ORIGINAL RESEARCH

Exploring the relationship between socioeconomic status and dog-bite injuries through spatial analysis

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A B S T R A C T

Introduction: Despite a reported socioeconomic gradient in health, little is known about relationship between socioeconomic status (SES) and frequency of dog-bite injuries. The primary objective of this study was to compare the frequency of dog-bite injuries, using data on dog-bite injury hospitalizations (DBIH), across different SES areas in Manitoba, Canada. The secondary objective of the study was to assess if frequency and pattern of DBIHs are similar to those of non-canine bite injury hospitalizations (NCBIH) and rabies post-exposure prophylaxis (PEP). SES grouping in this study was defined through rurality and area-wide income quintile groups.
Methods: Rural and urban Manitoba neighbourhoods were ranked according to average area-level incomes into five levels (quintiles) with equal numbers of people in each income level. Prevalence was defined as the number of cases of hospitalizations (whether dog-bite injury or non-canine bite injury) or PEP reported in the years 1984–2006, divided by the total population during the same time period and expressed as the number of cases per 100 000 population per SES grouping. The 95% confidence intervals (CI) were calculated using the approach for Poisson distribution.
Results: During 1984–2006, Manitoba's prevalence (CI) of DBIH (3.19 (2.97, 3.41) per 100 000 population) was lower than prevalence of NCBIH (4.08 (3.84, 4.32)) and PEP (7.24 (6.92, 7.57)). Prevalence of DBIH was higher in rural than in urban areas (DBIH: 3.58 (3.24, 3.92) vs 2.87 (2.59, 3.15), *p*<0.01) and higher in the lowest income quintile areas than in the highest, whether rural (5.18 (4.24, 6.26) vs 3.29 (2.55, 4.17), *p*<0.0001) or urban (3.65 (2.97, 4.44) vs 2.24 (1.73, 2.87), *p*<0.01). The patterns of relationship between SES (rurality and income levels) and prevalence of NCBIH and PEP were similar to those between SES and DBIH.

Conclusions: Although only a descriptive study, the results suggest that policies for control of dog-bite injuries should be area-specific. Prevention efforts could perhaps be improved by focussing not only on families, but also on neighbourhood regions.

Introduction

An inverse relationship between socioeconomic status (SES) and health is known to exist in general[1,2]. Specifically, certain injuries are known to occur at higher rates in rural areas and in lower SES areas, whether urban or rural[3-8]. While a handful of studies exist that suggest that dog-bite injuries occur at higher rates in rural areas[9,10], very few reports have attempted to explore the relationship between lower SES and higher frequency of dog-bite injuries. Therefore, the present descriptive study was primarily conducted to explore the relationship between lower SES and higher prevalence of dog-bite injury hospitalizations (DBIH) using data from the Canadian province of Manitoba. The secondary objective of the study was to assess if pattern of DBIHs is similar to patterns of non-canine bite injury hospitalizations (NCBIH) and rabies post-exposure prophylaxis (PEP). The authors sought to study the pattern of rabies PEP, because being bitten or injured by a dog (among other terrestrial mammals) continues to be a cause for seeking rabies PEP[11-14]. The results of the secondary objective of the study will allow for a comparison of the influence of SES on the epidemiology of DBIH with that of NCBIH and PEP. Such a study would uniquely add to the existing body of world literature on dog-bite injuries and would be valuable information for understanding how to prevent severe dog-bite injuries in people, especially children.

Methods

Prevalence of DBIH, NCBIH and rabies PEP was determined for the period 1984–2006. Prevalence in this study was defined as the number of hospitalizations (whether dog-bite injury or non-canine bite injury) or PEP reported during the study period divided by the total population during the same period and expressed as the number of hospitalizations or PEP per 100 000 people[15]. A detailed description of the databases used has been previously published[10].

Briefly, hospitalization and PEP data were extracted by patient's resident address for all postal code regions of Manitoba from administrative health databases in the Population Health Research Data Repository housed at the Manitoba Centre for Health Policy at the University of Manitoba[16]. This repository contains de-identified, person-level medical records for Manitoba's population. The data are de-identified but linkable across records and across time by an encrypted health number.

All-cause hospitalizations (both inpatient and outpatient admissions) from year 1984/85, contained in the Hospital Separation Abstracts database, was searched for bite-injury hospitalizations from 1984/85 to 2006/07. Dog-bite injuries were identified using the *International Classification of Diseases* 9th and 10th revisions (clinical modification (CM) and with Canadian enhancements (CA)): ICD-9-CM-code E906.0 and ICD-10-CA code W54[17]. Animal-bite injuries were identified through E codes in ICD9 (E906.1–E906.5) and W codes in ICD10 (W53, W55, W57–W59)[17]. These codes exclude venomous reptiles, arthropods and sea animals and focus on bite injuries inflicted by several land mammals, some of which are not further identified at a species level.

Physician billing claims in the Medical Services database and the Manitoba Immunization Monitoring System (1984/85 – 2006/07) (MIMS) were searched to identify rabies post-exposure vaccine tariff codes, given as AB-post rabies vaccine 8751 and IG-rabies immune globulin 8768. Tariff codes from the past (8752, 8753, 8754, 8755) for rabies inactive human diploid vac (post exposure) 2nd–5th dose (INIT series) were also identified for analysis. Further information on physician billing claims and diagnostic codes available in the claims was reported earlier. The

Population database was accessed to provide population counts or denominator to calculate prevalence for years 1984–2006. The 95% confidence intervals (CI) were calculated using the approach for Poisson distribution[18,19]. Poisson regression coefficients for each of the studied factors along with standard errors were determined[20].

Prevalence was compared between rural and urban Manitoba[21] across five Manitoba regions (northern, mid, southern, Winnipeg and Brandon) and across income quintile areas of Manitoba. Manitoba regions and area-level SES grouping variable (eg income quintile values for Manitoba Dissemination Areas) were previously created using postal codes[22]. Manitoba neighborhoods were ranked according to average income levels into five levels (with level 1 representing the lowest quintile and level 5 representing the highest quintile) with equal numbers of people in each level of income[22]. By its nature, the income quintile variable is an aggregate-level variable, albeit at the smallest census level (Dissemination Areas) and does not represent an individual/family income per se. Because income levels differed so much between urban and rural Manitoba, separate scales were developed for urban (represented by Winnipeg and Brandon regions) and rural (represented by northern, mid and southern regions) areas of Manitoba[21,22]. Accordingly, R1 and U1 represent the lowest quintile in rural and urban areas, respectively, and R5 and U5 represent the highest quintile in rural and urban areas, respectively.

Data were accessed at the Manitoba Centre for Health Policy and analyzed using Statistical Analytical System software v9.2 (SAS Institute; http://www.sas.com)[23].

Ethics approval

The study was approved by the University of Manitoba Health Research Ethics Board and by Manitoba's Health Information Privacy Committee (HIPC) under HIPC project number 2009/2010-08.

Results

Descriptions of identified cases of DBIH and rabies PEP have been previously published[10]. Of the 1072 NCBIH,

463 (42.7%) injuries were coded 'E906.4 – Bite of non-venomous arthropod'; 392 (36.1%) injuries were coded 'E906.3 – Bite of other animal except arthropod'; and 171 (15.8%) were coded 'W55 – Bitten or struck by other mammals', and represented the three largest groups of NCBIH. Prevalence of DBIH was lower than prevalence of NCBIH and rabies PEP in Manitoba. Prevalence of DBIH, NCBIH and PEP was higher in people aged <20 years compared with people aged ≥20 years and in males compared with females (Table 1). Prevalence of all three outcomes was higher in rural than urban areas (Table 2). The β coefficient associated with rural areas relative to urban areas was highest for PEP (0.97) and higher for NCBIH (0.59) than for DBIH (0.22). While the mid- and southern regions of Manitoba demonstrated the highest prevalence of PEP (17.68 and 10.34 per 100 000 population, respectively), the northern region (6.19) had the highest prevalence of DBIH (Fig1). Prevalence of NCBIH was high in northern (5.94), mid- (6.20) and southern (5.60) regions of Manitoba. Prevalence was higher in neighborhoods with lower income quintile groups than in neighborhoods with higher income quintile groups for all three outcomes studied.

Discussion

This study has established for the first time that prevalence of DBIH is higher in areas with lower SES groups than in areas with higher SES groups. This finding holds true when rural and urban quintile areas are separately analyzed as well, not just aggregated. SES grouping in this study was defined through area-wide income quintile groups. Findings also confirmed the higher prevalence of DBIH in rural and northern (remote) regions of Canada, a pattern that was previously observed while studying fatal dog attacks in Canada[24]. In addition, the study indirectly establishes the burden of DBIH relative to the burden from other animal-bite injuries. Although the prevalence of DBIH, in general, was lower than the prevalence of NCBIH and prevalence of rabies PEP, the pattern of relationship between SES and each of the outcomes studied was similar. The results of this study were consistent with the pattern of findings in previous studies that attempted to report on the relationship between SES and dog-bite injuries[25-28].

Table 1: Prevalence of dog-bite injury hospitalizations, non-canine bite injury hospitalizations and rabies post-exposure prophylaxis in the Canadian province of Manitoba, by age and gender

Demographic factor	Total population	Years 1984–2006								
		Dog-bite injury hospitalizations			Non-canine bite injury hospitalizations			Rabies post-exposure prophylaxis		
		N	Prevalence (95% CI)	p value	N	Prevalence (95% CI)	p value	N	Prevalence (95% CI)	p value
All	26 266 540	838	3.19 (2.97, 3.41)	–	1072	4.08 (3.84, 4.32)	–	1903	7.24 (6.92, 7.57)	–
Age (years)										
<20	7 533 610	467	6.20 (5.64, 6.76)	<0.0001	365	4.84 (4.35, 5.34)	0.0001	715	9.49 (8.79, 10.19)	<0.0001
≥20	18 732 930	371	1.98 (1.78, 2.18)	–	707	3.77 (3.49, 4.05)	–	1188	6.34 (5.98, 6.70)	–
Sex										
Male	12 963 308	467	3.60 (3.27, 3.93)	0.0002	557	4.29 (3.94, 4.65)	0.088	982	7.57 (7.10, 8.05)	0.05
Female	13 303 232	371	2.79 (2.50, 3.07)	–	515	3.87 (3.54, 4.20)	–	921	6.92 (6.48, 7.37)	–

CI, confidence interval

For example, in the USA, significant negative correlation was observed between dog bites and median household income distribution[25]. Biting dogs were more likely than non-biting dogs to live in neighborhoods where the residents' median incomes were less than the county median income value[26]. In France, 21% of children with facial dog-bite injuries were reported to belong to an unfavorable social environment[27]. In the UK, children that owned dogs lived in more deprived areas than those without dogs, and deprivation increased with number of dogs owned[28]. 'Pit bull or cross' and 'bull breed' dogs were more likely to be found in more deprived areas than other dog types[28]. Pit bulls or cross or bull breeds are categorized as dangerous dogs in several jurisdictions[9,10], although there is also no universal consensus on whether some breeds are more dangerous than other breeds of dogs[29-31]. Whether the observed high prevalence is an effect of increased number and density of dogs, type of dogs, resource availability or a combination of several factors is yet to be determined. In Ireland, a higher proportion of households own pet dogs in rural districts than in urban districts[32], a finding that possibly helps to understand why dog-bite injuries are more prevalent in rural areas than in urban areas.

Limitations in interpretation of study results

Because of the aggregate nature of area-wide income quintile variable, no inferences can be made about the SES of the individuals in the study. However, because of the small area used to produce average neighborhood income levels from the census, the individual incomes would be highly correlated with the overall average income. A different kind of study design is needed to determine if individuals with lower SES backgrounds are at higher risk of hospitalizations due to bite injuries or at higher risk of PEP. Also, because the postal code is derived from patient's residential address, no inferences can be made about the location at which bites and injuries were sustained. Still, previous studies have established that most dog-bite injuries occur at home and are inflicted by owned dogs[33,34].

Despite the descriptive nature of the present study, the pattern of results suggests that a community approach to control of injuries resulting from animal bites, specifically dog bites, could include area-specific strategies. Prevention efforts could be focussed not only at levels of families as currently practised[35,36], but also at the neighborhood level in order to decrease the disproportionate burden of bite injuries in lower SES areas. Further analytical studies from different regions and from different populations may help to better understand the role of SES in dog-bite inuries and to recommend targeted, area-based policies to potentially reduce bite injuries in children. Future studies can also help to understand whether the inverse relationship between SES and bite injuries requiring hospitalizations is also observed when studying bite-injuries of all severities.

Table 2: Prevalence of dog-bite injury hospitalizations, non-canine bite injury hospitalizations and rabies post-exposure prophylaxis in the Canadian province of Manitoba, by rurality, region and income quintile areas

Area of study	Total population	Years 1984–2006								
		Dog-bite injury hospitalizations			Non-canine bite injury hospitalizations			Rabies post-exposure prophylaxis		
		N	Prevalence (95% CI)	Beta coefficient (standard error)	N	Prevalence (95% CI)	Beta coefficient (standard error)	N	Prevalence (95% CI)	Beta coefficient (standard error)
Manitoba	26 266 540	838	3.19 (2.97, 3.41)	–	1072	4.08 (3.84, 4.32)	–	1903	7.24 (6.92, 7.57)	–
Rurality										
Rural	11 908 363	426	3.58 (3.24, 3.92)**	0.22 (0.07)	645	5.42 (5.00, 5.83)****	0.60 (0.06)	1306	10.97 (10.37, 11.56)****	0.97 (0.05)
Urban†	14 358 177	412	2.87 (2.59, 3.15)	–	427	2.97 (2.69, 3.26)	–	597	4.16 (3.82, 4.49)	–
Region										
Northern	1 616 556	100	6.19 (5.03, 7.52)****	0.78 (0.11)	96	5.94 (4.81, 7.25)****	0.70 (0.11)	111	6.87 (5.65, 8.27)****	0.60 (0.10)
Mid	3 579 717	128	3.57 (2.98, 4.25)*	0.23 (0.10)	222	6.20 (5.41, 7.07)****	0.74 (0.08)	633	17.68 (16.30, 19.06)****	1.54 (0.06)
Southern	5 085 496	154	3.03 (2.57, 3.55)	0.06 (0.09)	285	5.60 (4.97, 6.29)****	0.64 (0.08)	526	10.34 (9.46, 11.23)****	1.01 (0.06)
Brandon	1 091 109	32	2.93 (2.01, 4.14)	0.03 (0.18)	30	2.75 (1.86, 3.93)	−0.07 (0.19)	70	6.41 (5.00, 8.11)****	0.53 (0.13)
Winnipeg†	14 893 662	424	2.85 (2.57, 3.12)	–	439	2.95 (2.67, 3.22)	–	563	3.78 (3.47, 4.09)	–
Income quintile area										
Rural (R; lowest to highest)										
R1	2 046 426	106	5.18 (4.24, 6.26)****	0.84 (0.16)	184	8.99 (7.74, 10.39)****	1.64 (0.16)	237	11.58 (10.15, 13.15)****	1.24 (0.12)
R2	2 037 369	75	3.68 (2.89, 4.61)**	0.49 (0.17)	145	7.12 (6.01, 8.37)****	1.40 (0.16)	314	15.41 (13.71, 17.12)****	1.52 (0.12)
R3	2 050 470	69	3.36 (2.62, 4.26)*	0.41 (0.17)	116	5.66 (4.67, 6.79)****	1.17 (0.17)	248	12.09 (10.64, 13.70)****	1.28 (0.12)
R4	2 037 713	63	3.09 (2.37, 3.96)	0.32 (0.18)	82	4.02 (3.20, 4.99)****	0.83 (0.18)	247	12.12 (10.66, 13.73)****	1.28 (0.12)
R5	2 066 450	68	3.29 (2.55, 4.17)*	0.38 (0.17)	74	3.58 (2.81, 4.50)****	0.71 (0.18)	218	10.55 (9.19, 12.05)****	1.14 (0.12)
Urban (U; lowest to highest)										
U1	2 739 894	100	3.65 (2.97, 4.44)**	0.49 (0.16)	127	4.63 (3.86, 5.52)****	0.97 (0.17)	124	4.53 (3.76, 5.40)***	0.30 (0.14)
U2	2 740 888	85	3.10 (2.48, 3.83)	0.32 (0.16)	103	3.76 (3.07, 4.56)****	0.76 (0.17)	126	4.60 (3.83, 5.47)	0.31 (0.14)
U3	2 914 882	82	2.81 (2.24, 3.49)	0.27 (0.17)	79	2.71 (2.15, 3.38)*	0.44 (0.18)	137	4.70 (3.95, 5.56)	0.33 (0.13)
U4	2 956 305	77	2.60 (2.06, 3.26)	0.15 (0.17)	65	2.20 (1.69, 2.80)	0.23 (0.19)	106	3.58 (2.94, 4.34)	0.06 (0.14)
U5†	2 851 879	64	2.24 (1.73, 2.87)	–	50	1.75 (1.30, 2.31)	–	96	3.37 (2.73, 4.11)	–
Not assigned	1 824 264	49	2.69 (1.99, 3.55)	0.18 (0.13)	47	2.58 (1.89, 3.43)		50	2.74 (2.03, 3.61)	
Rural and urban										
R1 and U1	4 786 320	206	4.30 (3.74, 4.93)****	0.47 (0.11)	311	6.49 (5.77, 7.22)****	0.95 (0.11)	361	7.54 (6.76, 8.32)*	0.17 (0.08)
R2 and U2	4 778 257	160	3.35 (2.85, 3.91)	0.22 (0.12)	248	5.19 (4.56, 5.88)****	0.72 (0.11)	440	9.21 (8.35, 10.07)****	0.37 (0.07)
R3 and U3	4 965 352	151	3.04 (2.57, 3.57)	0.12 (0.12)	195	3.93 (3.39, 4.52)****	0.44 (0.12)	385	7.75 (6.98, 8.53)**	0.19 (0.08)
R4 and U4	4 994 018	140	2.80 (2.36, 3.31)	0.04 (0.12)	147	2.94 (2.49, 3.46)	0.16 (0.12)	353	7.07 (6.33, 7.81)	0.10 (0.08)
R5 and U5†	4 918 329	132	2.68 (2.24, 3.18)	–	124	2.52 (2.09, 3.01)	–	314	6.38 (5.68, 7.09)	–
Not assigned	1 824 264	49	2.69 (1.99, 3.55)	0.18 (0.13)	47	2.58 (1.89, 3.43)		50	2.74 (2.03, 3.61)	–

† Reference group
*$p<0.05$, **$p<0.01$, ***$p<0.001$, ****$p<0.0001$
CI, confidence interval

Acknowledgements

Key: Prevalence (95% confidence interval) of dog-bite injury hospitalizations and total population during the period 1984/85 – 2005/06 are given by Manitoba regions. Hashed area represents water bodies.

Figure 1: Regions and regional differences in the prevalence of dog-bite injury hospitalizations in the Canadian province of Manitoba.

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