the bite. As has previously been noted (Westgarth et al., 2008), it is expected that the precise nature (duration and character) of each human-canine contact be exposure specific. For instance, the excitable prancing around of some dogs, while waiting to be unleashed or let out of a kennel and the fact that some dogs come running at the sound of their owner's car entering the driveway or the back door opening, will all depend on the behaviour of the individual dog and human as well as the type of household it lives in. Thus, for example, human contact with a dog chained for a portion of the day will likely be different from human contact with a dog that usually sleeps in a family member's bedroom. Possible sequential pathways for bites following human-canine contact are, a) human-canine contact, human-play with dog, joint human-canine play and then a play-bite, b) human-canine contact, human-play with dog, joint human-canine play, canine non-play aggression and then a "play" bite, c) human-canine contact, human-play with dog, canine non-play aggression and then a "play" bite and d) human-canine contact, canine non-play aggression and then a non-play bite (Fig. 1). As noted for other outcomes (Terry et al., 2000), if each type of bite can result from the same type of intermediate human-canine contact, the exposure leading to that type of human-canine contact will have the same effect on each of the resulting types of bite. Consequently, no pathway leading from the

human-canine contact would be expected to result in proportionately more (or fewer) non-play bites (or bites during play) among exposed compared to unexposed dogs. Thus, a high percentage of bites during play with the victim among case series of dog bites may be a result of a given exposure creating the environment in which both play and non-play interactions with a dog could occur. This in turn leads to both types of bites. Additionally, the effects of these exposures on bites occurring while both victim and dog were playing (play bites) should not differ from their effects on bites occurring when only the victim was playing (“play” bites). This is because play by the victim serves as a common intermediate along the pathway for both these types of bites (Fig. 1). In the presence of common intermediates, neither prevarication nor misclassification of dog bites, by respondents, is likely to be the fundamental explanation for the results regarding the effects of exposures in Groups A and C.

Exposures acting subsequent to human-canine contact (Fig. 1, Group B) are more likely to be immediate determinants of dog bites and therefore have separate pathways to bites occurring in and outside of the context of play. Consequently, associations of these exposures with both types of bites are more likely to be distinct and there will be either proportionately more or fewer non-play bites among exposed versus unexposed dogs. A 95% CI for the proportionate bite ratio which includes only values greater than one for dogs which growled in the presence of visitors and strangers to the home, is consistent with this expectation.

The relative importance of the causal pathway from each exposure to a dog bite depends on the exposure’s prevalence. For example, low proportions of biters born at home and acquired for protection in San Francisco, suggest that causal pathways involving

these exposures result in a lower frequency of bites in San Francisco than in Kingston. Similarly, low proportions of neutered biters and biters without access to yard space in Kingston suggest that there, these exposures cause fewer dog bites than in San Francisco.

A limitation of this study is the use of a simple causal model which does not specifically define human-canine contact for each of the examined exposures. Additionally the study focussed primarily on environmental exposures felt to exert effects early in the causal path of to a dog bite. Recent analyses of cases series of dog bites suggest that immediately preceding the bites, a high percentage of child victims interacted, with the dog, in ways which might have triggered the incidents (Kahn et al., 2003; Reisner et al., 2007; Reisner et al., 2011). Thus it is possible that an investigation of the effects of more proximate exposures might reveal specificity in their effects on non-play bites relative to bites occurring during play. This type of investigation is particularly important as it pertains to human-canine play because of its importance to the human-canine relationship in some cultures (Messent, 1983; Rooney et al., 2001; Westgarth et al., 2008). In those contexts, it would be important for dog owners to know which types of playful human-canine interactions might lead first to canine non-play aggression and consequently result in human injury.

5. Conclusions

This study suggests that certain human-canine factors are equally associated with dog bites occurring during and outside of the context of play with the dog. To correctly interpret these results, it is necessary to consider that, in all likelihood, only some bites occurring during play occurred while the dog was actually playing. This is likely to be the

case with dog bites reported to health authorities as well. Nevertheless, if a particular exposure creates a human-canine environment and consequent human-canine contacts resulting in either play or non-play interactions with a dog, it will be a common risk factor for all types of dog bites resulting from these two interactions. This lack of specificity of effects could explain high percentages of bites occurring while the victim played with the dog and suggests that dog bite prevention strategies targeting some of these factors could simultaneously reduce the incidence of both types of bites.

The study also suggests that an investigation of factors acting during or subsequent to human-canine contact might reveal more specific exposure effects on non-play bites relative to bites occurring in the context of play with the dog. This will elucidate further aspects of the causal web of dog bites including the role of human-canine play in its etiology. Given the importance of human-canine play to many human-canine relationships, it is important to understand which types of human-canine play are likely to increase the frequency of dog bites and which are not, with the ultimate goal of reducing the prevalence of the former in favour of the latter. Apart from obvious public health benefits, this type of information will contribute positively to human-canine relationships and ultimately enhance canine welfare.

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Figure Legends**Legend for Fig. 1.**

Diagram indicating hypothesized points of action of exposures along the causal chain of dog bites.

Legend for Fig. 2.

Proportionate bite ratio estimates and associated 95 percent confidence intervals for the effects on non-play bites of human-canine interaction/environmental factors hypothesized to act a) only prior to human-canine contact, b) both prior and subsequent to human-canine contact and c) only subsequent to human-canine contact.

Table 1

Variables included in each hypothesized sufficient set of confounders during the modified Poisson regression procedure analyzing risk factors for non-play bites relative to bites occurring during play

Exposures	Code	Sufficient set of potential confounders^b
Dog's combined sex and neuter status	G	A, B, C,D, E, F, L, M, N
Sight/Hearing problems	J	A, B, C, D, F
Housing	O	A, B, C, D, K
Dog in house (hours/day)	P	A, B, C, D, F, H, I, M, O
Dog chained (hours/day)	Q	A, B, C, D, F, H, I, M, U
Dog locked up (hours/day)	R	A, B, C, D, F, H, I, M, U
Sleep in family member's bedroom ^a		A, B, C, D, F, H, I, P, M, O
Allowed in the presence of strangers	U	A, B, C, D, F, H, I, J, P, M, O
Can leave premises unaccompanied ^a		A, B, C, D, F, M, O, Q, R
Reason for acquiring dog	M	A, B, C, D, K, O
Dog's origin	N	A, B, C, D, O
Breed	H	A, B, C, D, K, M, O
Children (5-15 yrs.) living at home	K	A, B, C, D
Dog removed/allowed to retreat when fearful	V	A, B, C, D, F, H, I, K, M, O, U
Dog removed/allowed to retreat when growls ^a		A, B, C, D, F, H, I, K, M, O, U, V

A = Country, B = Respondent's age, C = Respondent's gender, D = Method of response, E = Age at acquisition, F = Current age, G = Dog's sex/neuter status, H = Breed, I = Dog breed weight based on breed standard, L =Length of ownership

^aNot included in any sufficient set of potential confounders

^bInitial set of potential confounders chosen for model selection

Table 2
Distribution of bites and non-bites by respondent's characteristics and country of origin: Kingston (Kgn.), Jamaica and San Francisco (SF), USA (2003-2004)

Exposure	Exposure categories	Bites during play			Non-play ^a bites		Non-bites ^a	
		Total Bites	Kgn. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b
Respondent's age (years)	≤ 20	45	2 (4)	2 (4)	6 (13)	0 (0)	30 (67)	5 (11)
	21 – 30	254	14 (6)	14 (6)	19 (7)	13 (5)	100 (39)	94 (37)
	31 – 40	338	14 (4)	25 (7)	21 (6)	31 (9)	136 (40)	111 (33)
	41 – 50	244	8 (3)	11 (5)	19 (8)	14 (6)	113 (46)	79 (32)
	51 – 60	175	9 (5)	6 (3)	12 (7)	12 (7)	91 (52)	45 (26)
	61 – 70	108	2 (2)	0 (0)	3 (3)	7 (6)	70 (65)	26 (4)
	≥ 71	49	0 (0)	2 (4)	2 (4)	1 (2)	35 (71)	9 (18)
Total:		1213^c	49	60	82	78	575	369
Respondent's gender	Male	533	18 (3)	35 (7)	32 (6)	28 (5)	270 (51)	150 (28)
	Female	689	31 (4)	26 (4)	50 (7)	51 (7)	308 (45)	223 (32)
Total		1222^c	49	61	82	79	578	373
Method of response	Alone	962	33 (3)	46 (5)	63 (7)	67 (7)	444 (46)	309 (32)
	Spouse/Companion helped	105	5 (5)	7 (7)	4 (4)	5 (5)	45 (43)	39 (39)
	Child helped	99	8 (8)	5 (5)	12 (12)	4 (4)	59 (59)	11 (11)
	Other individual helped	56	3 (5)	3 (5)	3 (5)	3 (5)	30 (54)	14 (25)
Total:		1222^c	49	61	82	79	578	373

^a Messam et. al., 2008

^b Row percentages. Not all percentages sum to 100 due to rounding error.

^c Differences in totals reflect differences in the number of responses to each question

Table 3

Distribution of bites and non-bites by exposures of interest: Kingston (Kgn.), Jamaica and San Francisco (SF)
USA (2003-2004)

Exposure	Exposure categories	Total	Bites during play		Non-play ^a bites		Non-bites ^a	
			Kgn.	SF	Kgn.	SF	Kgn.	SF
			n (%) ^b	n (%) ^b	n (%) ^b	n (%) ^b	n (%) ^b	n (%) ^b
By exposures thought to act prior to contact								
Dog's sex and neuter status	Male intact	441	24 (5)	18 (4)	40 (9)	14 (3)	298 (68)	47 (11)
	Male castrated	222	1 (<1)	15 (7)	4 (2)	33 (15)	19 (9)	150 (68)
	Female intact	336	23 (7)	18 (5)	34 (10)	11 (3)	221 (66)	29 (9)
	Female spayed	214	0 (0)	9 (4)	4 (2)	20 (9)	36 (17)	145 (68)
	Total:	1213 ^c	48	60	82	78	574	371
Sight/Hearing Problems	Yes	57	0 (0)	1 (2)	2 (4)	2 (4)	18 (32)	34 (60)
	No	1138	49 (4)	59 (5)	80 (7)	76 (7)	549 (48)	325 (29)
	Total:	1195 ^c	49	60	82	78	567	359
Housing	Yard space	1017	47 (5)	34 (3)	80 (8)	47 (5)	569 (56)	240 (24)
	No yard space	200	2 (1)	26 (13)	2 (1)	31 (16)	6 (1)	133 (67)
	Total:	1217 ^c	49	60	82	78	575	373
Dog in house (hours/day)	19-24 hrs.	537	20 (4)	42 (8)	34 (6)	56 (10)	114 (21)	271 (50)
	13-18 hrs.	128	4 (3)	13 (10)	4 (3)	13 (10)	35 (27)	59 (46)
	7-12 hrs.	80	5 (6)	5 (6)	6 (8)	9 (11)	26 (33)	29 (36)
	1- 6 hrs.	162	9 (6)	0 (0)	11 (7)	0 (0)	132 (81)	10 (6)
	0 hrs.	312	11 (4)	0 (0)	27 (9)	1 (<1)	269 (86)	4 (1)
	Total:	1219 ^c	49	60	82	79	576	373
Dog chained/leashed (hours/day)	1- 24 hrs.	111	17 (15)	2 (2)	13 (12)	0 (0)	69 (62)	10 (9)
	0 hrs.	1108	32 (3)	57 (5)	69 (6)	79 (7)	508 (46)	363 (33)
	Total:	1219 ^c	49	59	82	79	577	373
Dog locked up (hours/day)	19-24 hrs.	58	2 (3)	2 (3)	1 (2)	1 (2)	49 (84)	3 (5)
	13-18 hrs.	41	0 (0)	4(10)	3 (7)	2 (5)	27 (66)	5 (12)
	7-12 hrs.	150	8 (5)	13 (9)	9 (6)	9 (6)	64 (43)	47 (31)
	1- 6 hrs.	81	13 (16)	10 (12)	5 (6)	7 (9)	27 (33)	19 (23)
	0 hrs.	887	26 (3)	30 (3)	63 (7)	59 (7)	410 (46)	299 (34)
	Total:	1217 ^c	49	59	81	78	577	373
Sleep in family member's room	Yes	507	12 (2)	43 (8)	34 (7)	61 (12)	84 (17)	273 (54)
	No	709	37 (5)	16 (2)	47 (7)	17 (2)	492 (69)	100 (14)
	Total:	1216 ^c	49	59	81	78	576	373
Allowed in presence of strangers	Yes/Sometimes	876	30 (3)	56 (6)	61 (7)	74 (8)	295 (34)	360 (41)
	No	251	12 (5)	3 (1)	15 (6)	3 (1)	206 (82)	12 (5)
	Total:	1127 ^c	42	59	76	77	501	372
Can leave Premises unaccompanied	Yes	223	36 (16)	54 (24)	16 (7)	8 (8)	95 (43)	4 (2)
	No	1002	13 (1)	5 (<1)	65 (6)	70 (7)	480 (48)	369 (37)
	Total:	1215 ^c	49	59	81	78	575	373

^a Messam et. al., 2008

^b Row percentages. Not all percentages sum to 100 due to rounding error.

^c Differences in totals reflect differences in the number of responses to each question

Table 4
Distribution of bites and non-bites by exposures of interest: Kingston (Kgn.), Jamaica and San Francisco (SF)
USA (2003-2004)

Exposure	Exposure categories	Total	Bites during play		Non-play ^a bites		Non-bites ^a	
			Kgn. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b
By exposures thought to act both prior and subsequent to contact								
Reason for acquiring dog	Protection ^c	173	6 (3)	1 (1)	16 (9)	1 (1)	144 (83)	5 (3)
	Companionship ^d	623	31 (5)	44 (7)	38 (6)	56 (9)	194 (31)	260 (42)
	Other ^e	425	12 (3)	16 (4)	28 (7)	22 (5)	239 (56)	108 (25)
	Total:	1221 ^f	49	61	82	79	577	373
Dog's origin	Born at home	144	4 (3)	0 (0)	12 (8)	1 (<1)	125 (87)	2 (1)
	Acquired	1077	45 (4)	61 (6)	70 (6)	78 (7)	452 (42)	371 (34)
	Total:	1221 ^f	49	61	82	79	577	373
Breed	German Shepherd	47	3 (6)	2 (4)	9 (19)	2 (4)	29 (62)	2 (4)
	Rottweiler	43	2 (5)	0 (0)	4 (9)	0 (0)	33 (77)	4 (9)
	Labrador	40	0 (0)	6 (15)	1 (3)	2 (5)	4 (10)	27 (68)
	Shih Tzu	47	4 (9)	1 (2)	9 (19)	2 (4)	24 (51)	7 (15)
	Other	1045	40 (4)	52 (5)	59 (6)	73 (7)	488 (47)	333 (32)
	Total:	1222 ^f	49	61	82	79	578	373
Child (5-15 yrs.) living in home	Yes	311	17 (5)	10 (3)	33 (11)	8 (3)	199 (64)	44 (14)
	No	911	32 (4)	51 (6)	49 (5)	71 (8)	379 (42)	329 (36)
	Total:	1222 ^f	49	61	82	79	578	373
By exposures thought to act only subsequent to contact								
Dog removed/allowed to retreat when fearful in presence of visitors or strangers to home	Yes	141	5 (4)	5 (4)	7 (5)	8 (6)	67 (48)	49 (35)
	No/Sometimes	58	3 (5)	7 (12)	5 (9)	7 (12)	20 (34)	16 (28)
	Situation never occurred	1005	40 (4)	46 (5)	70 (7)	62 (6)	485 (48)	302 (30)
	Total:	1204 ^f	48	58	82	77	572	367
Dog removed/ allowed to retreat when growls in presence of visitors or strangers to home	Yes	116	4 (2)	3 (2)	25 (15)	8 (5)	110 (66)	16 (10)
	No/Sometimes	247	13 (5)	10 (4)	38 (15)	28 (11)	110 (45)	48 (19)
	Situation never occurred	790	32 (4)	46 (6)	18 (2)	41 (5)	345 (44)	308 (39)
	Total:	1203 ^f	49	59	81	77	565	372

^aData reproduced from Messam et al., 2008

^b Row percentages. Not all percentages sum to 100 due to rounding error.

^cAcquired for protection or for protection and other reasons excluding companionship

^dAcquired for companionship or for companionship and other reasons excluding protection

^eAll other combinations

^fDifferences in totals reflect differences in the number of responses to each question

Table 5.

Proportionate bite ratios (PBR_{NP}), risk ratios (RR), 95% confidence intervals (95% CIs) and confounders (CF) causing $\geq 10\%$ change in PBR_{NPs} and RRs for associations of selected factors with bites occurring during play, non-play bites, and non-play bites relative to bites occurring during play, Kingston, Jamaica and San Francisco (2003-2004)

Exposure	Exposure categories	Non-play bites vs. Bites during play			Bites during play			Non-play bites ^d		
		RR	95% CI	CF	RR	95% CI	CF	RR	95% CI	CF
By exposures thought to act prior to contact										
Dog's sex and neuter status	Male (intact)	1.09	0.99 – 1.20	F	4.15	1.87 – 9.20	A, F	2.56	1.51 – 4.34	A, F
	Male (castrated)	1.00	0.90 – 1.10		1.87	0.83 – 4.21	M, N	1.52	0.94 – 2.46	
	Female (intact)	1.08	0.98 – 1.20		4.76	2.10 - 10.81		3.22	1.86 – 5.59	
	Female (spayed)	1			1			1		
		n: 257 ^a			n: 976 ^b			n: 1026 ^c		
Sight/Hearing problems	Yes	1.14	0.93 – 1.39	none	0.26	0.04 – 1.85	F	0.41	0.15 – 1.09	F
	No	1			1			1		
		n: 260 ^a			n: 979 ^b			n: 1025 ^c		
Housing	Yard Space	1.03	0.93 – 1.14	A, K	0.77	0.48 – 1.24	A, B	0.86	0.57 - 1.30	A
	No yard space	1			1			1		
		n: 269 ^a			n: 1050 ^b			n: 1101 ^c		
Dog in house (hours/day)	19-24 hrs.	0.94	0.85 – 1.04	none	3.40	1.59 – 7.28	A, C	1.97	1.17 – 3.32	A, F
	13-18 hrs.	0.90	0.78 – 1.04		3.21	1.40 – 7.39	F, M	1.90	0.99 – 3.62	H, I
	7-12 hrs.	0.95	0.82 – 1.10		4.04	1.63 – 10.00		2.18	1.18 – 4.02	
	1- 6 hrs.	0.92	0.78 – 1.09		1.25	0.52 – 3.01		1.00	0.51 – 1.96	
	0 hrs.	1			1			1		
		n:262 ^a			n: 998 ^b			n: 1044 ^c		
Dog chained (hours/day)	1-24 hrs.	0.96	0.85 – 1.08	F	2.34	1.45 - 3.77	A, F	1.15	0.66 – 1.99	F
	0 hrs.	1			1			1		
		n: 248 ^a			n: 926 ^b			n: 974 ^c		

A = Country, B = Respondent's age, C = Respondent's gender, F = Dog's current age, H = Breed, I = Dog breed weight based on breed standards, K = Children (5-15 yrs.) living at home, M = Major reason for getting dog, N = Dog's origin

^aNumber of observations in final model = number of participants (271) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^bNumber of observations in final model = number of participants (1061) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^cNumber of observations in final model = number of participants (1112) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^dFrom Messam et al., 2008

Table 5. cont.

Proportionate bite ratios (PBR_{NP}), risk ratios (RR), 95% confidence Intervals (95% CIs) and confounders (CF) causing $\geq 10\%$ change in PBR_{NPS} and RRs for associations of selected factors with bites occurring during play, non-play bites, and non-play bites relative to bites occurring during play, Kingston, Jamaica (JA) and San Francisco, (USA) (2003-2004)

Exposures	Exposure categories	Non-play bites vs. Bites during play			Bites during play			Non-play bites ^d		
		PBR _{NP}	95% CI	CF	RR	95% CI	CF	RR	95% CI	CF
By exposures thought to act prior to contact cont.										
Dog locked up (hours/day)	19-24 hrs.	0.84	0.62 -1.13	F	1.25	0.48 – 3.28	A, F	0.44	0.07 – 2.76	F, U
	13-18 hrs.	0.97	0.85 – 1.10		1.34	0.59 – 3.03	H, I	0.93	0.35 – 2.46	
	7-12 hrs.	0.99	0.90 – 1.09		1.27	0.77 – 2.07	U	1.15	0.72 – 1.83	
	1- 6 hrs.	0.90	0.80 – 1.02		3.31	2.06 – 5.32		1.71	1.02 – 2.86	
	0 hrs.	1			1			1		
		n: 247 ^a			n: 926 ^b			n: 973 ^c		
Sleep in family member’s bedroom	Yes	1.06	0.99 – 1.15	none	1.04	0.70 – 1.56	F, P	2.54 (JA)	1.43 – 4.54	A ^e , F
		-			-			1.11 (USA)	0.67 – 1.85	H, P
	No	1			1			1		
		n: 259 ^a			n: 997 ^b			n: 1042 ^c		
Allowed in presence of strangers	Yes/Sometimes	1.08	0.95 – 1.22	A	1.37	0.79 – 2.40	F, I	1.77	1.03 – 3.04	F, H
	No	1			1		M	1		I
		n: 246 ^a			n: 902 ^b			n: 948 ^c		
Can leave premises unaccompanied	Yes	1.03	0.92 – 1.14	none	2.57	1.56 – 4.24	A, F	1.04 (JA)	0.63 – 1.72	A ^e , F
		-			-		M	3.40 (USA)	1.98 – 5.85	
	No	1			1			1		
		n: 258 ^a			n: 998 ^b			n: 1042 ^c		

A = Country, F = Dog's current age, H = Breed, I = Dog breed weight based on breed standards, M = Major reason for getting dog, P = Dog in house,

U = Allowed in presence of strangers

^aNumber of observations in final model = number of participants (271) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^bNumber of observations in final model = number of participants (1061) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^cNumber of observations in final model = number of participants (1112) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^dTaken from Messam et al., 2008

^eInteraction of exposure of interest with country

Table 6.

Proportionate bite ratios (PBR_{NP}), risk ratios (RR), 95% confidence Intervals (95% CIs) and confounders (CF) causing $\geq 10\%$ change in PBR_{NPS} and RRs for associations of selected factors with bites occurring during play, non-play bites, and non-play bites relative to bites occurring during play, Kingston, Jamaica and San Francisco (2003-2004)

Exposures	Exposure categories	Non-play bites vs. Bites during play			Bites during play			Non-play bites ^d		
		PBR _{NP}	95% CI	CF	RR	95% CI	CF	RR	95% CI	CF
By exposures thought to act both prior and subsequent to contact										
Reason for acquiring dog	Protection	1.03	0.91 – 1.17	none	0.64	0.28 - 1.44	none	0.82	0.49 - 1.38	none
	Companionship	0.94	0.87 -1.02		2.02	1.32 – 3.09		1.36	0.99 – 1.99	
	Other	1			1			1		
		n: 267 ^a			n: 1049 ^b			n: 1100 ^c		
Dog’s origin	Born at home	1.11	0.99 – 1.26	none	0.34	0.13 – 0.93	A	0.71	0.41 - 1.25	A
	Acquired	1			1			1		
		n: 267 ^a			n: 1049 ^b			n: 1100 ^c		
Breed	German Shepherd	1.06	0.92 -1.22	none	1.75	0.74 – 4.10	A, M	2.27	1.33 – 3.88	A
	Rottweiler	1.05	0.83 – 1.32		0.80	0.20 – 3.15		0.86	0.33 – 2.22	
	Labrador	0.84	0.66 - 1.66		1.19	0.54 – 2.59		0.54	0.18 – 1.64	
	Shih Tzu	1.06	0.92 – 1.22		1.46	0.62 – 3.43		2.09	1.22 – 3.59	
	Other	1			1			1		
		n: 267 ^a			n: 1049 ^b			n: 1100 ^c		
Children (5-15 yrs.) ^c living in home	Yes	0.99	0.91 – 1.09	A	0.98	0.62 – 1.53	A, D	1.13	0.80 – 1.58	A
	No	1			1			1		
		n: 267 ^a			n: 1053 ^b			n: 1104 ^c		
By exposures thought to act only subsequent to contact										
Dog removed/ allowed to retreat when fearful	Yes	0.99	0.87 – 1.13	none	0.86	0.46 – 1.58	A, F	0.78	0.46 – 1.30	F
	No/Sometimes	1.00	0.87 - 1.15		1.97	1.15 – 3.38	M	1.71	1.06 – 2.76	
	Never occurred	1			1			1		
		n: 245 ^a			n: 961 ^b			n: 961 ^c		
Dog removed/ allowed to retreat when growls	Yes	1.29	1.17 – 1.42	none	0.80	0.37 – 1.72	A, F	2.97	1.95 – 4.52	F, G
	No/Sometimes	1.26	1.16 – 1.37		1.49	0.95 – 2.36		3.55	2.54 – 4.97	U
	Never occurred	1			1			1		
		n: 236 ^a			n: 892 ^b			n: 892 ^c		

A = Country, D = Method of response, F = Dog's current age, G = Dog's sex/neuter status, M = Major reason for getting dog, U = Allowed in presence of strangers

^aNumber of observations in final model = number of participants (271) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^bNumber of observations in final model = number of participants (1061) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^cNumber of observations in final model = number of participants (1112) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^dTaken from Messam et al., 2008

(a) Factors exerting effects prior to human–canine contact

(b) Factors exerting effects both prior and subsequent to human–canine contact

(c) Factors exerting effects subsequent to human–canine contact