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Manuscript Title:
Dog-bites, rabies and One Health:
Towards improved coordination in research, policy and practice

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Abstract

Dog-bites and rabies are neglected problems worldwide, notwithstanding recent efforts to raise awareness and to consolidate preventive action. As problems, dog-bites and rabies are entangled with one another, and both align with the concept of One Health. This concept emphasizes interdependence between humans and non-human species in complex socio-ecological systems. Despite intuitive appeal, One Health applications and critiques remain under-developed with respect to social science and social justice. In this article, we report on an ethnographic case-study of policies on dog bites and rabies, with a focus on Calgary, Alberta, Canada, which is widely recognized as a leader in animal-control policies. The fieldwork took place between 2013 and 2016. Our analysis suggests that current policies on rabies prevention may come at the expense of a 'bigger picture' for One Health. In that 'bigger picture,' support is needed to enhance coordination between animal-control and public-health policies. Such coordination has direct relevance for the well-being of children, not least Indigenous children.

Keywords:

Canada; rabies; injuries; health promotion; dogs; medical anthropology; veterinary medicine; criminology

Introduction

In this article, we point to a need for inter-sectoral and multi-jurisdictional coordination with respect to rabies and dog-bites. In doing so, we build on the observation that the social sciences remain under-represented in the One Health literature (Friese & Nuyts, 2017), even as this journal has played leadership roles in elevating social science in One Health research. As a concept, One Health refers to interdependence between humans and non-human species in complex socio-ecological systems (Zinsstag et al., 2011). *Social Science & Medicine* began to publish contributions regarding One Health, social science and social justice in 2009 (Rock et al., 2009; Singer, 2009), and a One Health special issue appeared in 2015 (Craddock & Hinchliffe, 2015). That special issue focused on efforts to halt the spread of zoonotic infections, reflecting current trends in One Health applications and critiques (Friese & Nuyts, 2017).

The present article expands the scope of social science contributions to One Health scholarship, by considering dogs, rabies, human injuries, and public policies as entangled phenomena. In other words, none of these things truly exists as discrete entities or variables, such that 'life is the ongoing, dynamic result of human and nonhuman interactions over time' (Nading, 2013, 60). Dog-bites can spread rabies and other zoonoses; dog-bites routinely cause injury; and the risks for rabies and for dog-bites are unevenly distributed, geographically and socio-economically, largely due to policy influences. By implication, policies addressing dogs, rabies and dog-bites ought to complement one another.

Below, we present an ethnographic case-study in which we seek to assess the extent of policy complementarity as regards dog-bites and rabies. By attending to the current situation in Canada, we seek to illustrate the value of relational coordination (Gittell, 2011) with respect to the tasks entailed in both rabies prevention and dog-bite prevention. We also call for ontological

coordination (Mol, 2002), so that professional practice and information systems duly reflect overlapping risks within living systems (Hinchliffe & Whatmore, 2006). But first, we provide some background information on rabies and injuries from dog-bites.

Background

Under the auspices of the United Nations' Millennium Development Goals, infectious diseases such as HIV, tuberculosis and malaria have dominated global health policies and programs. As the United Nations has sought to reorganise its activities around the recently-ratified Sustainable Development Goals, 'neglected diseases' are now firmly on the agenda (UN, 2015). Accordingly, the WHO (2016a) recently endorsed a plan to eliminate human cases of rabies by 2030. And yet, given that rabies is a zoonotic disease, such a plan cannot be effectively deployed without drawing upon the One Health concept and without attending to the multi-species entanglements that surround rabies.

One Health has intuitive appeal, but applications will never be straight-forward. To date, most One Health applications have targeted non-human species, so as to reduce the incidence of infectious disease in human populations (Friese & Nuyts, 2017). Prevention of infectious diseases in people is complicated enough, but insufficient, both practically and ethically. Hence we extend the distinction in public health between 'mere prevention' and 'health promotion' to One Health. Unlike most efforts to stop people from developing zoonotic infections, One Health promotion entails policy-guided programs and services to alter interactions throughout complex systems, for mutual benefit amongst humans and non-human species (Rock, 2016; Rock et al., 2015; Rock & Degeling, 2015, 2016). That said, when seeking to promote One Health, a series of challenges beset coordination across academic disciplines, professions and policy realms (Degeling et al., 2015; Hinchliffe, 2015; Rock et al., 2009).

In keeping with conceptualizing One Health promotion in terms of complex systems, the WHO (2016a) has recommended improved coordination for the sake of rabies prevention. More specifically, the WHO (2016a) has pressed for concerted efforts to improve access to post-exposure prophylaxis (PEP), but also to decrease reliance on PEP by expanding the reach of programs to vaccinate dogs against rabies. A related WHO (2015b) report has endorsed dog-bite prevention as essential to rabies prevention. This latter report endorsed educational interventions as well as veterinary services, specifically rabies vaccinations and sterilization surgeries (to help prevent dog-bites, via dog population control). We reference this holistic approach throughout the analysis that follows, by considering rabies and dog-bite policies in Canada. Our approach to One Health promotion, however, explicitly attends to animal welfare along with social welfare (Rock et al., 2015; Rock & Degeling, 2015).

The World Health Organization (WHO, 2013a) justifiably characterizes rabies as a 'neglected disease of poor and vulnerable populations.' Globally, more than 55,000 people die annually from rabies (Hampson et al., 2015; WHO, 2013a). Rabies deaths are gruesome, and about 40% of the fatalities occur in children (WHO, 2016a). Worse yet, deaths from rabies represent needless suffering, given that '[r]abies elimination is feasible by vaccinating dogs' (WHO, 2013a). The WHO takes this stance on prevention because dog-bites almost always account for rabies incidence in people. In fact, experts believe that dog-bites account for more than 99% of all instances of human exposure to rabies (WHO, 2013a).

Each year, to prevent rabies, more than 15 million people worldwide receive PEP following dog-bites (WHO, 2016a). PEP for rabies is efficacious (Crowcroft & Thampi, 2015; Hampson et al., 2015), yet PEP is not always available or completed, especially in low-income and remote settings (Hampson et al., 2015). Besides the expense of PEP supplies, PEP administration is

time-sensitive and time-consuming for professionals, patients and families. The WHO (2013b) recommends immediate cleansing of the wound followed by vaccine therapy, then administration of rabies immunoglobulin; current standards call for at least four intramuscular doses to be administered by a trained professional over a period of four weeks. Patients, families and providers may feel distress during the course of post-exposure risk assessment and PEP administration (Cleaveland et al., 2006), adding to the reasons why systematic vaccination of dogs against rabies is preferable to systematic reliance on PEP to prevent rabies in people (WHO, 2013a). Furthermore, unvaccinated dogs suspected of rabies exposure, as well as dogs whose vaccination status is uncertain, may be killed to prevent further spread of the disease. Ethical questions regarding animal welfare and culling are therefore relevant to rabies control (Cleaveland et al., 2006; Degeling et al., 2016).

The WHO (2015a) estimates that dog-bites account for injuries in the tens of millions, year after year. And as with rabies, most dog-bite victims are children (WHO, 2015a). In biomedicine, the term 'injury' refers to energy transfers in amounts or at rates that exceed the threshold for tissue damage (Baker et al., 1992, v; Haddon Jr, 1980). We acknowledge, however, that this way of thinking about injury downplays psychosocial impacts (Langley & Brenner, 2004), which can be profound in dog-bite threats or injuries (Boat et al., 2012; Boyd et al., 2004). Nevertheless, dog-bite surveillance is so rudimentary that the WHO (2015a) cannot report on the global incidence of injuries from dog-bites, never mind point to policies and scalable programs to prevent their occurrence. By public health surveillance, we mean the 'systematic ongoing collection, collation and analysis of data and the timely dissemination of information to those who need to know so that action can be taken' (Last, 2001, 174). Accordingly, the WHO (2015a) recommends initiatives to 'determine the burden and risk factors' for dog-bites, to

strengthen 'emergency response services,' and to promote 'research…on effective prevention interventions and populations most affected.'

Even in countries such as Australia and Canada, where the infrastructures to support healthcare and public health are sophisticated, dog-bite surveillance and research remain under-developed (Ozanne-Smith et al., 2001). Preventive education is routinely recommended to lessen the incidence and impact of dog-bites (e.g., WHO, 2015b), but evaluations have tended to be small in scale. A systematic review of educational interventions targeting children and youth identified only two studies that met the inclusion criteria on research design (i.e., randomized controlled trials or controlled before-after studies); and neither study measured dog-bite incidence as an outcome (Duperrex et al., 2009). The authors concluded, 'Education of children and adolescents should not be the only public health strategy to reduce dog bites and their dramatic consequences' (Duperrex et al., 2009, 2). Policy research and reforms also deserve consideration (Ozanne-Smith et al., 2001).

Methodology

This article derives from an ethnographic approach to case-study research on public policy (Agar, 2006; Wedel et al., 2005). By 'public policy,' we mean 'a formal decision or plan of action that has been taken by, or has involved, a state organisation' (Richards & Smith, 2008, 1). More specifically, we report on research that aimed to distil best practices for promoting One Health via animal-control policies. By 'animal control,' we mean efforts to regulate interactions amongst humans and non-human animals within a defined territory (Aronson, 2010). The University of Calgary's Conjoint Health Research Ethics Board approved this study.

Three cities and five towns in the Canadian province of Alberta participated in our study. In Alberta, municipal councils may adopt and enforce bylaws on domestic animals (Rock, 2013).

(In some places, such as the United States, bylaws are called 'ordinances.') MR and DR examined bylaws on dogs and related policy documents for each municipality in our study (Altheide, 1987). Next, DR observed and informally interviewed front-line officers (n=8) during regular shifts (i.e., ride-alongs), and then DR scheduled a series of in-depth interviews with front-line enforcement officers and managers (n=13) in these municipalities (Spradley, 1979). DR personally conducted all of these interviews and documented them in fieldnotes (Emerson et al., 1995). The formal interviews with front-line officers and managers were digitally recorded, and then DR transcribed these recordings verbatim in a naturalistic style.

The importance of inter-sectoral and multi-jurisdictional coordination emerged early on in our study. Of particular relevance to this article, a dog unexpectedly tested positive for rabies in the research setting (Mema et al., 2012). Agar (2006, 64) calls situations like these 'rich points' because they signal 'a difference between what you know and what you need to learn.' To learn more about inter-sectoral and multi-jurisdictional coordination in relation to animal-control policies and public health, we expanded our protocol in several ways that pertain to this paper. MR and DR examined local, provincial, national and international policies regarding animal welfare, animal bites and rabies prevention; MR and DR conducted in-depth interviews with physicians specializing in public health and preventive medicine, who assess rabies risk following animal bites in Alberta (n=2); MR interviewed an animal-control officer with expertise in assessing dog behaviour and risk to public safety, alongside this officer's supervisor (n=2); and together, MR and CD carried out in-depth interviews with veterinarians who have played leadership roles in expanding access to veterinary services for low-income communities, in Alberta as well as in northern Canada (n=5). Below, we emphasize coordination between animal-control and public-health policies. To do so, we focus on the City of Calgary, a municipality of

about 1.3 million people and 120,000 dogs (Rock, 2013). This city has earned a national and international reputation for leadership in animal-control policies (Caulfield, 2011; City of Calgary, 2009; Parliament of Victoria, 2016).

Our analysis, which proceeded in tandem with data collection, crystallized insights through immersion in the research setting and in the dataset (Borkan, 1999). We used NVivo® to assist with organizing our dataset, and we refined our understanding iteratively within the research team and directly with participants (Spradley, 1979). In addition, DR presented and discussed emergent findings at four conferences attended by officers who enforce a variety of bylaws, including animal-control bylaws, throughout Alberta. As with all ethnographic research, we continually engaged in processes of comparison and contextualization (Agar, 2006). The concepts of 'relational coordination' and 'ontological coordination' enriched our comparisons and our appreciation for contextual characteristics. The literature on 'relational coordination' suggests that communication between people whose roles depend on one another should be frequent, timely, accurate, and problem-solving in orientation (Gittell, 2011). Hence 'relational coordination' entails interpersonal interactions alongside a high-level view on priorities and processes, as people use technologies to perform tasks (Gittell, 2011). This emphasis on technological and task integration resonates with Mol's (2002) conceptualization of 'ontological coordination' in modern medicine and epidemiology. Because similar problems take different forms across settings, such as homes, hospitals, and even databases, '[t]he drawing together of a diversity of objects…involves various modes of *coordination'* (Mol, 2002, 83, emphasis added). In contexts where 'relational coordination' and 'ontological coordination' are lacking, policies may be misconceived and policy implementation may be misaligned.

Findings and Context

Animal-control policies pertain to the promotion of One Health, especially in contexts where their implementation explicitly seeks to improve both human and non-human lives. Historically, local governments' animal-control policies stem from struggles to prevent the spread of infectious diseases, notably rabies, and to protect the animals themselves from harm (Beers, 2006; Pemberton & Worboys, 2013). During the twentieth-century, as rabies and other infections declined in Western countries, local governments redirected their animal-control policies toward the threat of dog-bite injuries, as well as toward public nuisances associated with dogs, including barking, fouling and roaming (Aronson, 2010). As a result, animal-control policies increasingly focus on dog-owners and their behaviour (Borthwick, 2009). Put simply, people undergo regulation through policies on pets.

The City of Calgary exemplifies these international trends (Rock, 2013; Rock, 2017; Rock et al., 2015). 'Responsible pet owner regulations are necessary to balance an individual's right to own a pet with the responsibility to ensure that the pet does not become a nuisance or danger in the community,' or so states the City of Calgary's *Responsible Pet Ownership Policy* (2006, 1). To ensure that domestic animals do not become a public nuisance or threat, the 'Calgary model' for animal-control policy emphasizes four domains and synergies amongst them: 1) licensing and identifying pets; 2) meeting the emotional and physical needs of pets; 3) procuring pets ethically; and 4) providing veterinary services to pets, especially sterilization surgeries (Rock et al., 2015). Implementation of the *Responsible Pet Ownership Bylaw* (2016 [2006]), we have learned, extends to coordination with governmental and non-governmental organizations, including the Calgary Humane Society and Calgary Police Services. We point to a few such examples below. Yet as we will show, despite the City of Calgary representing a 'best-

case scenario' when it comes to One Health promotion at the local level, we found little evidence of coordination with health professionals. We also found that dog-bites and rabies risk have socio-economic components that current policies and implementation strategies have done little to redress. As a result, inequities persist in risk exposure as well as in access to preventive veterinary services. Furthermore, despite extensive utilization of emergency services for dog-bite injuries in children, we found the public-health response to rabies continues to exceed the response to dog-bites. Moreover, the response to rabies remains reactive, with an emphasis on assessing dog-bite cases for rabies risk and PEP after the fact. Animal-control officers do intervene to prevent dog-bites from occurring in the first place, but without recognition or support from public-health officials.

Animal-control policies and dog-bite prevention

Under the *Responsible Pet Ownership Bylaw*, dog-bites as well as being chased or struck by a dog are offences (City of Calgary, 2016 [2006]). Rules like these are typical features of animal-control policies (Aronson, 2010). What is unusual is that animal-control officers in Calgary systematically classify dog-aggression incidents by severity, with reference to a rubric known as the Dunbar (2016) scale. In incidents involving multiple punctures, or worse, animal-control officers with specialized training then assess the offending dogs' behavioural tendencies. And whenever animal-control officers deem that dogs cannot be safely returned to their owners, the officers strive to rehome these animals. As explained by an animal-control officer who specializes in behavioural assessments,

> So, I mean one of the options we give is that they can transfer ownership to the City. If I can place it, I will. And I can show you the back of my office door, it's all of them. We call them "blue survivors" because they have survived the blue

> juice. They should've died but the stars aligned. And we're able to take the Border Collie that bites little kids when he gets out and put him on a sheep farm. He's just fine. And those are the success stories. So to be able to sit here and say that to a dog owner, honestly that if I can home your dog properly, I'll do it. [Intv#14032016_01]

Euthanasia orders are rare (Rock, 2013), and we learned that the City routinely refers owners of aggressive dogs to certified trainers at the Calgary Humane Society. Municipal animal-control officers routinely refer dog-bite victims to Alberta Health Services for medical treatment, but cooperation usually ends there. As one animal-control officer explained in an interview, 'we tell the person to go to the hospital if the skin is broken' [Intv#16102015_01].

Without biting anyone, aggressive dogs can still have negative impacts on people's health. In particular, aggressive dogs may deter outdoor play amongst children as well as walking, jogging and cycling amongst adults in urban areas (McCormack et al., 2010; Toohey & Rock, 2011). Furthermore, intimidating behaviour in dogs may presage dog-bites (WHO, 2016b), so early intervention may avert injury and trauma. Indeed, the lowest level on the Dunbar (2016) scale refers to incidents in which a dog may growl, lunge or snarl, but without the dog's teeth coming into contact with the target's skin (see also: Wrubel et al., 2011). Accordingly, Calgary's animal-control officers take complaints about intimidating dogs seriously. During a ride-along, an animal-control officer described a memorable case involving an aggressive dog 'at large' [FN_10062015_01]. The incident eventually involved the deployment of two animal-control officers, eight police cars (each staffed by two officers with Calgary Police Services), and a Calgary Police helicopter to track down the dog. After one of the animal-control officers discharged a $C0_2$ cartridge (using a device that resembles a fire

extinguisher), the dog ran back to the owner's yard. There, the animal-control officers were finally able to contain the dog.

Systematic investigation of dog-aggression complaints and ticketing appear to be effective in preventing dog-bites (Clarke & Fraser, 2013), and in Calgary, complaints about intimidating dogs have declined precipitously since the 1980s. At the same time, the size of the human and dog populations have grown exponentially (Rock, 2013). Put another way, statistical evidence for the City's approach to One Health promotion has accumulated for more than a quarter of a century. Currently, the City (2016 [2006]) may fine owners between CAD$200 and CAD$2,000 following confirmation of a dog-aggression incident.

When investigating dog-related complaints, the City's database on dog licensing assists with efficient tracing. Calgary's *Responsible Pet Ownership Bylaw* stipulates that owners must purchase a licence for their dogs, and compliance is remarkably high, at about 90% (Rock, 2013). To encourage citizens to license their pets, the City reinvests the revenue in ways that promote One Health (Rock, 2013). Examples include: returning dogs 'at large' to their rightful owners by driving them home right away; operating a modern shelter to house impounded animals; rehoming impounded animals; educating the public; and subsidizing sterilization surgeries for pets belonging to low-income citizens. Such services may help in minimizing stress levels amongst dogs, in ensuring that dogs enter homes that meet their needs, in improving public awareness of dog-bite risks and reporting, in reducing the number of unwanted puppies, and in facilitating proper care and socialization for all puppies. For these reasons, animal-control services that are subsidized by licensing fees may prevent dog-bites from occurring (Rock et al., 2015).

Even as animal-control policies may promote One Health and avert dog-bite injuries, the City of Calgary's comprehensive data on dog-ownership and dog-bites have yet to be closely compared, nor linked, with data from Alberta Health Services on dog-related injuries. Nonetheless, Alberta Health Services keeps systematic records of treatment for dog-bites. A related project entailed analysing medical records for dog-bites and related injuries in emergency departments throughout Alberta (Jelinski et al., 2016). That project unearthed substantial differences in utilization of emergency services across the province. For example, the utilization rate for dog-related injuries was 64/100,000 in Calgary, versus 90/100,000 in Edmonton. Nevertheless, these cities closely resemble each other in population size and socio-demographic profile. Such differences merit further investigation, for example, in relation to municipal animal-control policies in the City of Calgary and the City of Edmonton, respectively.

Overall, dog-bite surveillance remains under-developed throughout Canada, which detracts from One Health. To begin, Canada lacks basic statistics on dog-bite incidence. According to the Canada Safety Council (2005), 'Our [dog-bite] problem is likely as serious as that of our southern neighbour,' and based on telephone surveys, the annual incidence of dog-bites in the United States has been estimated at 1.5% to 2% (Gilchrist et al., 2008; Sacks et al., 1996). Across Canada, 43 people died from injuries caused by dog-bites between 1980 and 2002, with an adjusted mortality rate of 0.05/100,000 amongst children 1-4 years old (PHAC, 2005). And in 2002-2003, the adjusted hospitalization rate due to dog-bites was 1.57/100,000 for the Canadian population and 5.87/100,000 amongst children 1-4 years old (PHAC, 2005). Up-to-date information on dog-bite morbidity, mortality and hospitalizations are not publicly available.

Detailed data on dog-bite injuries are available through from the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP). CHIRPP tracks injuries treated in the

emergency departments from a selection of paediatric and general hospitals. Together, these hospitals serve as sentinel sites for the purposes of public health surveillance (Mackenzie & Pless, 1999). To capture information about what the patient was doing when injured, what went wrong, and the setting, both emergency staff and patients (or their care-givers) complete 1-page questionnaires. CHIRPP personnel then enter the responses into a multi-site database (PHAC, 2016). Despite continual updating, CHIRPP data on dog-bites have not been released for over a decade (PHAC, 2005).

Between 1990 and 2003, data on 17,745 dog-related injuries were entered into the CHIRPP database (PHAC, 2005, 2). Of these, 13,921 (78.4%) were dog-bites; the remainder resulted from being struck by a dog (PHAC, 2005, 2). During this time, dog-bites accounted for more emergency visits to CHIRPP hospitals (n=4,333) than did ice-hockey injuries (n=3,198) amongst children between 5 and 9 years old (PHAC, 2005, 9). Over the last decade, paediatric injuries in ice-hockey have become research and prevention priorities across Canada (e.g., Emery et al., 2010; McKay et al., 2014), partly in relation to CHIRPP data (Macpherson et al., 2006), and to an extent that paediatric dog-related injuries have not. Whereas CHIRPP data suggest that dog-bites rank within the top-10 causes of pediatric injury (PHAC, 2005), a 2010 Delphi study on priorities to prevent injuries in Canadian children did not even mention dogs (Pike et al., 2010).

The lack of coordination between animal-control services and health services is particularly concerning for Indigenous children, who live with higher risks for dog-bites than do their peers in Canada. Indeed, a 2014 Delphi study ranked dog-bites as a top-10 priority for injury prevention amongst Indigenous children in Canada (Pike et al., 2014). Participants in this Delphi study also ranked animal-control services as a top-10 priority, due to their potential value

for injury prevention, as well as for the prevention of rabies and other infections (Pike et al., 2014, Appendix).

The likelihood of being injured by a dog appears to increase with latitude in Canada, and Indigenous people comprise a greater proportion of the human population in northern Canada than in southern Canada, notwithstanding the politics of Indigenous status in statistical portraits (Andersen, 2016; Elias et al., 2015). An analysis of dog-bite hospitalizations in Manitoba found a north-to-south gradient (Raghavan et al., 2014). Similarly, our recent analysis of dog-bites treated in emergency departments across Alberta found a north-to-south gradient (Jelinski et al., 2016). In addition, Health Canada (2014) has flagged dog-bites as a concern for Indigenous communities in Alberta.

Whereas improved coordination between animal-control policies and public health in places like Calgary would entail stronger relationships amongst protagonists, and might extend to data-sharing agreements, animal-control services are absent altogether in many northern and Indigenous communities in Canada (Pike et al., 2014). The lack of investment in animal-control services is long-standing and the negative impacts are far-reaching. For example, partly due to 'hundreds of stray dogs,' government officials determined that a particular Indigenous community in the Northwest Territories 'was not an appropriate site for the development of a school' in the 1960s (Davison & Hawe, 2012a, 217). In response, government officials authorized the construction of a school nearby. Today, that distance represents a barrier to student attendance and engagement, while also impacting inter-generational contact and family ties within the community (Davison & Hawe, 2012b). In the words of one elder,

> The school being out of the community, you know being 13 km away, is quite difficult. The kids leave in the morning, it is dark, they come back and it is dark and their life is in the school (cited in Davison & Hawe, 2012b, 69).

At the time of writing, our team is adapting 'the Calgary model' for One Health promotion in collaboration with local communities, charitable organizations, and governmental agencies in the Northwest Territories. This initiative reminds us that 'the Calgary model' pivots on the Western notion that people should regard pets simultaneously as private property and as tantamount to nonhuman persons (Rock & Degeling, 2013). One Health may have global reach as a concept, but in practice, One Health hinges on local knowledge, suppositions, and contingencies (Hinchliffe, 2015).

Animal-control policies and rabies prevention

Dog-related injuries remain far more common than rabies exposure. Indeed, more people died from dog-bite injuries between between 1980 and 2002 alone (n=43) than have died from rabies since 1924 (n=24) in Canada (PHAC, 2005, 2011). Hence we have felt discouraged by the extent of resources available for rabies prevention, compared with dog-bite prevention. This disjuncture worries us because dog-bites remain the main vector of potential exposure to rabies in people. By implication, rabies policies tend to emphasize the prevention of human disease, rather than One Health promotion (Rock & Degeling, 2015). Little is being done to help people, notably Indigenous and low-income people, in exercising a collective form of control over dog-related risks in accordance with their values. Nevertheless, such an approach to One Health promotion could augment well-being in a multitude of human and canine lives.

Throughout Canada, rabies is a reportable disease, and a federal agency must receive notification whenever rabies is suspected (Government of Canada, 1990 [2015], 1990 [2016]).

Rabies investigations, however, fall under the jurisdiction of the provincial and territorial governments in Canada. As stated on its website, Alberta Health Services 'provides follow-up for animal bites (dogs, cats, bats, and other animals) *to make sure people don't get rabies*' (2016, emphasis added). By implication, employees of Alberta Health Services do not aim to prevent dog-bites from occurring in future by collating 'lessons learned' in the process of rabies investigations. An animal-control officer described the division of labour with Alberta Health Services as follows:

> As for Alberta Health Services, when it comes to dog bites they have to do a quarantine, and they normally call and talk to the parents and stuff and they kind of do their own investigation. We just let them know what happened, and then we handle our part, and they handle theirs, and their part that they're concerned about is only disease, quarantine, things like that….. [Intv#15102014_01]

Moreover, unlike some jurisdictions (Aronson, 2010), Alberta Health Services does not operate a program to help ensure that all dogs in the province receive rabies vaccinations. Furthermore, Alberta Health Services does not subsidize the sterilization of dogs belonging to low-income owners, which could reduce the likelihood of dog-bites and thus rabies exposure. The City of Calgary does subsidize the sterilization of dogs in low-income households (Rock, 2013), yet our interviews with veterinarians revealed that demand for subsidized veterinary services outstrips supply in Calgary.

Human exposure to the rabies virus has become uncommon in Canada, but vigilance is still necessary. First, rabies remains endemic in several species of Canadian wildlife, notably bats, racoons, skunks, and foxes (Tataryn & Buck, 2016). Whenever people report being bitten

by wildlife, public health authorities assess risk and, if warranted, they authorize PEP (Tataryn & Buck, 2016). The following example from Alberta illustrates the public-health significance of endemic rabies in wildlife. In 2007, a 73-old man died from rabies following a bat-bite that occurred just outside Calgary (Johnstone et al., 2008). This individual did not seek medical treatment until he became symptomatic, many months later. Contact-tracing identified nineteen people at risk. They each received PEP, with the exception of a healthcare professional who received booster injections to supplement prior vaccination (Johnstone et al., 2008).

A second reason for vigilance is that by coming into contact with wildlife, dogs may be exposed to rabies (Tataryn & Buck, 2016). For example, the rabid bat whose bite ultimately killed an Albertan near Calgary could have bitten someone's dog, thereby exposing additional people to rabies. In another Canadian example, drawn from southern Ontario, 'two large dogs – Lexus and Mr. Satan – got into a fight with a sick raccoon in the back of an animal services van' (Casey, 2016). These dogs were inoculated and then quarantined as a matter of public safety. This example from Ontario illustrates the pertinence of local governments and their animal-control services for rabies prevention, along with dog-bite prevention.

A third reason for vigilance is that rehoming dogs may spread the risk of rabies. This risk is illustrated by a positive test result for canine rabies in Calgary, after a puppy was rehomed from northern Canada without being vaccinated against rabies (Mema et al., 2012). 'The five-month-old puppy had come from Nunavut,' CBC News (2013) reported. 'Health officials say the incident is a good reminder to pet owners to keep vaccines up to date.' A similar situation arose the following year (Curry et al., 2016). In both incidents, testing revealed the variant of rabies associated with Arctic fox (Curry et al., 2016; Mema et al., 2012).

In the Calgary incident, contact-tracing identified 14 people who been in contact with the rabid puppy (Mema et al., 2012). The 8 contacts who received PEP due to high-risk exposure included a veterinarian who had treated the puppy in Calgary (Mema et al., 2012). In addition, contact-tracing revealed that the rabid puppy had bitten an unvaccinated dog, whose owners opted for euthanasia over quarantining their pet for at least 6 months (Mema et al., 2012). Public-health officials devised a communication strategy and handled media inquiries (Mema et al., 2012). This communication strategy did not include the City of Calgary and its animal-control managers, to the best of our knowledge. Indeed, media coverage did not quote animal-control managers, despite advising that off-leash dogs were at some risk for exposure to rabies from wildlife, such as bats (CBC News, 2013). Yet, off-leash dogs and public parks fall under the City of Calgary's jurisdiction.

In an interview for this research project, the public-health physician who led contact-tracking after a puppy tested positive for rabies in Calgary reflected:

> For a dog to have rabies is really not news. For a dog to have rabies in Alberta, it is news. But the rescue piece, right, like this is a problem somewhere else, and now we are seeing this welfare [issue] – animal welfare groups bringing dogs into here. [Intv#04112014_01]

As implied by this quote, exposure to rabies is a daily possibility in northern Canada. There, dogs usually spend their lives outdoors, so contact with wildlife is perennial. In remote communities where veterinary services are inaccessible, which is the situation for most of northern Canada, the federal government has waived the stipulation that rabies vaccination must be performed by a licensed veterinarian (Curry et al., 2016). Nevertheless, uptake is far from optimal.

For instance, when Calgary-based veterinarians began offering outreach clinics in a handful of remote communities in the Northwest Territories, only 37% of the treated dogs had previously received the rabies vaccine (Brook et al., 2010, 1120). Furthermore, these dogs disproportionately belonged to professionals from southern Canada, such as teachers. Recently, public-health officials contacted the veterinarian who has spearheaded these outreach clinics, after a rabid fox had been sighted near one of the communities. This veterinarian confirmed that an exposed dog's rabies vaccination was up to date. As a result, the dog's life was spared, to the relief of all concerned [FN#20161125_01]. This example highlights that rabies vaccinations not only prevent the spread of rabies, but also the killing of dogs, and concomitant distress in people. Hence, policies and programs that enable widespread vaccination of dogs against rabies instantiate One Health promotion.

With respect to Canadian policy on rabies, representatives from multiple levels and sectors of government, together with representatives from non-governmental organizations, collectively developed a management plan that was released in 2009 (Tataryn & Buck, 2016). To incorporate some recent changes in federal policy along with 'lessons learned' about multi-jurisdictional coordination (Curry et al., 2016), an expert panel is revising the plan (Tataryn & Buck, 2016). The key point is that despite low risk to humans in most places throughout Canada, any legitimate threat of rabies triggers coordination amongst officials and official records (as per Gittell, 2011; Mol, 2002). Nonetheless, these coordinated responses do not consistently involve local governments and their animal-control services.

In future, public-health responses to rabies in the Calgary area might benefit from coordination with the City in contact-tracing as well as in strategic communications. Recall that 90% of all dogs in Calgary have been licensed, which means that the City maintains descriptive

information for all these dogs along with mailing addresses and contact information for their owners in a searchable database. The City already uses this database to educate dog-owners about its *Responsible Pet Ownership Bylaw* and dog-bite prevention (Rock, 2013). Furthermore, news stories concerning off-leash dogs and other dog-related issues in Calgary frequently cite animal-control managers, as a matter of public education (Toohey & Rock, 2015).

At the same time, local governments might do more to help in protecting public health by ensuring that all dogs receive vaccinations for rabies and other serious infections. Animal-welfare organizations also have roles to play when it comes to preventive veterinary services. Already, the City of Calgary as well as the Calgary Humane Society vaccinate all dogs prior to rehoming. Also, like many local councils (Aronson, 2010), the City of Calgary charges less to license sterilized dogs than to license intact dogs (2016 [2006]). And as mentioned already, the City uses licensing revenue to subsidize veterinary sterilization of pets belonging to low-income owners (Rock, 2013). The City could consider extending such incentives and subsidies to vaccinations. A broader issue is inequitable access to preventive veterinary services, which local governments and animal welfare organizations may mitigate but cannot resolve, even by coordinating their efforts. To the extent that preventive veterinary services protect and promote human health, provincial and territorial governments in Canada should consider the potential benefits of subsidized programming.

Discussion

Our ethnographic study of local governments paid close attention to the City of Calgary, as a 'model city' for animal-control policy and services. Rather than sterling examples of One Health promotion through multi-jurisdictional coordination between local and provincial agencies, we found heavy reliance on PEP for rabies prevention, a weak commitment to

systematic vaccination of dogs against rabies, and a relative neglect of dog-bites with respect to policy and practice within public health. The neglect of dog-bites is particularly problematic in low-income communities as well as in northern Canada, where residents tend to be Indigenous (Pike et al., 2014). Indigenous and low-income communities also experience challenges in accessing basic veterinary services, such as sterilization and vaccination of dogs against rabies. Discussions regarding health equity should broaden to include One Health promotion, animal-control policies and veterinary services.

Poor coordination with respect to rabies and dog-bites may stem partly from conceptualizing these problems in linear cause-effect terms, rather than as complex socio-ecological systems characterized by multi-species entanglements. Accordingly, to follow Mol (2002), dog-bites do not tend to 'cohere' with rabies in statistical portraits, nor in policy statements, nor in practical interventions stemming from policy statements. Furthermore, treating rabies and dog-bites as discrete problems extends into asymmetrical surveillance. Rabies prevention commands far more attention and resources than dog-bite prevention, even though these problems are inextricably linked in actual lives.

Based on participant-observation, interviews and policy-related statements in the Canadian context, we found evidence of relational coordination (as per Gittell, 2011) in assessing rabies risk and in administering PEP, but not in extending rabies prevention to encompass dog-bite prevention as a broader concern for One Health promotion. Rabies prevention and dog-bite prevention are separate enterprises – both organisationally and as institutional practices. Our research has led to speculations about ways to strengthen responses to dog-bites in research and policy, but our study did not involve quantifying relational coordination, nor concerted efforts to improve relational coordination (Gittell, 2011). That said,

we believe that research and interventions to enhance policy alignment and task integration between animal-control and public-health services should be pursued. To that end, our team has shared results from this study and related research with animal-control officers and public-health officials in a variety of settings. Most recently, in May 2017, we hosted a symposium on dog-bites at the Alberta Municipal Enforcement Association's annual conference. We invited a collaborator, a physician-epidemiologist, to present preliminary results from a chart-review of pediatric injuries from dogs. The dialogue following this presentation identified privacy legislation and related concerns as an obstacle to closer collaboration in dog-bite cases. More generally, we have noticed a lack of familiarity with municipal animal-control policies amongst healthcare professionals and scant attention within health promotion to the enforcement of such policies. Indeed, despite the acknowledged importance of smoking bans in tobacco control, to name but one example, researchers in public health have largely ignored the matter of enforcement. We are aware of just one in-depth study of how and the extent to which smoking bans are enforced. This study of enforcement took place in Calgary, and highlighted divergent worldviews between health promotion and enforcement practitioners, as well as a lack of appreciation for the work of enforcement amongst healthcare professionals (Patterson et al., 2009). In our own study, we have noticed that animal-control officers and managers seem to see themselves as upholding 'public safety,' as compared with 'public health.'

Conclusion

Overall, we find that public-health surveillance is lacking for dog-bites in Canada. Given the extent of resources that are already invested in rabies surveillance, and the potential for interventions targeting dog-bites to reduce reliance on PEP and associated burdens (for patients, providers and systems), we believe that preventive programs for rabies should encompass

vaccination of dogs as well as dog-bite prevention. Greater coordination is urgently needed to reduce the negative impacts of both dog-bites and rabies, especially in disadvantaged communities.

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