



Title	Risk factors for dog bites occurring during and outside of play: Are they different?
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Publication date	2012-11-01
Publication information	Messam, Locksley L. McV., Philip H. Kass, Bruno B. Chomel, and Lynette A. Hart. "Risk Factors for Dog Bites Occurring during and Outside of Play: Are They Different?" Elsevier, November 1, 2012. https://doi.org/10.1016/j.prevetmed.2012.05.007 .
Publisher	Elsevier
Item record/more information	http://hdl.handle.net/10197/10217
Publisher's statement	This is the author's version of a work that was accepted for publication in Preventive Veterinary Medicine. Changes resulting from the publishing process, such as peer review, editing, corrections, structural formatting, and other quality control mechanisms may not be reflected in this document. Changes may have been made to this work since it was submitted for publication. A definitive version was subsequently published in Preventive Veterinary Medicine (107, 1-2, (2012)) https://doi.org/10.1016/j.prevetmed.2012.05.007
Publisher's version (DOI)	10.1016/j.prevetmed.2012.05.007

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

2

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24 Abstract

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

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

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

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

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

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70 1. Introduction

71 Research on dog bites has revealed that they can result in disfiguring and
72 psychologically scarring injuries (Mathews and Lattal, 1994; De Keuster et al., 2006;
73 Kesting et al., 2006; Morgan and Palmer, 2007) sometimes ending in death (Sacks et al.,
74 2000). These injuries financially burden the public health system (Weiss et al., 1998), often
75 hurt owner-dog relationships (Reisner et al., 1994; Hart, 1995; Burt, 1997), and have a
76 negative impact on society's view of dog rearing (Serpell, 1995; Hunthausen, 1997).

77 Research focusing on the circumstances of dog bites mentions that some bites
78 occur during play (Parrish et al., 1959; Thompson, 1997; Guy et al., 2001; Ozanne-Smith
79 et al., 2001; Horisberger et al., 2004), which is both a type and a trigger of aggression
80 (Beaver, 1983; Wright and Nesselrote, 1987; Landsberg et al., 1997). Overall, various
81 studies report between 5 and 29% of dog bites occurring either as a sequel to or during
82 play with the dog (Beck et al., 1975; Szpakowski et al., 1989; Shewell and Nancarrow,
83 1991; Ashby, 1996; Guy et al., 2001; Maragliano et al., 2007; O'Sullivan et al., 2008). One
84 possible explanation for the high percentages of bites occurring during play among
85 reported dog bites is that certain exposures might be risk factors both for bites occurring
86 during play as well as for bites occurring outside of the context of play. Nevertheless,
87 systematic study of bites occurring while the victim is playing with the dog has largely
88 been neglected. Distinguishing between the two types of bites in studies will help to
89 uncover the specificity, or lack thereof, of underlying associations with potential risk
90 factors, help to clarify aspects of the causal web of dog bites and thus provide a basis for
91 intervention aimed at reducing total dog bite incidence. It should also help explain the high
92 proportion of bites occurring during play among the total numbers of bites.

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

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

111

112 **2. Materials and methods**

113 *2.1. Study protocol*

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

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

119

120 *2.2. Study participants and study sites*

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

129

130 *2.3. Outcome Determination*

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

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

153

154 2.4. *Exposure assessment*

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

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

173

174 2.5. Data Analysis

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

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

183 $PBR_{NP} = PB_{NP}^{E+} / PB_{NP}^{E-}$, where PB_{NP}^{E+} and PB_{NP}^{E-} were the proportions of non-play biters

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

185 Functional forms of continuous variables were determined using fractional polynomials
186 (Royston and Altman, 1994) and directed acyclic graphs (DAGs) were used to create a
187 subset of potential confounders to control for each exposure of interest (Greenland et al.,
188 1999) (Table 1). The owner's age, gender and method of response were included in each of
189 these subsets and for each exposure of interest, identical subsets to those previously
190 reported for analyses of non-play bites were used (Messam et al., 2008). Initially, to detect
191 differences in PBR_{NP} attributable to city of residence, interaction terms consisting of the
192 factor of interest with country were added to each model. These terms were retained if the
193 corresponding regression coefficients were statistically significant ($p < 0.05$). Finally, a set
194 of confounders for each factor of interest was selected from its respective DAG via
195 forward selection using the change-in-estimate method (Greenland, 1989) with a $\geq 10\%$
196 change in the estimated PBR_{NP} required for retention in the model.

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

201

202 **3. Results**

203 *3.1. Study Population Characteristics*

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

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

222 Twelve percent of biters in Kingston were born at their current home compared to
223 1% in SF, and more biters in Kingston (97%) had access to yard space than in SF (59%).
224 In SF, more biters were neutered (56% compared to 7% in Kingston) and fewer (1%) were
225 acquired for protection than in Kingston (17%).

226

227 *3.2. Proportionate bite ratios for non-play bites*

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

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

231 associated 95% CIs tended to be narrow (Tables 5 and 6, Fig. 2 (a) to (c)). Ninety five
232 percent confidence intervals for effects of the exposures thought to act i) prior to contact
233 and ii) the exposures thought to act both prior to and subsequent to contact all included 1
234 (Tables 5 and 6, Fig. 2 (a) to (c)). For example, having yard space was associated with a
235 3% increase in the proportion of non-play bites ($PBR_{NP} = 1.03$; 95% CI: 0.93 to 1.14),
236 showing that the data is compatible with both increases and decreases in the proportion of
237 non-play bites as well.

238 Proportionate bite ratios with 95% CIs excluding one were found only for
239 exposures thought to act exclusively subsequent to contact. For instance, the proportion of
240 non-play bites among dogs that were always removed after growling in the presence of
241 visitors and strangers to the home compared to the proportion of non-play biters among
242 dogs that had never growled in the presence of visitors and strangers was $PBR_{NP} = 1.29$
243 (95% CI: 1.17 to 1.42). Using the same comparison group, the PBR_{NP} was 1.26 (95% CI:
244 1.16 to 1.37) for dogs that were either never or only sometimes removed after growling in
245 the presence of visitors and strangers to the home.

246

247 *3.3. Risk factors for bites occurring during play with the dog.*

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

252

253

254 4. Discussion

255 With few exceptions (Beck et al., 1975; Messam et al., 2008), bites occurring
256 during and outside of play are routinely pooled together for analysis. To our knowledge,
257 this is the first report of data collected with the express purpose of distinguishing between
258 both types of bites. Previously, in case series conducted in urban areas, Ashby (1996)
259 (5%), Beck (1975) (9.6%), Shewell and Nancarrow (1991) (12%), Szpakowski (1989)
260 (12.5%), Guy (2001) (28.6%) and Horisberger (2004) (14%), reported lower percentages
261 of dog bites occurring (among total reported bites) while the victim played with the dog
262 than the 40% reported in this study. This difference is difficult to explain as published
263 reports yield little information on exactly how bites occurring during play with the dog are
264 distinguished from bites occurring outside of the context of play. Others, Georges and
265 Adesiyun (2008) (32%) and Parrish (1959) (33%) reported estimates more similar to this
266 study's, but combined petting and playing with the dog into one exposure category. Thus,
267 apart from differences in study populations, differences in case definitions are likely to
268 explain these differences in estimates.

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

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

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

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

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

301 This study has primarily focussed on environmental factors which in exerting their
302 effects prior to human-canine contact (Fig. 1, Groups A and C) are not immediate causes
303 of dog bites. Nevertheless, they provide the environmental context for different types of
304 dog bites to occur by determining the type of human-canine contact which precedes the
305 bite. As has previously been noted (Westgarth et al., 2008), it is expected that the precise
306 nature (duration and character) of each human-canine contact be exposure specific. For
307 instance, the excitable prancing around of some dogs, while waiting to be unleashed or let
308 out of a kennel and the fact that some dogs come running at the sound of their owner's car
309 entering the driveway or the back door opening, will all depend on the behaviour of the
310 individual dog and human as well as the type of household it lives in. Thus, for example,
311 human contact with a dog chained for a portion of the day will likely be different from
312 human contact with a dog that usually sleeps in a family member's bedroom. Possible
313 sequential pathways for bites following human-canine contact are, a) human-canine
314 contact, human-play with dog, joint human-canine play and then a play-bite, b) human-
315 canine contact, human-play with dog, joint human-canine play, canine non-play aggression
316 and then a "play" bite, c) human-canine contact, human-play with dog, canine non-play
317 aggression and then a "play" bite and d) human-canine contact, canine non-play
318 aggression and then a non-play bite (Fig. 1). As noted for other outcomes (Terry et al.,
319 2000), if each type of bite can result from the same type of intermediate human-canine
320 contact, the exposure leading to that type of human-canine contact will have the same
321 effect on each of the resulting types of bite. Consequently, no pathway leading from the

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

334 Exposures acting subsequent to human-canine contact (Fig. 1, Group B) are more
335 likely to be immediate determinants of dog bites and therefore have separate pathways to
336 bites occurring in and outside of the context of play. Consequently, associations of these
337 exposures with both types of bites are more likely to be distinct and there will be either
338 proportionately more or fewer non-play bites among exposed versus unexposed dogs. A
339 95% CI for the proportionate bite ratio which includes only values greater than one for
340 dogs which growled in the presence of visitors and strangers to the home, is consistent
341 with this expectation.

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

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

348 A limitation of this study is the use of a simple causal model which does not
349 specifically define human-canine contact for each of the examined exposures. Additionally
350 the study focussed primarily on environmental exposures felt to exert effects early in the
351 causal path of to a dog bite. Recent analyses of cases series of dog bites suggest that
352 immediately preceding the bites, a high percentage of child victims interacted, with the
353 dog, in ways which might have triggered the incidents (Kahn et al., 2003; Reisner et al.,
354 2007; Reisner et al., 2011). Thus it is possible that an investigation of the effects of more
355 proximate exposures might reveal specificity in their effects on non-play bites relative to
356 bites occurring during play. This type of investigation is particularly important as it
357 pertains to human-canine play because of its importance to the human-canine relationship
358 in some cultures (Messent, 1983; Rooney et al., 2001; Westgarth et al., 2008). In those
359 contexts, it would be important for dog owners to know which types of playful human-
360 canine interactions might lead first to canine non-play aggression and consequently result
361 in human injury.

362

363 **5. Conclusions**

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

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

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

385

386 **Acknowledgements**

387 The authors expressly acknowledge the assistance of staff of the following
388 veterinary clinics in facilitating data collection: All Creatures, All Pets, Animal Care,
389 Chang's Veterinary Clinic, JSPCA, Noah's Ark, Phoenix Veterinary Clinic, Veterinary
390 Medical (Kingston, Jamaica), Pet's Unlimited, SFSPCA and the Avenues (SF, USA).

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524 **Figure Legends**

525 **Legend for Fig. 1.**

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

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530 **Legend for Fig. 2.**

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

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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. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b	Kgn. n (%) ^b	SF n (%) ^b
<i>By exposures thought to act prior to contact</i>								
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
<i>By exposures thought to act both prior and subsequent to contact</i>								
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
<i>By exposures thought to act only subsequent to contact</i>								
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_{NP}s 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
<i>By exposures thought to act prior to contact</i>										
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
<i>By exposures thought to act prior to contact cont.</i>										
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
<i>By exposures thought to act both prior and subsequent to contact</i>										
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		
<i>By exposures thought to act only subsequent to contact</i>										
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

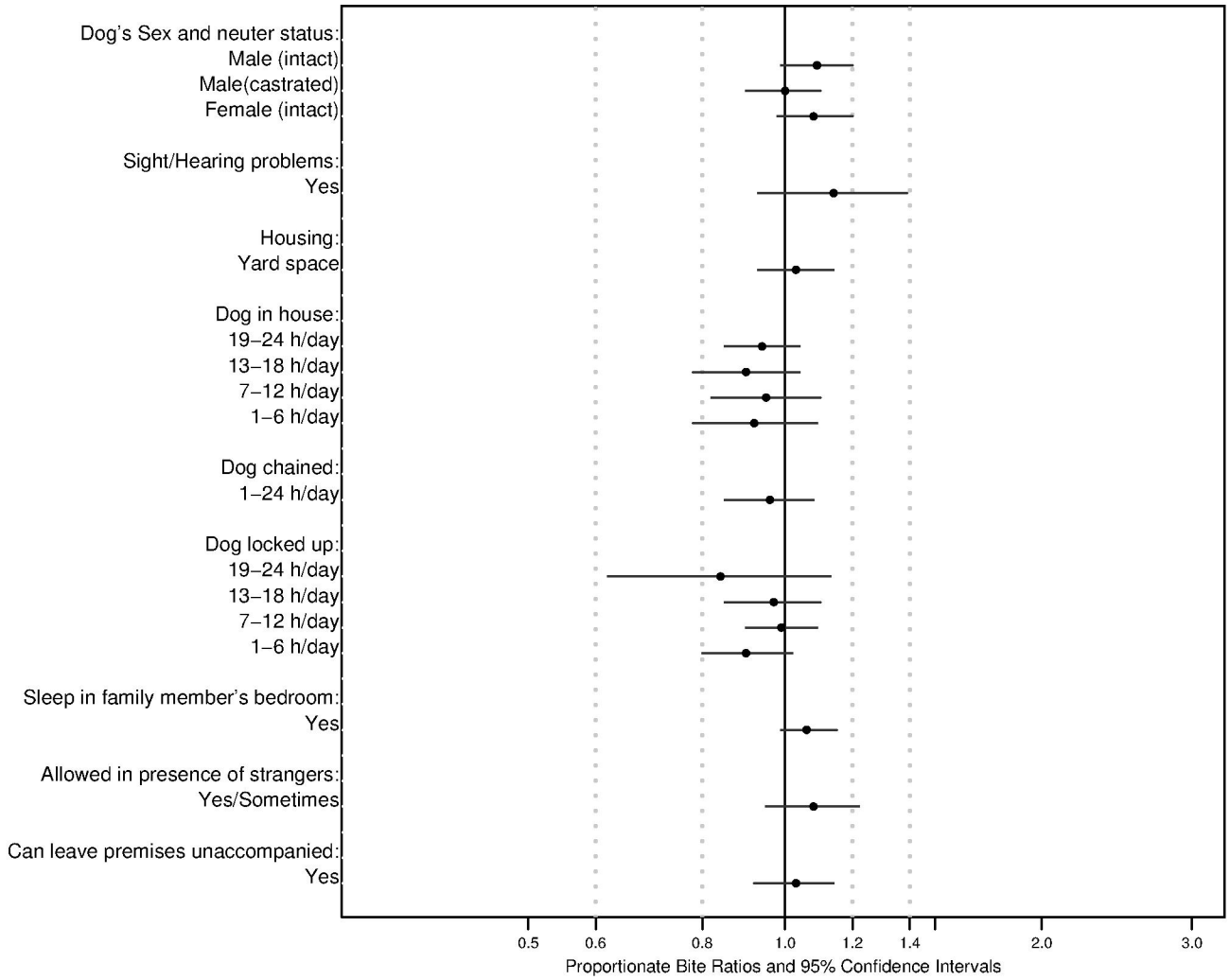
^aNumber of observations in final model = number of participants (271) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^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

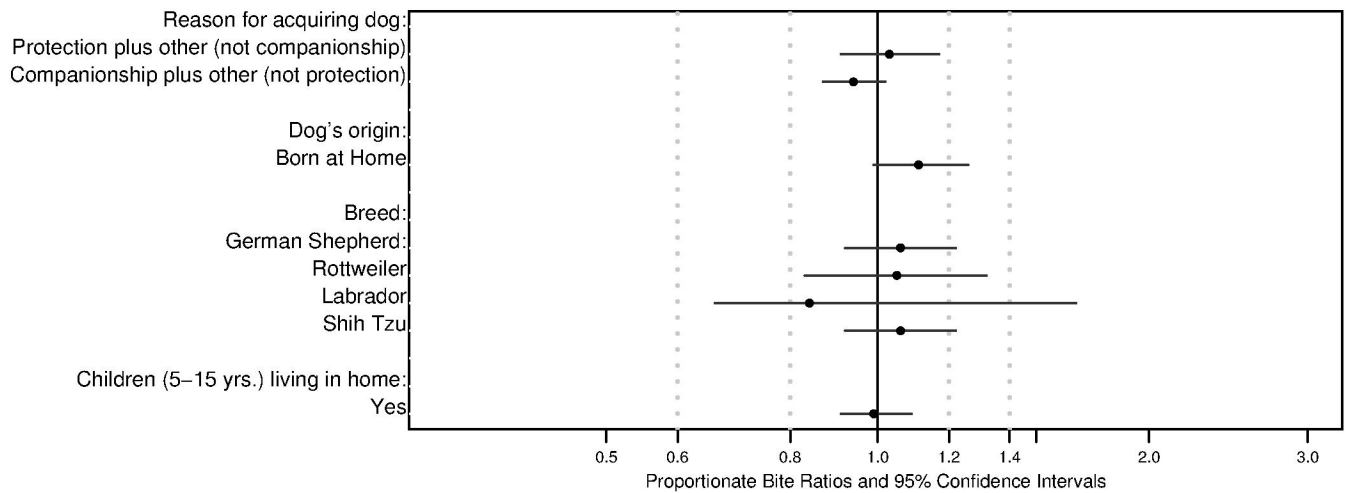
^cNumber of observations in final model = number of participants (1112) minus the number of participants with missing data for at least one variable in the necessary set of confounders

^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

