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SYSTEMATIC REVIEW

Scoping decades of dog evidence: a scoping review of dog bite-related sequelae

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Abstract

Objectives There has been considerable literature published focusing on various sequelae to dog bites over the last three decades. Much of the literature has focused on rabies, particularly canine rabies variant, which accounts for the majority of rabies deaths worldwide. This paper describes the complications, the pathogens, and other sequelae resulting from dog bites documented in the literature.

Methods This paper used evidence found through a scoping review which charted the published peer-reviewed and non-peer-reviewed gray literature and online information relating to dog bite incidents. Each complication or sequela was additionally assessed from the viewpoint of Canadian Indigenous, rural, and geographically remote communities, which experience a high number of dog bite incidents annually.

Synthesis Peer-reviewed literature ($N = 693$; case report, original research, and review articles) provided detailed information on specific pathogens, infections, and diseases of interest, especially rabies. However, in addition to these, the sequelae from dog bites may include moderate to severe injuries that further result in anxiety around dogs or post-traumatic stress disorder (PTSD).

Conclusions While a lot of focus in the literature is on rabies as a sequela to dog bites, the impacts of anxiety and PTSD are not as well articulated. Treatment of dog bite injuries may be standardized; however, improved collaborations between diverse health professionals (physicians, veterinarians, counseling services, animal behaviourists, and others) could be of considerable benefit in decreasing the effects of dog bites.

Résumé

Objectifs De nombreux documents ont été publiés sur diverses séquelles des morsures canines au cours des trois dernières décennies. Une grande partie de la littérature s'est concentrée sur la rage, en particulier la variante canine, qui représente la majorité des décès mondiaux par rage. Cet article décrit les complications, les maladies et d'autres séquelles résultant des morsures canines documentées dans la littérature.

Méthodes Cet examen de la portée a permis de dresser la liste de la littérature publiée et grise, et de l'information en ligne afin d'examiner les conséquences identifiées des incidents des morsures canines. Chaque complication ou séquelle a également été évaluée du point de vue des communautés autochtones, rurales et éloignées du Canada, qui subissent chaque année un nombre élevé de morsures de chien.

Synthèse La littérature évaluée par des pairs ($N = 693$; rapport de cas, travaux de recherche originaux et articles de synthèse) a fourni des informations assez détaillées sur des agents pathogènes spécifiques, des infections et des maladies d'intérêt, en particulier la rage. Cependant, en plus de celles-ci, les séquelles des morsures canines peuvent inclure des

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blessures modérées à graves qui peuvent entraîner davantage d'anxiété à propos des chiens ou des difficultés avec le stress post-traumatique (SSPT).

Conclusions Même si la littérature sur les séquelles des morsures canines se concentre beaucoup sur la rage, les effets de l'anxiété et du SSPT ne sont pas aussi bien exprimés. Bien que le traitement des blessures par morsures canines puisse être normalisé, le développement de liens entre plusieurs professionnels de la santé (les médecins, les vétérinaires, les services de conseil, les comportementalistes et d'autres professionnels de la santé) pourrait avoir l'énorme avantage de réduire les effets des morsures de chien.

Keywords Dogs · Bites · Risk factors · Epidemiology · Rabies · Bacteria · Post-traumatic stress disorder

Mots-clés Chiens · Morsures · Facteurs de risque · Épidémiologie · Rage · Bactéries · Syndrome de stress post-traumatique

Introduction

While relationships with dogs have the potential to provide a myriad of emotional and physical health benefits, risk also exists when in proximity to any animal (McNicholas et al. 2005). Most domestic animal attacks focus on dogs as the offenders, while the second most common offenders are cats (Rhea et al. 2014a). Although most interactions with companion animals are positive and healthy, having any animal in the vicinity offers the potential for aggressive encounters with or without the transmission of infectious disease.

While information on post-bite consequences is often focused solely on rabies, there are other recognized sequelae that should be considered when dog bites occur. Depending on the dog-human interaction, dog bite incidents can lead to an array of repercussions, including but not limited to wound infections, rabies, disfigurement, death, and post-traumatic stress disorder (PTSD) (Gilchrist et al. 2008; Rothe et al. 2015). In Canada, fatalities and serious dog bites often make media headlines, with an emphasis on those in Indigenous rural or geographically remote communities (Raghavan 2008).

Available literature can provide a wealth of material, albeit not always a complete compilation of evidence. This paper presents information found through a scoping review which was designed to identify relevant available information regarding a range of topics focusing on the epidemiology of dog bites, interventions to prevent dog:human aggressive behaviour, and dog population management, with a focus on First Nations, rural and remote communities in Canada (Fig. 1). While rabies, as prime sequela, provides important information for dog population control, other sequelae were also collected within the framework of the scoping methodology. As a side benefit, this paper presents the range of possible sequelae to dog bite incidents identified.

Methods

This work used a scoping review following Arksey and O'Malley's (2005) framework, with additional considerations as suggested by Landa et al. (2011) and Colquhoun et al. (2014). Two overarching research questions focused the search based on an initial scan of pre-eminent articles: (a) *What is the epidemiology surrounding dog bites?* (*Including sequelae*) and (b) *What interventions could best be used to prevent dog bites?* To maintain consistency, strict scoping review methods were constructed and executed for both peer-reviewed and gray (non-peer-reviewed) literature.

Peer-reviewed literature

As the objective was to perform a sensitive exploration of the literature, broad lists of keywords were created using five thesauri (Encarta, Roget's, Collins, Wordsmyth, and MacMillan). After consultation with librarians, an initial searching design was established, including databases, searching features (i.e., keyword requirements, wildcard functions, etc.) and user-friendly platforms. Search strings were established and run through nine selected databases (PubMed, MedLine, Web of Science, Biosis, Embase, OIE Database, CAB Abstracts, Agricola, and Animal Behavior) to obtain references containing elements of the search strings within the title, abstract, or keyword fields. In addition, to exhaustively collect all relevant citations, reference lists of key literature and references, existing networks and websites, relevant organizations, and conference proceedings were scrutinized to enhance procurement of documents.

A minimum of two search runs were performed at least one day apart per database, and requiring a search "hit" of total retrieved articles to be within 0.1% to ensure statistical reliability and reproducibility. Once a stable set of references was obtained from a database, references were saved into EndNote X6 (Thomson Reuters, New York, NY, USA) prior to being uploaded into DistillerSR (Evidence Partners, Ottawa, Canada). Deduplication based on citation was completed using Endnote, DistillerSR, and Microsoft Excel 2010. Title, abstract, and article level screening was also completed in DistillerSR and then loaded into Excel for more comprehensive topic level analysis.

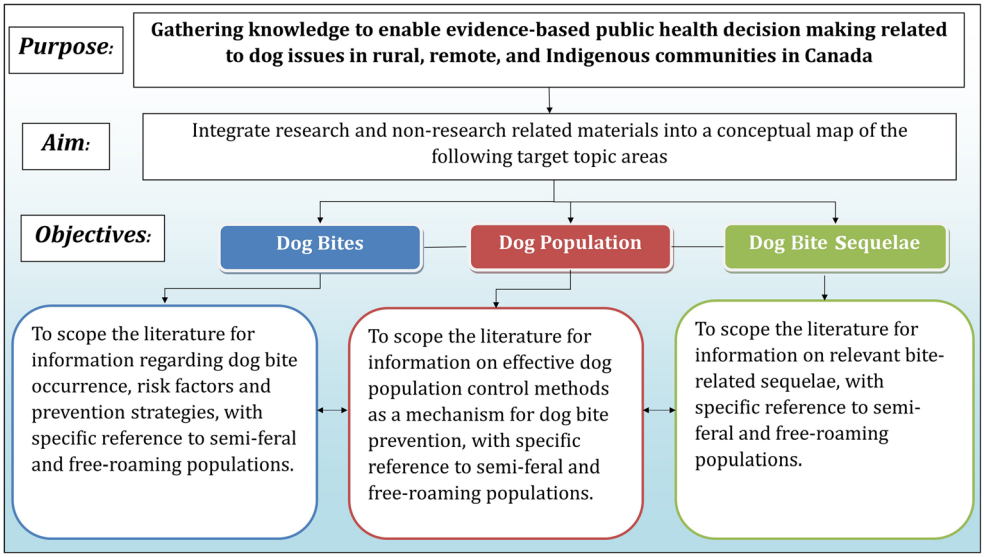

Fig. 1 Overarching purpose, aim, and specific objectives for the scoping review process

Title screening was performed by one reviewer using basic inclusion criteria determining broad relevance to the study purpose. Abstract, article, and topic screening levels required a minimum of two team members to assess inclusion and exclusion criteria. Articles required the agreement of two observers to be excluded; for disagreements, articles were reassessed for consensus. Relevant articles published (and available) between January 1, 1985, and December 15, 2015, in English, French, Spanish, Portuguese, or German were included. Abstract conference proceedings were excluded from peer-reviewed literature unless they provided sufficient data. Studies were not excluded due to study design, methodological rigour, or methods of data analysis. All articles were kept for reference but only used in the scoping review assessment if they were original research, case reports, or topically relevant literature reviews (Fig. 2).

For all relevant articles, key topics and findings were summarized by a minimum of two reviewers (Fig. 2). These articles and their corresponding data were separated into study types, and were thoroughly assessed for subject matter, themes, novel information, and evidence to meet one of the three primary objectives. In situations of disagreement, articles were discussed to reach consensus. It was noted that a significant number of the articles discussing dog bites were directed toward rabies elimination; therefore, a quick inspection was completed to determine the number of articles focused specifically on rabies.

Synthesis and summation

As the initial research questions were extensive in design, breadth, and scope, a large volume of literature was amassed. Findings were categorized into sections and topic areas based on themes likely to be relevant for policy makers and community advisors, following which results were closely scrutinized. More detail to the methods can be found in Dhillon (2016).

Results and discussion

A total of 1093 peer-reviewed journal articles were identified in the overall scoping review (after article and type screening). A total of 693 of 1093 discussed or mentioned dog bite-related sequelae (Fig. 2), of which 61% (420/693) focused on rabies. All case reports ($N = 197$) focused on or mentioned post-bite sequelae, ranging from injury to infections to death (only 23%, 46/197 focused on rabies). Many review articles focused on dog-bite sequelae (95%, 160/168; 58%, 97/168 focused on rabies). Approximately 60% (365/606) of original research articles mentioned or discussed sequelae, with 3 articles focusing specifically on PTSD and 11 detailing dog bite-related fatalities.

Overall complications of dog bites

In 1994 in the United States, approximately 799,700 reported dog bite injuries/year required hospital medical interventions, up from 585,500 in a previous survey in 1986 (Sacks et al. 1996a). Almost 10 years later, an estimated 885,000 dog bites/year required hospital medical attention (Gilchrist et al. 2008). However, taking the national population increase into consideration, the risk of medically treated bites remained stable (3 bites/1000) between surveys (Gilchrist et al. 2008; Sacks et al. 1996b). A study based on national injury surveillance data estimated that 368,245 bites/year required emergency visits (MMWR C 2003), an incidence risk of 1.29 emergency dog bite visits/100,000 population, which is similar to a previous study from a decade earlier (Weiss et al. 1998).

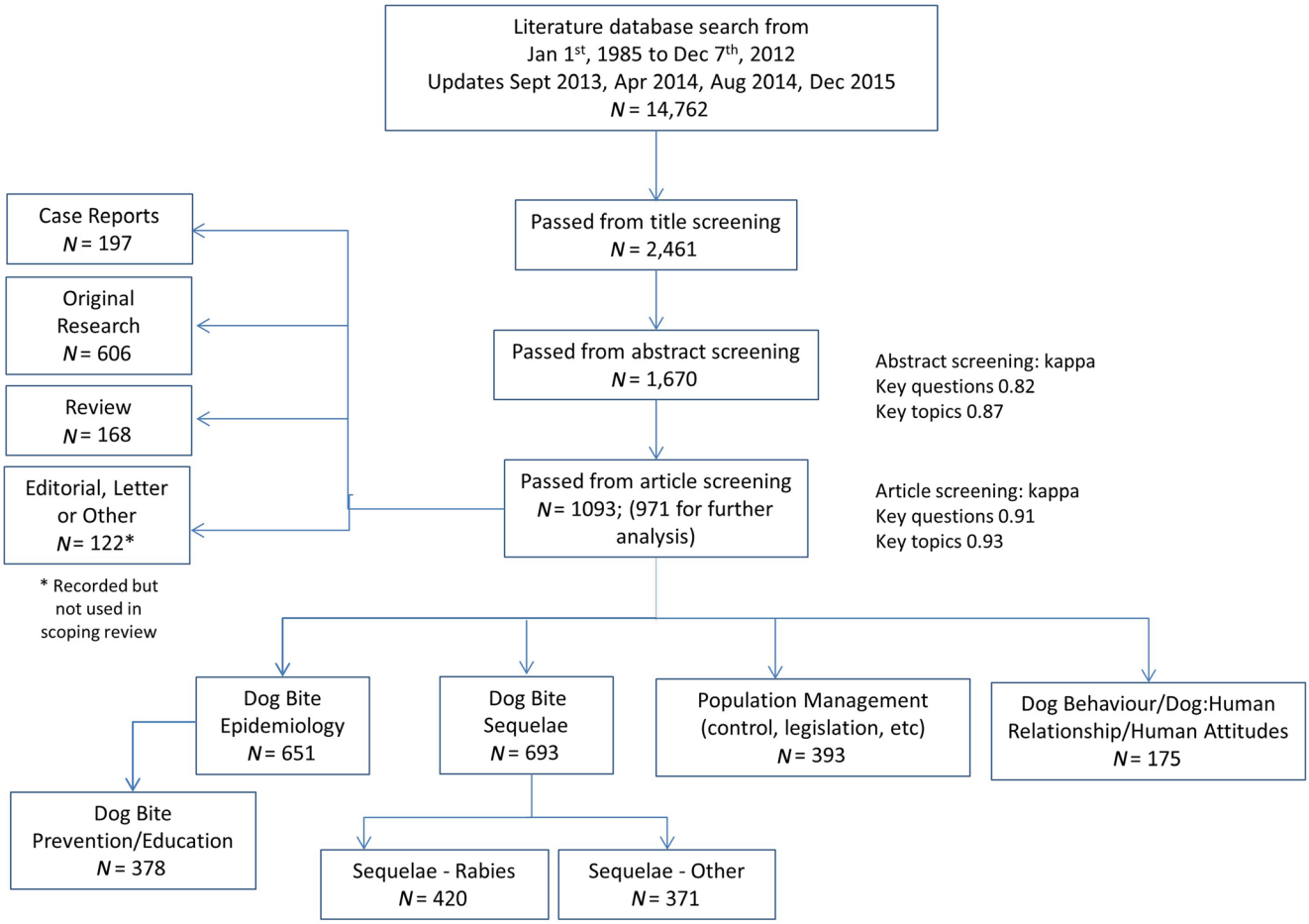

Fig. 2 Final flow of peer-reviewed material through the scoping review process to topic screening, as of December 2015

While for most reported dog bite incidents treatment is on an out-patient basis, the proportion of hospitalized bite victims can be as high as 28%, especially when bites occur in children (Bernardo et al. 2000; Daniels et al. 2009; Rhea et al. 2014b). In fact, Ozanne-Smith et al. (2001) reported 56.8% of children aged 0 to 9 years were hospitalized. Lang and Klassen (2005) described a hospitalization risk of 2.3 hospitalizations/100,000 population in Edmonton, Alberta, similar to a California-based study on all age groups of 2.6 hospitalizations/100,000 population (Feldman et al. 2004). Comparable estimates are reported for children (< 20 years), general state populations and the non-native Alaskan population (Bjork et al. 2013; Day et al. 2007; Castrodale 2007). The hospitalization risk for Alaskan Native and American Indian children was 1.7 to 2 times greater than for their non-native counterparts across the US, while across all age groups the Alaskan native risk was 3 times greater than that for their non-native Alaskan counterparts (Bjork et al. 2013; Castrodale 2007). The Indigenous Alaskan risk was significantly lower than the hospitalization risk of 65 per 100,000 population that was reported on the Rosebud reservation (Russell et al. 2001). No data for Canadian Indigenous populations were available in the literature.

Injuries resulting in hospitalization or death were often attributed to larger breeds of dogs or breed types such as pit bulls (Bini et al. 2011; Brogan et al. 1995; Shields et al. 2009); however, Daniels et al. (2009) reported only 28% of hospitalized cases reported breed, a common feature of other papers as well (Castrodale 2007; Morales et al. 2011). Most recorded dog-related incidents result in a single-bite wound, but severe mauling can result in multiple wounds (Lone et al. 2014; Schalamon et al. 2006). Daniels et al. (2009) and Thompson (1997) found that attacks on young children are more often to the head and neck, with death perhaps as a result of damage to vital vessels and the child's fragile skull structure. Brogan et al. (1995) identified three fatal pediatric cases, all of which had multiple, extensive injuries including intracranial trauma. In addition, likely due to children's smaller size or capacity to respond to the circumstances of the bite, the majority sustain deep wounds rather than superficial scratches or lacerations (Daniels et al. 2009; Schalamon et al. 2006). Older children and adults were more

commonly bitten on the extremities; either the hands or lower limbs (Knobel et al. 2005; Hon et al. 2007; Garcia 1997; Alabi et al. 2014; Maragliano et al. 2007; Sacks et al. 2000). Bite locations are key considerations for disease transmission and clinical progression.

Of great importance is whether a dog bite or attack ends in a fatality. Sacks et al. (1989) assessed dog bite fatalities in the US between 1979 and 1998, and concluded an estimated risk of 6.7 dog bite deaths/100 million population per year. During the next two decades, this annual risk remained steady at 7.1 deaths/100 million population (Sacks et al. 1996b; Langley 2009). While Alaska reported one of the highest dog bite incidences and hospitalization risk of all the other states, it also reported the highest death risk, particularly involving Alaskan natives (Castrodale 2007; Langley 2009; Dalton et al. 1988). When assessing fatal dog incidents in the US, 4 out of 5 publications reported most attacks involved only one dog (Sacks et al. 1996b; Shields et al. 2009; Sacks et al. 1989; Patronek et al. 2013; Centers for Disease Control and Prevention 1997). However, serious reported dog bite injuries or fatalities in Canada, specifically in rural or geographically remote areas, were more commonly associated with multiple dogs exhibiting pack behaviour (Raghavan 2008). Additional demographic differences exist concerning dog-related fatalities in the US and Canada; in Canada, fewer fatalities occurred on average per year, and more fatalities occurred in remote or rural areas, specifically on First Nations land, often involving multiple free-roaming dogs (FRD) (Raghavan 2008).

Sequelae: rabies

With readily available access to post-exposure rabies prophylaxis in most industrialized countries, the primary dog bite-related diseases are bacterial wound infections. Particularly, canine rabies vaccinations have dramatically reduced or even eliminated the prevalence of the canine rabies variant (main variant responsible for human rabies deaths worldwide) in many countries (Lembo et al. 2010, 2011; Yin et al. 2013). In these regions, canine and human interactions with wildlife rabies reservoirs affected by non-canine rabies variants or travel abroad to countries with the canine rabies variant are more likely to be the source of rabies exposure (Table 1) (Lembo et al. 2010; Hampson et al. 2009). This is in sharp contrast to other nations with lower levels of vaccination coverage for canine rabies, less access to adequate post-exposure rabies prophylaxis, and/or higher numbers of FRDs (Table 1) (Cleaveland 2003; Cleaveland et al. 2007, 2006; Sudarshan and Narayana 2010; Zinsstag 2013; Zinsstag et al. 2009, 2007). In these areas, public apprehension regarding rabies generally focused on FRDs as the exposure vector (Suzuki et al. 2008). Given most human rabies-related deaths occur in Africa and Asia (Gsell et al. 2012; Adedeji and Okonko 2010), it was often suggested that a dog population management system which incorporates broad-reaching vaccination campaigns could dramatically transform the global level of canine variant-associated rabies (Lembo et al. 2011; Franka et al. 2013; Rupprecht and Kuzmin 2015; Tenzin et al. 2015; Mustiana et al. 2015).

While Canada rarely has clinical human rabies cases, several rabies variants remain endemic: the bat variant across Canada, racoon variant in eastern Canada, skunk variant in western Canada, and arctic fox variant in the north (Aenishaenslin et al. 2014; Goodwin et al. 2002). Dogs exposed to rabid wildlife may become the means of human exposure to the wildlife variants, particularly in northern, rural, or remote locations. Dog rabies vaccination in Canada is performed exclusively through the services of a veterinarian, a service which is not always available in northern, rural, or geographically remote communities. A study in Ottawa-Carleton, an urban location with ample veterinary services, revealed that 95% of registered dogs were vaccinated (Goodwin et al. 2002). Comparatively, in the Wellington-Dufferin-Guelph region (encompassing both urban and rural homes), only 58.5% of dogs involved in biting incidents had been vaccinated for rabies (Bottoms et al. 2014). Given that in many Indigenous communities across Canada there are a considerable number of unvaccinated FRDs, there is a higher possibility of exposure if active rabies transmission is present in wildlife.

Although canine rabies has a fairly low basic reproductive rate (Hampson et al. 2009), elevated levels of rabies within specific reservoirs, higher dog densities, and increased frequency of dog:human interaction elevate the risk of transmission (Knobel et al. 2005; Kitala et al. 2002). In addition, several authors indicated that while dog bites with potential for rabies exposure appear to disproportionately target children (Abubakar and Bakari 2012; Davlin and Vonville 2012), deaths due to rabies in countries like China disproportionately affect middle-aged men, particularly rural farmers (Song et al. 2014). Clearly, increasing the awareness of and access to post-exposure treatment for all ages is needed. In Canada, bites (as defined by the World Health Organization as exposure category 2 and 3), particularly those occurring in unprovoked situations where the dog, particularly free-roaming, is not available for assessment, should be treated with caution as they pose a greater risk for rabies exposure (Canada 2016).

Sequelae: bacterial infections

Approximately 3–30% of dog bite cases result in severe infections (Cummings 1994; Lewis and Stiles 1995; Talan et al. 1999). Given that severe infections and deaths due to dog bites are typically investigated, it can be more positively surmised that severe bacterial sequelae are uncommon. Since dog bites

Table 1 Principal** human rabies vectors (excluding bats) by region (and country) as identified in the scoping review process

Region	Countries[a] with studies identified in scoping review	Principal vector discussed
Africa (excluding North Africa)	Angola; Cameroon; Central African Republic; Chad; Ethiopia; French Guinea; Guinea; Ivory Coast; Kenya; Madagascar; Malawi; Mali; Mozambique; Nigeria; Senegal; Sierra Leone; South Africa; Tanzania; Uganda; Zimbabwe	Dogs
South and East Asia and Pacific	Bangladesh; Bhutan; Bosnia; Cambodia; China; East Timor; India; Indonesia; Kashmir; Philippines; Sri Lanka; Thailand; Vietnam	Dogs
	Japan;	Travel abroad
Oceania	Australia; New Zealand	Travel abroad
Europe	Austria; UK; France; Germany; Italy; Lithuania; Luxembourg; Poland; Portugal; Romania; Slovenia;	Terrestrial mammals[b]; travel abroad
	Spain; Turkey;	Dogs
Latin America and the Caribbean	Argentina; Bolivia; Brazil; Chile; Grenada; Haiti; Mexico; Puerto Rico;	Dogs; terrestrial animals[b];
Middle East and North Africa	Egypt; Iran; Lebanon; Morocco; Nepal; Pakistan; Tunisia	Dogs
	Israel;	Dogs; travel abroad
North America	Canada; USA;	Terrestrial mammals[b]; travel abroad

**The principle vector discussed in the journal article(s) is presented even though this may no longer be the current vector in the specific country or region

[a] Areas currently (2018) considered to be free of rabies (excluding bats): Antarctica, Austria, Australia, Belgium, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Papua New Guinea, Portugal, Singapore, Spain, Sweden, Switzerland, UK, Hong Kong Islands, the Mediterranean Islands, Bahamas, Fiji, Jamaica, and other islands. For more information visit: http://www.who.int/rabies/en/

[b] Domestic animals may become rabid by exposure to terrestrial mammals, thus creating a secondary opportunity for human exposure to wildlife rabies variants

in general are under-reported, true dog bite-related disease transmission is likely lower than the reported literature would seem to indicate.

More than 100 species of bacteria have been isolated from bacterial infections of dog bites (Table 2), suggesting that most oral flora of dogs have the potential to be pathogenic. Infected wounds tend to present as polymicrobial, with combinations of aerobic and anaerobic bacteria present (Talan et al. 1999; Abrahamian and Goldstein 2011). While case reports are often skewed toward novel findings or oddities, based on review articles it appears that the top three pathogen groups are *Pasteurella*, *Staphylococcus*, and *Streptococcus* (Talan et al. 1999; Abrahamian and Goldstein 2011; Goldstein 1989). It is important to note that some of the bacterial species found in dog bite wounds could originate from the skin of the person bitten, seeded in the wound inflicted by the dog but not from the dog's oral flora specifically (Abrahamian and Goldstein 2011; Oehler et al. 2009). However, studies specifically assessing canine oral flora were not included in this scoping review.

In this scoping review, 26% (52/197) of all case reports and 59% (52/88) of the case reports specifically focusing on bacterial agents focused on *Capnocytophaga canimorsus*. Interestingly, Talan et al. (1999) suggested only 2% (1/50) of dog bite wounds contained *Capnocytophaga spp.* Pers et al. (1996) reviewed 39 cases of the relatively deadly pathogen, previously called CDC group DF-2. *Capnocytophaga* has a reported predilection for adult asplenic, arteriosclerotic heart disease, or alcoholic patients; however, apparently healthy individuals may also become infected. The main reported transmission routes were dog bites, licking of wounds by dogs or dog owners with no reported wounds (Pers et al. 1996). This pathogen is considered susceptible to penicillin treatment; however, the authors warned that it can develop into a septicemia even in negligible wounds that do not appear to require treatment.

Talan et al. (1999) found that infected wounds were mostly purulent without abscess formation, followed by non-purulent wounds characterized by cellulitis, lymphangitis, or both. Infection, characterized by frequency and spectrum, was similar in bites presenting at less than 8 h after event compared to more than 12 h after event (Goldstein 1989). Many patients reportedly performed some sort of self-administered topical therapy such as washing the wound prior to attending a clinic, which may influence the pathogen frequency and distribution within wounds (Goldstein 1989). In some instances, initial lack of treatment (either due to patient reluctance to seek care, lack of resources, or physician inexperience) results in severe disfigurement or mortality (Abrahamian and Goldstein 2011; Oehler et al. 2009; Chhabra and Ichhpujani 2003; Chhabra et al. 2015; Morgan et al. 1995). Other than differences in access to treatment, Indigenous residents in Canada do not appear to be at increased risk over other ethnic groups for developing post-bite infections.

Table 2 Comprehensive list of bacteria (and a few fungi) isolated from dog bite wounds

Bacteria	Previously known as (~ also valid nomenclature)
Acinetobacter spp Baumanii (*wolfi*)	*A. baumanii = Acinetobacter calcoaceticus var anitratus*
Actinobacillus spp (*actinomycetemcomitans*)	*~ Aggregatibacter actinomycetemcomitans*
Actinomyces spp (*neuii* (*subspp anitratus*), *viscosus*)	
Aeromonas hydrophilic	
Bacillus spp (*circulans*, *firmus*, *subtilis*)	
Bacteriodes spp (*ovatus*, *pyogenes*, *tectus*, *uniformis*)	*Bacteroides ovatus ~ B. fragilis subsp ovatus*
Bergeyella zoohelcum	*Weeksella zoohelcum*, *CDC group II-j*
Brevibacterium spp	
Brevundimonas diminuta	*Pseudomonas diminuta*
Campylobacter spp (*gracilis*, *ureolyticus*) (*curvus*)	*Bacteroides spp* (*gracilis*, *ureolyticus*) *Wolinella curvus*
Capnocytophaga spp (*canimorsus*, *cynodegmi*, *ochracea*)	*C. canimorsus = CDC group Dysgonic Fermenter* (*DF-2*)
CDC group Non-oxidiser 1 (*NO-1*)	
Chromobacterium spp.	
Citrobacter spp (*amalonaticus*, *freundii*, *koseri*)	
Clostridium spp (*perfringens*, *tetani*)	
Corynebacterium spp (*afermentans*, *aquaticum*, *auriscanis*, *canis sp. nov.*, *freiburgense jeikeium*, *minutissimum*, *pseudodiphtheriticum*)	*C. aquaticum = Leifsonia aquaticum*
Dermabacter hominis	
Diphtheroids (*Erysipelothrix rhusiopathiae*, *Erysipelothrix insidiosa*)	
Eikenella corrodens	
Enterobacteriaceae spp (*cloacae*)	
Enterococcus spp (*Non-group D*, *avium*, *durans*, *faecalis*, *malodoratus*)	
Escherichia coli	
Eubacterium spp (*plautii*)	
Filifactor alocis	*Fusobacterium alocis*
Flavobacterium spp (*brevis*)	*Flavobacterium CDC Group IIa; Empedobacter brevis*
Flavimonas oryzihabitans	
Frederiksenia canicola	
Fusobacterium spp (*canifelium*, *gonidiaformans*, *necrophorum*, *nucleatum*, *russii*)	
Gemella morbillorum	*Streptococcus morbillorum*
Haemophilus spp (*aphrophilus*)	*Hemophilus aphrophilus = CDC group HB-2*
Klebsiella spp (*oxytoca*, *pneumoniae*)	
Lactobacillus spp (*jensenii*, *lactis*)	
Leptotrichia spp (*bacillus*)	
Micrococcus spp (*lylae*)	
Moraxella spp (*catarrhalis*, *osloensis*, *phenylpyruvica*)	*M. osloensis = M. duplex*, *Mima polymorpha var oxidans* *N. weaverii = CDC group M-5*
Mycobacterium kansasii	
Neisseria spp (*animaloris*, *canis*, *meningitidis*, *subflava*, *weaverii*, *zoodegmatis*)	*N. animaloris = CDC group Eugonic Fermenter* (*EF*)*-4a* *N. weaverii = CDC group M-5* *N. zoodegmatis = CDC group* (*EF*)*-4b*
Oerskovia spp	
Pasturella spp (*canis*, *dagmatis*, *multocida* (*subsp gallicida*, *subsp multocida*, *subsp septica*), *stomatis*)	*~ P. gallicida*, *P. septica*
Pediococcus damnosus	
Peptostreptococcus spp (*anaerobius*, *asaccharolyticus*, *canis*, *magnus*, *prevotti*)	*~ Peptococcus spp* (*asaccharolyticus*, *magnus*, *prevotti*) *P. magnus = Diplococcus magnus* *P. prevotti = Micrococcus prevotti* *P. gulae ~ P. gingivalis* *P. salivosa ~ P. macacae*

Table 2 (continued)

Bacteria	Previously known as (~ also valid nomenclature)
Porphyromonas spp (*cangingivalis*, *canoris*, *cansulci*, *circumdentaria*, *gulae*),(*asaccharolytica*, *endodontalis*, *gingivalis*, *levii-like*, *macacae*, *salivosa*)	~ *Bacteroides spp* (*asaccharolyticus*, *endodontalis*, *gingivalis*, *levii*, *macacae*, *salivosus*)
Prevotella spp (*bivia*, *buccae*, *denticola*, *heparinolytica*, *intermedia*, *melaninogenica*, *zoogleoformans*)	~ *Bacteroides spp* (*bivia*, *buccae*, *denticola*, *heparinolyticus*, *intermedius*, *melaninogenicus*, *zoogleoformans*)
P. stercoris	*B. fragilis*
Propionibacterium spp (*acidi-propionicus*, *acnes*, *freudenreichii*, *granulosum*)	
Proteus mirabilis	
Pseudomonas spp (*aeruginosa*, *fluorescens*, *vesicularis*)	*P. aeruginosa* = *Bacterium aeruginosa*
Spirilium spp (*minor*)	
Staphylococcus spp (*aureus* (& *MRSA*), *auricularis*, *cohnii*, *delphini*, *epidermidis*, *intermedius*, *pseudintermedius*, *saprophyticus*, *warneri*, *xylosus*)	~ *Aurococcus spp*, *Micrococcus spp Staph warneri* = *Staph hominis*
Stenotrophomonas maltophilia	
Stomatococcus mucilaginosus	
Streptobacillus moniliformis	*Haverhillia multiformis*
Streptococcus spp α,β and γ-*hemolytic* (*agalactiae*, *anginosus*, *constellatus*, *dysgalactiae*, *equinus*, *gordonii*, *intermedius*, *mitis*, *mutans*, *pyogenes*)	*Strep gordonii* = *Strep sanguis*
Tannerlla forsythia	*Bacteroides forsythia*
Veillonella spp (*parvula*)	
*Rare Oddities noted (including a few fungi)	*Bartonella vinsonii*, *Blastomyces dermatitidis*, *Brucella canis*, *Mycobacterium fortuitum*, *Paeceilomyces lilacinus*, *Pseudallescheria boydii*, *Reimesella spp*

While potentially not exhaustive, the list of microbes was compiled by compiling those mentioned in articles assessed in the scoping review (case reports, original research, and reviews) (Talan et al. 1999; Abrahamian and Goldstein 2011; Smith et al. 2000). Some bacteria were not capable of being identified past the genus level

Sequelae: PTSD and other manifestations of fear or anxiety

While dramatic long-term effects of dog bites (such as permanent scarring and disfigurement, infection, and pain) are clearly visible, other sequelae such as post-traumatic stress disorder, emotional distress and anxiety (due to embarrassment of scars, increased fear of dogs or unknown situations, etc.), nightmares, and economic costs (time lost from work or school, medications, medical equipment, etc.) are often overlooked (Dixon et al. 2012; Chomel and Trotignon 1992; Ji et al. 2010). Boat et al. (2012) found that in more than 70% of cases, concerned parents described the development of new behaviours within one month of incident, such as fearing and avoiding dogs, and separation anxiety in their children, but also as benign as playing with toys differently. The majority of parents also developed feelings of guilt, anger, or anxiety due to the incident (Boat et al. 2012). According to Peters et al. (2004), more than 50% of children showed evidence of complete or partial PTSD (formal evaluation) one month after sustaining injuries from an aggressive dog:human encounter. Ji et al. (2010) found that 5% (19/358) of animal bite victims developed PTSD within three months of initial presentation at the emergency department, half of those who were showing symptoms of acute stress disorder at initial presentation. While there was no association between age or gender and PTSD development, there was an association between wound severity and PTSD development (24% of severely injured compared to 0.4% of mildly injured) (Ji et al. 2010). There were no studies assessing how long these symptoms persisted for nor what factors favoured the development of abnormal behaviours post-incident.

Overall, it is clear that children develop PTSD symptoms from a variety of frightening experiences, for which it is suggested that their development can be mediated by maternal factors, specifically supportiveness (Boat et al. 2012; Peters et al. 2004; Rossman et al. 1997). Rossman et al. (1997) compared children aged 4 to 9 years old with different groups of stressors: mild stress such as death of pet or rejection at school, single occurrence dog attacks, and parent violence such as physical or sexual abuse or neglect. Within the dog attack group, although boys were found to report more PTSD symptoms than girls, parents thought the girls had higher symptom levels, and overall, younger children were at higher risk of

PTSD symptomology. Again, there is no evidence in the literature that Indigenous residents in Canada would be at an increased risk of developing fear-induced anxieties as compared to other ethnic groups; however, there may be fewer social supports available for victims in northern communities.

Specific treatments for dog bite-related sequelae

With the wide range of potential bacteria causing infection, lengthy incubation (a minimum of 7–10 days) within both aerobic and anaerobic cultures is recommended for culture and sensitivity testing; thus, penicillins with the addition of clavulanate (potassium) or doxycycline are currently recommended as initial treatment (Chhabra and Ichhpujani 2003; Talan et al. 1998; Presutti 1997, 2001; Stevens et al. 2005). However, culturing wounds has not been found to be predictive of subsequent severe post-bite infections. Based on a meta-analysis of prophylactic administration of antibiotics for dog bite wound infections, a reduced risk of infection of 0.56 (95% CI, 0.38 to 0.82) was identified for those given antibiotics versus those not given any prior to observable infection (Cummings 1994). Yet in other controlled trials, meta-analyses and retrospective reviews, there is both evidence for and against the use of antibiotic prophylaxis; primarily, supporting evidence exists for use in high risk patients (Sabhaney and Goldman 2012). Cheng et al. (2014) used a meta-analysis technique to show that primary wound closure did not increase the incidence of wound infection. Dire et al. (1994) concluded that wounds that required debridement, full thickness wounds, or those in older patients and females were at higher risk of infection. Thus, the basics of treatment are reported to include wound irrigation, debridement, and consideration for antimicrobial therapy (pre-emptively or in response to infection, particularly in high risk patients) (Dire 1992; Fleisher 1999; Griego et al. 1995; McDermitt et al. 2002; Smith et al. 2000). McDermitt et al. (2002) provided a summary table of the selected antibiotics reportedly effective against common dog bite pathogens (based on susceptibility by pathogen).

Appropriate wound care includes prophylaxis for tetanus and rabies (Griego et al. 1995; McDermitt et al. 2002). While tetanus following bites from any species is extremely rare, a single case study did document a fatal case of generalized tetanus (*Clostridium tetani*) following a dog bite (Radjou et al. 2012). It was concluded that the source was environmental but recommended that tetanus prophylaxis be considered even for atypical situations, such as dog bite cases. Rabies prophylaxis, on the other hand, was the most common topic of dog bite management articles, even in countries free of the canine variant, such as Canada. Post-exposure prophylaxis, if given appropriately, is highly effective against the development of clinical rabies (Mshelbwala et al. 2014; Meslin and Briggs 2013; Amlan et al. 2005; De Benedictis et al. 2012; Fayaz et al. 2011; Frias et al. 2011; Hampson et al. 2008; John and Patnaik 2005; Quiambao et al. 2008). At a minimum, proper wound management should include irrigation of the wound, particularly with soap or an iodine solution, and an assessment of the risk of rabies transmission (Griego et al. 1995; McDermitt et al. 2002).

Access to both human health and veterinary services within each community would be the ideal situation; however, this is not a common feature for Indigenous, rural, or geographically remote communities in Canada (Schurer et al. 2015). Access to services allows for the best treatment of dog bite victims, as well as characterization of the rabies status of the dog involved. Cooperation across health disciplines, including counseling services, may be especially important with severe injuries or death, as the repercussions extend beyond the dog bite victim to the entire community (Schurer et al. 2015). In France, when a dog bites an individual, regardless of vaccination status or circumstances of the bite incident, the dog is required to be seen by a veterinarian at least three times within a 15-day period (Chomel and Trotignon 1992). While specific visitation with a veterinarian may not be possible in some communities, implementation of similar requirements to see an animal behaviourist or animal trainer could prove useful in some situations. Development of connections between health providers, animal behaviourists, and other professionals could be of huge benefit in the face of growing concerns over dog bites in communities in Canada.

Conclusions

Currently, most of the literature available pertaining to complications or sequelae of dog bites is related either to controlling, preventing, or treating rabies within dog (and human) populations, or the surgical and medical treatments of dog bite victims. Given all the possible sequelae and repercussions resulting from a dog bite, it is critical that community members be encouraged to report and seek medical attention for any injury sustained that breaks the skin. Although remote locations (northern, remote, Indigenous, or generally communities without resources) may not have the means of treating complicated injuries, initial treatment (such as wound irrigation or cleaning with soap) can begin, and should the circumstances merit it, the victim can be moved to a larger medical centre. In addition, timely medical examination ensures that post-exposure prophylaxis is initiated when patients may be at risk for diseases such as rabies. While dramatic long-term impacts of dog bites such as permanent scarring and disfigurement, infection and pain are important, other sequelae such as post-traumatic stress or anxiety and economic costs should not be overlooked. While the development of sequelae is not associated specifically with ethnicity, there may be factors present within the cultural or social environment that

predispose ethnic groups to experience these outcomes more often. Dog bites are a national concern that should bring together multiple health professionals (physicians, veterinarians, counseling services, and animal behaviourists) to work toward the common "one health" goal of decreasing bites and their side effects.

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