Perceptions and Practices of Dog Ownership and Rabies Control at a Human–Wildlife–Domestic Animal Interface in South Africa

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There is a supplemental table Table S1 but it is not cited in the text

Abstract

Rabies is efficiently controlled through mass vaccination of dogs. In an area of South Africa where free vaccination campaigns were implemented following rabies re-emergence, the required 70% vaccination coverage was challenging to reach. Understanding the factors affecting the efficiency of mass vaccination is helpful in guiding long-term rabies control efforts. This study aimed to assess the communities' knowledge and perceptions of dogs, rabies and the related risk, and control behaviors in a rural rabies-endemic interface area. Combined with informal discussions and participative observations, we organized 18 focus group discussions with men, women, and children -stratified by dog ownership status- in three villages in the Mnisi community in the Mpumalanga Province in north-east South Africa. This community highly valued hunting dogs despite hunting of wildlife being illegal. Although people did not have a clear idea of how dogs acquire rabies, they were aware of the presence of the disease and its zoonotic nature. A dog bite was always associated with rabies risk but was also a source of conflict between dog owners and bite victims, hampering bite health care management. Dog vaccination was perceived as a means to prevent diseases from spreading to humans and other animals, to protect dogs from diseases but also to cure disease. Lack of awareness, misinterpretation of health promotion messages and specific beliefs among adults seemed to hinder participation in rabies vaccination campaigns. Involving and educating staff from clinics and wildlife reserves during vaccination campaigns would tackle rumors, clarify dog bite and dog vaccination procedures and improve the relationship among stakeholders. Further anthropological studies focusing on people owning dogs for hunting may provide a better understanding of rabies transmission patterns and risk factors in this community.

Keywords: anthropology, dogs, human–animal interaction, rabies, South Africa, vaccination

Background

Rabies is endemic in many parts of the developing world, where domestic dogs are the primary maintenance host of the virus, and responsible for the vast majority (> 90%) of human exposures and deaths (WHO, 2018). Once clinical signs develop, rabies is almost invariably fatal. It is transmitted when the virus is introduced into bite wounds, open cuts in the skin, or onto mucous membranes from saliva or other infectious material such as neural tissue (Manning et al., 2008). Canine rabies is a neglected disease that predominantly affects poor and vulnerable populations living in rural areas in Africa and Asia (Knobel et al., 2005). Although important progress has been made in Africa on vaccine coverage in dogs (Davlin and VonVille, 2012), challenges in mobilizing resources as well as cultural and operational barriers still remain to be better understood and contextually addressed (Bardosh et al., 2014; Jibat et al., 2015). As a result of various public awareness campaign initiatives (Balaram et al., 2016), nowadays, populations in developing countries are relatively well aware about the existence of the disease, with in some regions an improved understanding of key issues relating to rabies exposure and prevention (Lembo and Partners for Rabies Prevention, 2012; Hasanov et al., 2018). Yet, critical knowledge gaps on rabies prevention strategies and on the appropriate response to dog bites, still affect attitudes and practices towards general rabies control (Hergert and Nel, 2013; Sambo et al., 2014). Highly underreported due to a lack of surveillance and laboratory infrastructure (Fooks et al., 2014), a lack of reliable field-based tests (Warrell and Warrell, 2015) and misdiagnosis (Mallewa et al., 2007), the burden of rabies

(estimated at 59,000 human deaths and 8.6 billion USD economic losses annually) impacts public health sector budgets, local communities and livestock economies in the poorest regions of the world (Hampson et al., 2015).

Rabies in dogs as well as in humans can be controlled and in certain instances eliminated in developing countries by mass vaccination of dogs (summarized in Table 1 of Cleaveland et al., 2006, Zinsstag et al., 2009). Regarded as the most cost-effective strategy available, mass dog vaccination programs over consecutive years are recommended by the recent Global Strategic Plan to end human deaths from dog-mediated rabies by 2030 (WHO-FAO-OIE, 2018). To control rabies, it is estimated that at least 70% of the dog population should be vaccinated during annual vaccination campaigns (WHO, 2018). Understanding dog ownership dynamics, the human-dog relationship, and the ecology of the dog population, all of which may vary geographically or be affected by socio-cultural determinants (Knobel et al., 2008), is therefore helpful in guiding long-term rabies control efforts in particular areas.

Rabies re-emerged in the Bushbuckridge District, Republic of South Africa (RSA) in January 2008 (Mkhize et al., 2010), and subsequently spread throughout the district, resulting in at least 380 suspected cases in dogs and other animals, and one human death. Two years later, in 2010, a rabies outbreak occurred in dogs in urban areas of Gauteng Province, resulting in a human fatality (Sabeta et al., 2013). Although both outbreaks were brought under control through free mass vaccination of dogs, they highlighted the risk of reintroduction of the disease into areas with low dog vaccination coverage, and the need to understand peoples' perceptions of dog ownership and the determinants of behavior towards rabies control in these low-

income communities, urban as well as rural. However, anthropological studies on canine vaccination in Africa remain scarce (Bardosh et al., 2014).

To understand how local realities intersect with technical solutions (Bardosh et al., 2014) and how challenges of dog vaccination for rabies may be addressed in this particular South African context, we conducted a socio-anthropological study among a population experiencing a recent re-emergence of rabies. The research objectives, were to assess levels of awareness and socio-cultural barriers to control, identify gaps in knowledge to improve educational messages that accompany vaccination campaigns and correct post-exposure prophylaxis (PEP) after dog bites, inform future quantitative work on aspects of rabies epidemiology, dog ecology and ownership, and to further combine results to make recommendations on rabies control policy and vaccination implementation.

Methods

Study Area

Combined with informal discussions and participative observations, a qualitative research study was conducted in a site that falls within the Mnisi Community Program (MCP), a joint initiative by the University of Pretoria, the Mpumalanga Veterinary Services and the Mnisi Traditional Authority, to promote sustainable livelihoods through research into human and animal health, animal production and resource utilization (https://www.up.ac.za/mnisi-community-programme). The Mnisi study area (Figure 1 and Online Supplemental file including Table S1) is located in the Bushbuckridge District in Mpumalanga Province in north-east South Africa. The

Mnisi community consists of approximately 29,500 ha of communal land and shares 75% of its boundary with wildlife reserves (Berrian et al., 2016).

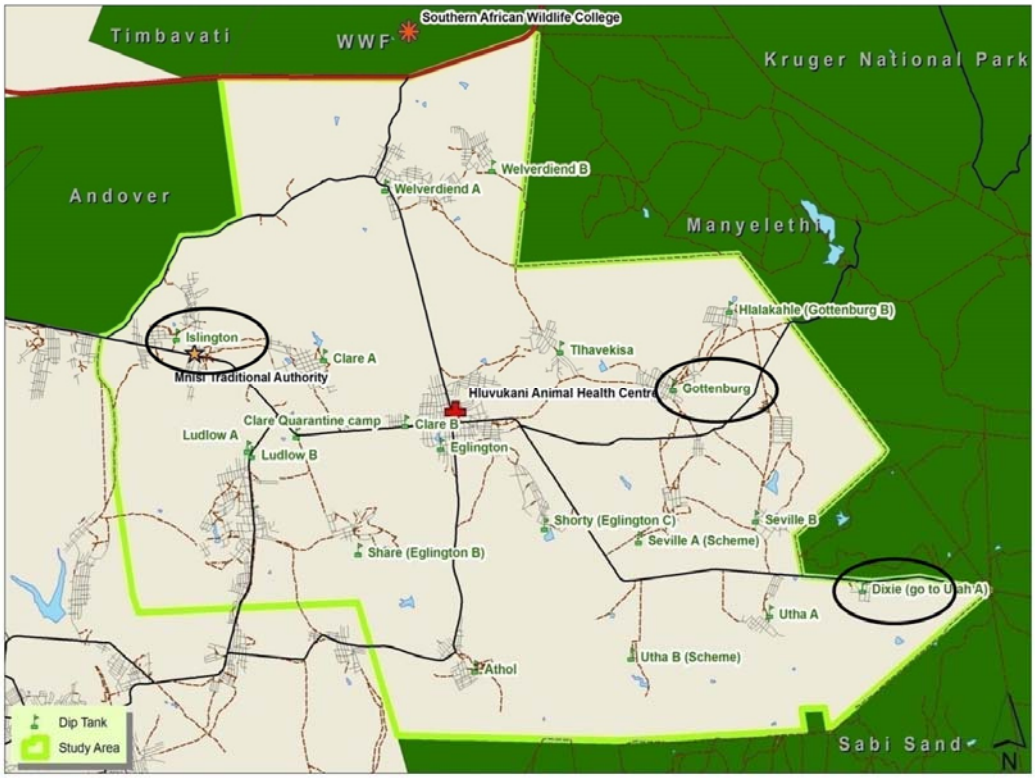

Figure 1: Map of the Mnisi study area (outlined in light green), Mpumalanga Province, Republic of South Africa, highlighting the location of the three selected villages (black circles). Image courtesy of Mnisi Community Program, University of Pretoria.

Study Design

Eighteen focus group discussions (FGD) were conducted in three villages, of which one was a pre-test exploitable for analysis (FGD 01). FGDs included a total of 146 participants (50 women, 48 men, and 48 children) (Table 1). The three villages (Dixie, Gottenburg, and Islington) were selected from those where the headmen (traditional leaders), acting as the gatekeepers to the villages, agreed to the study and had time to invite people to participate. Separate homogeneous FGDs were held with men, women, and children (from minimum 10 years old and under the age of 18) in

each village. Participants were stratified because they were expected to have different perceptions and behaviors regarding dog and rabies management. Heterogeneous groups were considered likely to hamper the quality of the data (Morgan, 1998; Grudens-Schuck et al., 2004). To evaluate possible differences in perceptions, FGDs were also stratified by dog ownership status, with ownership defined as having at least one dog in the yard of their household. This resulted in FGDs with participants from households owning one or more dogs, FGDs with participants not owning dogs and FGDs with mixed ownership groups, some participants owning dogs and others not (Table 1). The groups were constituted based on the willingness and availability of the participants who met the inclusion criteria of the respective group category (e.g. being a woman not owning a dog) and who preferably did not belong to the same household as other participants, to obtain a wider range of ideas and perceptions from the community. We were unable to create a group of males not owning dogs. The FGDs were conducted in the local language Xitsonga of the Shangaan people and its number and variation allowed us to reach theoretical data saturation (Yardley, 2000).

Table 1: Characteristics of the focus group discussions (FGD) by dog ownership status, group categories and villages

Focus Group Discussion Number	Dog Ownership Status	Group Categories	Villages	Number of Participants
1	Mixed	Women	Dixie	10
2	Mixed	Women	Islington	6
3	Non-owners	Women	Islington	5
4	Owners	Men	Islington	9
5	Mixed	Men	Islington	9
6	Mixed	Children	Islington	11
7	Owners	Women	Gottenburg	7
8	Non-owners	Women	Gottenburg	8
9	Mixed	Men	Gottenburg	6
10	Owners	Men	Gottenburg	5
11	Owners	Children	Gottenburg	9
12	Non-owners	Children	Gottenburg	8
13	Mixed	Women	Dixie	7
14	Owners	Women	Dixie	7
15	Mixed	Men	Dixie	9
16	Mixed	Men	Dixie	10
17	Owners	Children	Dixie	10
18	Non-owners	Children	Dixie	10
Total	Mixed (8) Non-owners (4) Owners (6)	Women groups (7) Men groups (6) Children groups (5)	Dixie (7) Islington (5) Gottenburg (6)	$n = 146$ Women (50) Men (48) Children (48)

Data Collection

Data collection took place from October to November 2011, after a first field visit in February 2010 and before a second round of data collection (ethnographic observations) from July to August 2013, focusing especially on the hunting dogs category (part of a second article). The number of participants per FGD varied from 5 to 11 (Table 1). Three facilitators (one man and two women) from the MCP, fluent in Xitsonga and familiar with the study area and the animal-human health issues, were identified and trained to moderate, report, and translate to the principal investigator (ST). All the FGDs took place in outdoor places, such as in a participant's yard. The moderator, reporter, and translator roles were switched between the three facilitators after each discussion. The discussions lasted about 40 minutes and were recorded on a video camera. The following topics were discussed: perceptions of dogs (ownership, roles of dogs, positive and negative aspects, etc.), dog management (type of care, barriers to veterinary care, etc.), perceptions of risk behaviors (healthy dog,

vaccination, bites, etc.), knowledge and perceptions of rabies (canine and human rabies, treatment, prevention, etc.), and perceptions of control options (vaccination, role of the government, dog sterilization, culling stray dogs, etc.). The themes discussed were slightly adapted to the group's category in order to ensure their interest and active participation during the discussion.

We complemented this data collection by systematically engaging in informal discussions with villagers, livestock keepers, school teachers, nurses, and veterinary technicians, and using a participatory observation approach during meetings with livestock owners and their dogs (Figure 2), at the human health clinic following up an incident of dog bite, and during encounters at the Hluvukani Animal Health Center (HAHC) for the diagnosis of a rabid dog.

Figure 2: Picture of dogs with cattle and livestock owners at the dip tank (Photo by Pierre Dorny; co-author).

Data Processing and Analysis

We transcribed the recordings of the FGDs and translated them from Xitsonga into English[1]. To improve reliability, three researchers (ST, DK, & GS) independently reviewed the written transcripts before entering them into the software. Text analysis of the transcriptions and the notes taken during the FGDs was supported by the NVivo 11® software (QSR International Pty. Ltd., Melbourne, Australia, 2008), which allows classification and sorting of data to explore relationships and trends. The principal investigator (ST) elaborated the coding tree with the major themes emerging, following an inductive approach, and discussed it together with the other investigators, until consensus was reached (DK, GS, JVR, TM, SG, PD, and MB).

The main results of each topic discussed are described in more detail and illustrated with anonymous quotes, chosen for their representativeness, appropriateness, and revealing quality. To highlight the observed patterns and respect as much as possible what was expressed in the discussions, the order used to present opinions and ideas shared by the participants for each topic reflects the level of importance given by the participants to these topics (going from a strong to a weaker consensus). The reflections, observational notes, and informal discussions from the iterative process of the several field visits could not be totally separated from the analysis of this set of data.

Ethical Considerations

Ethical clearances were obtained from the Research Ethics Committee of the Faculty of Humanities, University of Pretoria (South Africa), from the Ethical Committee of the Antwerp University Hospital (Belgium) and from the Institutional Review Board

of the Institute of Tropical Medicine, Antwerp, Belgium (11 29 3 779). We sought approval from the local authorities and community leaders before the commencement of the study.

Finally, we sought individual written consent or assent from the participants to enroll in the FGD and to video record the discussion. Participation was entirely voluntary, and no names were recorded. We took care to phrase the questions appropriately and respectfully. Written informed consent was obtained from each participant 18 years of age or older, and from parents (or guardians) for child participants. Written assent was obtained from child participants (10–17 years old). FGDs with children were not conducted during school hours.

Results

Role of Dogs

Results indicated that communities owned dogs primarily for security reasons: to guard houses, cattle herds, and fields from thieves, wildlife and witches, and secondarily for hunting.

Hunting dogs, usually from a special breed and bought at a high price (up to 1000 Rand), were highly valued in the Mnisi community despite the illegality of hunting wildlife. Dogs were also seen as a source of income, although this was only mentioned by men and children. Companionship was also raised, especially by children for whom dogs were animals to play with and make people happy. Finally, for men, owning dogs was also part of their ancestral lifestyle.

> It is a custom as it is part of our culture, we grew up finding that our parents and elders like dogs. (FGD 10)

Although dogs were sometimes considered as livestock by their owner and therefore deserving the same care, they were not consumed. Yet, one participant mentioned that eating rabid dogs was to be avoided to prevent rabies (see section on rabies transmission to humans).

Dog Ownership (Definition, Type of Care, and Duties)

A dog owner, usually man or boy, was defined as someone who was followed by his dog, who liked dogs and did not fear them and who had a dog in his yard. It was the person who took care of the dog, like a farmer for his livestock or a "father" for his children.

One child also mentioned that dog owners were the ones always eating meat, referring to the wildlife hunted by dogs. All participants preferred owning male dogs because in comparison to females they do not get pregnant, attract fewer males, are deemed stronger, run faster, and are more aggressive.

Taking care of a dog primarily included providing appropriate food for it to be healthy and making sure that it did not look for its own food out of the yard.

> Most of us do have an interest in keeping dogs or animals but the problem is we don't know how to take good care of them. […] You just don't put your

> dog in your yard and think it will take care of itself; so if you don't feed it once it goes out of the yard and will steal and also bite people. (FGD 15)

This was reflected in the predominant view that roaming around for food was perceived as a risk for the dog's health (see section on dog diseases) and damage to third parties, creating conflicts with the "victims" because dog owners, considered responsible of their animals, would have to pay for the damages. This was perceived as very problematic in a rural context of poverty and unemployment.

> You have to pay as the community does know whose dog it is. (FGD 05)

Stealing (eggs, chicken, and goats) and biting (people and other animals) were the two main negative features of dog ownership. Among the health threats perceived, being bitten by a dog was the first one mentioned by all the groups but more often by dog owners (from dog-owning and mixed groups). The following health risks were also mentioned: eating food contaminated by dogs (licking dishes, defecating, and urinating in the yard on the vegetables, sharing the same water), eating after touching dogs (playing, brushing them), and children being in contact with puppies. The women were the only ones who raised the latter two issues.

Taking a sick dog to the veterinarian was the second main duty for a dog's owner, although many stated that reaching the animal clinic was difficult mainly because of the distance, lack of transport or money to pay for it. The other options mentioned were bringing dogs to the dip tank[2] (Figure 2) of their village (green flags; Figure 1), calling the veterinarian or using traditional medicine.

As a third duty, mainly according to men and dog owners, a person owning dogs should make sure they were safe inside the yard (build good fences, chain it during the day and release it during the night). This was to avoid trouble with people (stealing and biting), to be sure the house was well guarded and to also ensure the dogs were safe from people (e.g., being stolen, poisoned or hit by a car) or from wildlife (e.g., being killed by a lion).

Among the other main perceived duties, participants (mainly owners and mixed groups) mentioned: treat them well (like a person), train them well in the sense of not stealing, not defecating indiscriminately and not biting, and vaccinate them.

The importance and level of care given to dogs depended on what they were used for (e.g., for security, for hunting) and differed between groups. In general, women seemed to care less about dog welfare than men or children; for them, feeding dogs was too expensive, or dogs were useless because they do not produce meat, hence they preferred investing their time and money in livestock.

Dog Categories

There were two principal categories of dogs: owned and unowned dogs, the latter called “Mgewu” in Xitsonga, meaning “street” dogs (mirroring the concept of “street” kids). Rather than being ownerless, they were considered neglected.

> All have owners; it's only that their owners are unable to take good care of them. (FGD 01)

Nevertheless, unowned dogs were mainly regarded as the ones that steal, live in the street, look unhealthy (skinny, shedding their fur, untidy) and are dangerous because they suffer from diseases (e.g., "Kwashiorkor", see below), bite or even kill people. Women and the groups of dog owners were the ones mostly discussing this category of unowned dogs.

Owned but unwanted dogs were said to be sold (children groups), given away (mainly men groups and dog owners) or killed (women groups and non-dog owners). Among the owned dogs, there were subcategories such as the hunting dogs that seemed to have a very particular status compared with other useful dogs such as "security" or "shepherd" dogs.

> You neither kill nor sell for money. (FGD 17)
>
> Some people do come in search of puppies, and I just give them away. [..].
>
> And I will just choose the ones I need first. (FGD 10)
>
> We just hang it into the bush and left it to die there. (FGD 03)

Local Knowledge of Dog Diseases and "Rihuhumbyana"

On the question about the diseases dogs can get, the men and the mixed ownership groups provided most of the information. Rabies was mentioned most often and is called "*Rihuhumbyana*" in Xitsonga, a word associated with insane, madness, senseless, frenzied, crazy, and literally translated as "the madness of dog" (as it does in other languages like kiSwahili). A suspected rabid dog was described to be primarily a dog willing to bite anything found in its way (people, animals, and things), getting mad (acting strangely, not behaving as usual, and running as if dancing),

shedding its fur, not eating, not willing to be approached, being numb. As other signs of rabies infection in dogs, a few participants mentioned salivating and shivering. Being "co-infected with Kwashiorkor," running away, and living in the bush were also mentioned by the participants.

The second most common disease of dogs was "Kwashiorkor," which is a medical term used to describe a clinical condition, mostly observed in children suffering from severe malnutrition. It is characterized by edema and an enlarged liver with fatty infiltrates, resulting from a deficiency of proteins. Here "Kwashiorkor" became in Xitsonga a word used to designate a state of health that makes dogs scratch and shed fur when they are not well fed. "Kwashiorkor" symptoms were also often considered as the symptoms of a rabid dog (see above).

> Sorry there is something in need to say… Diseases that affect dogs we can compare it like a toddler, as if is not well fed it will suffer of kwashiorkor. The toddler's skin will look pale showing that the child suffers of malnutrition do you understand? As I own a dog, I have to take good care of it as compared to my own dear child whom if sick must be taken to hospital. So we have dogs but we do not regularly take them to the clinic. (FGD 15)

The third main disease was one dogs developed from eating fish bones from cans.

> Moderator (Mod): How do you define a healthy dog? How can you see that this dog is healthy?

Women (W) 7: Only by looking at it. If it is well fed it attracts you but some dog's skin is worn out.

W4 & W5: Shedding of fur.

W7: You can be able to spot that they are unhealthy and suffer of malnutrition. As they are sometimes given fish bones and you can tell that they are not safe.

W3: It is not good feeding dogs with fishes.

[…]

W4: They sometimes lick fish cans in the dumping hole, so we need to burn those tins after use. (FGD 08)

All these three perceived "diseases" were each time discussed in relation to rabies.

Among other diseases and conditions mentioned to be affecting dogs, participants listed: ticks, worms, "AIDS," blisters, coughing, female back becoming reddish, snake bites, and unknown diseases coming from the forest.

Although rabies was not well known in general nor experienced by the participants in their village, a dog bite of a human was always associated with a risk of rabies. Rushing to the health clinic, both as victims or as dog owners, was the most frequently mentioned first response in this situation, just before the answer of seeking at first an arrangement with the dog owner. Only one man referred to washing the wound "using methylated spirit" (FGD 15) before getting to the hospital.

The conflicts arising in the aftermath of a dog bite between victims, dog owners, and the health clinic were mainly mentioned by women. Dog owners are expected to pay

for all the victims' costs in the case of a dog bite, including transport to health center and treatment. They also mentioned that the victims have to report the case to the police before treatment can be given.

> My concern is with the owners of dogs that are so dangerous, they are very rude, if you come gently they will be so harsh just like their dogs; you will be even scared of telling whose dog is responsible. And when you go to the clinic, they will say - We will not help unless you provide a letter from the police station. (FGD 08)

All the FGD participants expressed a clear preference for not killing a dog after a bite incident as there were many other reasons besides rabies which could cause a dog to bite, i.e. someone chasing/beating dogs, bitches with puppies, dogs defending their homestead from strangers or provocation.

> Yes, because everyone makes mistakes, but a dog cannot speak. (FGD 08)

The alternatives proposed were to have the dog examined by a veterinarian, to chase it away or to tie it until it was examined by a veterinarian or died, as there was no place to take them (e.g. animal shelter). Instead of killing the suspected rabid dog, some participants, mainly male owners, also suggested to get it vaccinated or injected but some women mentioned that owners will just abandon them.

> Yes, and be vaccinated and no other way, after three months be checked if they still have the disease. (FGD 04)

Several statements indicated that the participants perceived rabies as a treatable disease, in humans as well as in dogs after a bite incident. Humans were said to be cured with pills, injection, and treatment from the clinic or by traditional medicine.

> I have noticed one thing traditionally that I have seen a lot when a dog accidentally bites someone. Its owners used to remove a single fur from its skin. They burn it. And rub the wound [with the ashes] where there is teeth marks. (FGD 10)

Dogs were said to be treated by injections, by feeding them well, and by bringing them to the veterinarian.

Regarding the transmission of rabies to humans, dogs were the only ones to be blamed and mainly due to bites (from their saliva like snake poison, mixing with blood). According to women groups, humans could also be infected if they ate meat from animals that were bitten by a rabid dog or by sharing drinking water or dishes licked by it. Other rabies transmission pathways mentioned by the participants were non-vaccinated dogs, living together with dogs as they do with children (sharing the same water and air, dog fur in the food), eating meat from a rabid dog, and eating without washing hands after touching a dog.

> Like if my dog is rabid and is in pain, and we decide to kill it and then eat the meat, that is when we will be infected. (FGD 01)

On the other hand, the origin of the disease in dogs was mainly unknown. Some people suggested dogs were infected by wild animals such as jackals and hyenas from the game reserves while sharing the same places for eating, or feeding on infected bushmeat (e.g. warthog meat) or beef.

> It comes from jackals, hyenas and dogs eat where those animals had eaten and therefore get infected by the disease. (FGD 05)

Although elusive, this link between rabies, wildlife, and hunting was stressed again when a woman from FGD 02 said that "dogs that do not go hunting will never contract rabies."

Beside other dogs, ticks, antelopes, and the "air (atmosphere) from the game reserve" were also blamed as sources of disease transmission by a few participants. Some participants perceived rabies as a natural disease among dogs. Feeding dogs on tinned fish bones was also mentioned by a few men to be the origin of rabies in dogs.

Among the measures mentioned to prevent rabies, dog vaccination and regularly consulting a veterinarian were the two most important. Keeping dogs well (well tied, not eating from elsewhere) and not raising too many dogs were also stressed as preventive measures, as was burning the carcasses of rabid dogs.

> They say if it [the dog] is rabid it has to be burnt when it dies, it is not recommended that we eat. (FGD 01)

Vaccination

Dog Vaccination in General: Participants were aware of the value of vaccination in general (not specifically for rabies) to prevent dogs from becoming sick and spreading diseases. Dog vaccination was said to be for preventing rabies, Kwashiorkor and hair loss (shedding of fur), AIDS, and famine.

Each of the studied group categories considered vaccination essential. Women were the most frequent to say that vaccination of dogs prevents them from transmitting disease to humans through bites, and only women mentioned that vaccinating dogs was indicated for dogs that were biting people or were aggressive. For men and children, the purpose of vaccinating dogs was rather therapeutic. A few male owners said dog vaccination was to avoid transmission of infection to cattle by bites and to avoid dogs being killed if they bit someone. Very few participants said they did not know the real purpose of dog vaccination.

Regarding the timing of vaccination, some participants said it had to be done when they were informed that the veterinarians were coming, when it was time as the dogs should "stay injected" (immunized) all the time. For two groups of owners (women and men), vaccinating dogs had to be done when dogs were still young but after the age of 3 months.

Vaccination Against Rabies: The main perceived aim of dog vaccination against rabies was that bites from dogs would not infect humans anymore and that the rabies vaccine would prevent the disease (the latter point was mentioned by all groups

except children). Also, a curative purpose of dog vaccination was mentioned by both groups owning dogs and children not owning dogs, but not by women.

Barriers Against Dog Vaccination: For the non-dog owners, dog vaccination was efficient and no barriers or negative effects were perceived. For the dog owners and mixed groups, perceived barriers to vaccination were more often raised and it was also mentioned that vaccination did not work for every dog.

> Mod: OK. Does vaccination work in dogs?
>
> Man (M)3: We can call it luck as in some dogs it works well in some it doesn't.
>
> M2: Yes, it is luck to work on yours.
>
> M4: In some it does and in others it does not. (FGD 10)

Five different narratives were reported by the participants regarding rabies vaccination, each of them providing key information about perceived or experienced barriers to participation in dog vaccination campaigns.

1) "Injection is to cure dogs after having bitten somebody. If it dies…."

> Children (C) 1: Ours at home was injected and died.
>
> C2: This one is grieving.
>
> […] C1: The problem is that after it was injected it just got worse and died.
>
> C3: Got crippled.
>
> C1: It suddenly, eishh..

[…] C3: Didn't they poison it? (FGD 06)

This first narrative raised the confusion existing between therapeutic injection (with a purpose of treating) and vaccination (with a purpose of preventing), both administered by means of a syringe. Hence, for dog owners if the dog died a few hours or days after vaccination (for treatment), the vaccine itself would be responsible for its death, even if it died after being hit by a car.

2) "Vaccination is a plan for game lodges to kill hunting dogs."

This narrative came mostly from informal discussions with people owning dogs for hunting and who were experiencing conflicts with owners of game (wildlife) lodges and the park management. Dogs were said to be killed sometimes by eating poisoned meat balls thrown during the night into the yards of people owning hunting dogs. Hunting wildlife inside as well as outside the Kruger National Park and private game parks is illegal and considered as poaching, even small game hunting. From participant observations and informal discussions with community members, however, it appeared that for the community, the land and the wildlife still belong to them and their ancestors. In addition to remaining a traditional activity for the Xitsonga speakers, hunting is also a means to survive and cope with unemployment (getting food for the family and making money by selling bushmeat).

3) "Vaccination makes dogs weaker, less aggressive, and having less appetite."

M1: With dog vaccination? I once had dogs back then. After being vaccinated, they seem less strong than the way they used to be, they were weakened.

M5: They look numb.

M1: Yes. But when not vaccinated, you find that they do not. They seem strong. But if not vaccinated its aggressiveness stays the same. But if vaccinated its aggressiveness becomes less. (FGD 10)

The third narrative was built around the belief that after receiving the vaccine, dogs looked generally less active and less aggressive, hence less capable to be a good "security guard" to protect against thieves and aggressions or to hunt. The origin of this belief was said to come from the posters found in the veterinary clinics or health centers showing a picture of a very aggressive rabid dog and saying that in order to avoid that (an aggressive dog), dogs need to be vaccinated against this disease (Figure 3).

Figure 3: Picture of the poster found at the Hluvukani Animal Health Centre (acknowledgement Agricultural Research Council - Onderstepoort Veterinary Research, Onderstepoort, South Africa).

4) “Dogs are trained not to bite, hence less risk to spread rabies, hence no need for vaccination.”

According to this fourth narrative, a dog by its nature or through being well trained by its owner would not bite people unless they deserved it.

> If your dogs had not been trained once they bark, and they bite that person, you as an owner have a problem with your dogs. You did not train them to know that people do visit your home. (FGD 10)

This meant that if a dog would not bite people, there would be no risk of infecting people with rabies, hence no need to vaccinate it against this disease. This belief was sustained by the other idea that rabies was seen as a natural disease in dogs.

> According to its nature, a dog is not expected to bite people, and does not bite people with no reason. Its teeth shiver if it wants to bite a person. (FGD 04)

5) “Not knowing for which disease the vaccination is for”

The last narrative hindering dog vaccination was based on the lack of information said to be given by the veterinarians or animal health technician, or people helping during vaccination campaigns, about the vaccination purpose and the vaccine content.

> It depends on what the vaccination is for, both between dogs and livestock, as we do not have a broad knowledge on that. As maybe if you feel the pain, they [animal health technician] might just inject you only a part of vaccination, and

that gets complicated after. There are many diseases maybe for which vaccination would be for. (FGD 15)

Dog Vaccination Campaigns: The persons who agreed to participate in future vaccination campaigns, mainly men and children, raised some conditions: only if they are not at work/school, if the campaign takes place nearby their home and if dogs do not die following the injection. Some participants were also willing to assist veterinarians, mainly children and women, and as such learning more about how to prevent diseases.

The dog owners made also some recommendations to the state veterinarians regarding those campaigns: to have more frequent vaccination and veterinarian visits, be consistent in the follow-up, give a better explanation why and against which disease veterinarians are vaccinating their animals, honor the scheduled vaccination campaigns, and inform them on time.

Barriers to Access the Veterinary Clinics: For all the three villages, the levels of accessibility of the dog population to animal health care was hampered by the fact that the clinics were too far from their home and that they rarely had private transport to carry the dog, as it was not allowed to bring a dog on public transport in South Africa, as well as taxis.

M3: Where am I going to put it? Can you board a taxi along with it?

M8: It is also already dangerous for the one sitting next to it.

M4: It is dangerous.

> M8: Even to myself, I will just be hurt, but … Yes, it is too hectic. (FGD 05)

Therefore, finding a way to reach the clinic was considered to be difficult and too expensive. Other barriers mentioned were not having enough phone credit to call a veterinary clinic in case of emergency, the lack of information (not knowing where and when to go), the general lack of knowledge, laziness, and the fact that the dog could recover spontaneously.

Role of the Government to Keep Dogs Safe: Generally, the groups mixing dog owners and non-owners provided most suggestions about how the government could or should support people regarding dog management. In contrast, the groups of dog owners and the children provided little feedback about it, but obtaining veterinary drug supplies and being assisted with feed for dogs were considered the most important support for all the groups. The main support adults—with the exception of owners—were asking from the government was free dog vaccination.

> Dogs are like cattle we have to pay when they are sick, but if they are to be vaccinated it must be free as we are just preventing diseases. But if they say we have to pay, we will. (FGD 09)

Adults were also asking to be assisted for feed (and water) and more importantly for men to be taught how to prevent dogs from getting sick. According to some respondents, the government should also provide a nearby animal health clinic, mobile veterinarians, a social grant for the dog owners (to make them more involved

with vaccination campaigns and to decrease the number of street dogs), and build a shelter to keep unwanted dogs.

Discussion

Our study highlights key socio-cultural factors among the Mnisi community regarding rabies control measures, especially dog vaccination and dog bite management. Although there has been a growing scientific interest in dog rabies control in Africa during the last two decades (Jibat et al., 2015), we present to our knowledge the first socio-anthropological study of contemporary rabies dog vaccination in South Africa.

Many previous epidemiological surveys and studies on knowledge, attitudes, and practices (KAP surveys) identified certain rabies vaccination barriers and human rabies risk factors and captured the relative importance of social and cultural factors in the field of rabies control and elimination (Digafe et al., 2015; Kaare et al., 2009; Matibag et al., 2007; Sambo et al., 2014;; Schildecker et al., 2017; Wallace et al., 2017 among others). Yet, our study illustrates that vaccination coverage is clearly influenced by local dog ownership practices, which in turn are mediated by several contextual factors: historical, social, cultural, political, economic, and ecological, particularly here in relation with the colonial period, the establishment of Protected Areas on land traditionally occupied and used by indigenous people, and the Kruger National Park (KNP) management (Anthony, 2007; Cock and Fig, 2000; DeGeorges and Reilly, 2008).

Various studies on practices characterized as “responsible dog ownership” have been conducted in Western societies (Meyer and Forkman, 2014; Rohlf et al., 2010). The

World Organization for Animal Health (OIE) is currently revising its standards on stray dog population control[3] by advocating for more responsible dog ownership. The Global Alliance for Rabies Control (GARC) has also placed emphasis on enhancing public awareness and/or education regarding responsible dog ownership, identified as a key factor to be addressed to successfully control and eliminate rabies.[4] The set of responsibilities raised by our participants about what dog ownership implies for them–such as feeding, providing health care and safe environment (confining), training, and socializing–may be different from the ones advocated and commonly adopted in developed countries (see also the 15 guidelines for Responsible Pet Ownership provided by the American Veterinary Medical Association[5]). In economically disadvantaged communities such as the Mnisi population, the observed lack of care regarding dogs (and domestic animals in general) is often cast in negative terms, but it is crucial to highlight that more structural drivers also influence people's decision-making or social practices regarding animal management (MacGregor & Waldman, 2017). Addressing dog ownership responsibility by a simple linear process of education and social engineering will not address the constraints faced by dog owners due to a lack of resources (e.g., accessible and affordable veterinary care, transport, material and cost of fencing, etc.). While the focus is often on socio-demographic factors that need to be considered when developing rabies control strategies in African settings (Gsell et al., 2012; Hampson et al., 2009; Mpolya, 2019), having a local and systemic understanding of what "responsible dog ownership" means to people (including for whose and for what type of dogs), is important as a starting point to successfully engage with communities.

Although respondents demonstrated reasonably good knowledge of rabies, including its zoonotic component with especially the role of dogs in transmission and common clinical signs in animals and humans, multiple opinions were identified about its source, control, and treatment among the different groups. None of the groups of respondents had a clear idea of how dogs become infected with rabies and many blamed wildlife. Living at the edge of the KNP, speculations about wildlife playing a role in rabies transmission are understandable, although not supported by evidence (Grover et al., 2018). Despite the frequent occurrence of rabies in black-backed jackals in Limpopo Province, bordering Mpumalanga Province in the north, jackals have not played a notable role in the transmission of rabies in and around the KNP (Mkhize et al., 2010).

While dog bites were identified as a rabies risk, they also posed a source of conflict between dog owners and bite victims, which could hamper good bite case management. Fear of having their dog killed, or being held responsible for payment of someone's medical treatment were motivations for dog owners to participate in rabies control activities (Bardosh et al., 2014; Séverine Thys, own observations). However, from the bite victim's perspective, this ownership responsibility was felt to lead to social pressure to not disclose the dog nor the owner's identity. This was compounded by the risk that the cause of the bite incident might be attributed to the victims, highlighting that the notion of social responsibility of the owner and the victims is generally reflecting much broader divisions within the community (Bardosh et al., 2014).

Already identified in other studies (Ali et al., 2013; Bardosh et al., 2014; Castillo-Neyra et al., 2017; Muthiani et al., 2015), participation in rabies vaccination campaigns was affected by irregular and infrequent mass vaccination campaigns, tenuously scheduled follow-up times, and lack of information about the vaccines and the process of the campaign. Barriers such as inappropriate schedules could be solved by avoiding school or work time for example, as suggested by men and children who are the ones most willing and in charge to bring the dogs. The suggestion made by women and children to assist the veterinarians during the campaign raised the importance given by our participants to gain more knowledge but also to get an opportunity to dispel possible suspicions through community-assisted campaigns.

Vaccine hesitancy due to mistrust of human vaccination programs in low to middle income countries (Cobos Muñoz et al., 2015; Mills et al., 2005), and increasingly in high income ones (Dubé et al., 2013), is replete in the literature. The following barriers to human vaccination may also apply to veterinary vaccination programs: rumors, conspiracies, concerns about the quality of the vaccine, i.e. counterfeit, expired or of low quality, especially when delivered for free, side effects and harmfulness, lack of clarity about the benefits of vaccination (Abakar et al., 2018; Yahya, 2007). These may be affected by divergences in issues of power, knowledge, religion, interests, and social norms between different social groups (Bardosh et al., 2014). Differences between biomedical and local understandings, which are known to lead to community resistance to vaccination programs (Waller & Homewood, 1997) were also captured in our narratives: misperception of vaccination purposes, i.e. curing rather than preventing owing to the same act of injecting; rumors of elimination of hunting dogs orchestrated by lodge managers owing to human-wildlife

conflicts (HWCs); the vaccine making dogs less aggressive, possibly due to misinterpretation of health promotion messages of posters; the belief that a well-trained dog does not bite and therefore is not harmful for the community; and suspicions due to a lack of information about the vaccine.

Our qualitative research provides in-depth information on reasons for not vaccinating dogs, which was a gap identified by the systematic review of Davlin and VonVille (2012) on canine rabies vaccination and domestic dog population characteristics in low to middle income countries. Several vaccination barriers were found similar to those in other developing countries. Yet, this qualitative research approach revealed specific local barriers which remain key to improving compliance, even among the more general patterns commonly observed.

The further added value of our study was the inclusion of different groups among household members (women, men, and children) and examination of the perspective of non-dog owners in regard of dog ownership practice, social responsibility, and rabies control awareness. Breakdown of information provided by the three different demographic groups of dog owners may be useful to inform recommendations. In general, women seemed to care less about dog welfare than men or children but were more informed about health threats from dogs; dog ownership was mainly a male activity and adult male owners remained the decision-makers regarding dog care; children were too young to be owners themselves although they were the ones playing and enjoying most the presence of dogs. The conflicts arising in the aftermath of a dog bite between victims, dog owners, and the health clinic were mainly mentioned by women. Finally, men and children expressed particular interest to actively

participate in vaccination campaigns and to learn more about dog health in general. Combined with a participative approach and collaboration with health communication experts, the collected information and further discussions with the different group categories will contribute to the development of more appropriate disease control posters; for instance by addressing the identified misleading link made between an aggressive dog and the need for a (rabies) vaccine.

However, our study and the data obtained do have several limitations. We omitted to include the perspectives of other local actors (such as frontline health and veterinary workers and lodge managers) who by their perceptions, behaviors, and contexts were also influencing dog vaccination campaigns. Capacities, norms, and policies of implementing institutions also play a central role in rabies control efforts (Bardosh et al., 2014). The non-homogeneity of certain groups regarding the dog ownership status may have caused information bias as well as hampering participation in the discussion and discomfort.

In conclusion, these data provide information with potential immediate local benefits as well as broader and longer-term implications for a more widespread participation in dog rabies vaccination in the Mnisi community of South Africa.

The recommendations developed from this study have an implication for (veterinary) public health and could offer some applications to vaccination programs in other areas also located at a human-wildlife-domestic animal interface and beyond. As canine rabies poses a threat not only to human health, but also for dog welfare and wildlife conservation, the lack of trust should be addressed or restored at several levels:

- Develop an information, education, and communication program on rabies knowledge gaps and the misinterpretations of messages regarding vaccination.
- Clarify the procedure in the case of dog bite incidents by (1) including the importance of first aid care of the wound before seeking medical attention, and (2) adapting the process; for example, by removing the need for a police report before the start of treatment, in order to avoid barriers to care access and delays, to protect the victims from the dog owners' possible dishonesty or reprisals but also to ease the communication between health officers and veterinarians/animal health workers.
- Involve health clinics and game lodges in vaccination campaigns in order to address rumors.
- Include more regularity, sensitization, and time during rabies vaccination campaigns such as face-to-face information sessions together with vets and the Community Development Forum[6] about existing dog diseases, transmission, and treatments; purpose and details regarding dog vaccination; tips on how to train and manage dogs.
- Invite community members who manifested interest to participate actively in the implementation of vaccination campaigns for moving towards more community-directed vaccination efforts for rabies.
- Address human-wildlife conflict issues for sustainable development by ensuring that the interventions are effective in terms of community equity rather than emphasizing only the efficacy of current tools and strategies (Bardosh et al., 2014). A cross-cultural research approach to prevent and mitigate conflict and aid in coordinated action will be useful in advancing an

understanding of human–wildlife conflict at this interface (Manfredo and Dayer, 2004).

- Broaden the constituency for support, offering the potential for developing integrated control measures that involve veterinary public health, tourism, wildlife conservation and animal welfare agencies (Regea, 2017).

Furthermore, mixed-methods investigations adopting a socio-ecological approach focused explicitly on the dynamic interactions between nature and society and committed to place-based and solution-driven research across multiple scales (Gardner et al., 2013) would be appropriate in such human-wildlife-domestic animal interface settings. This kind of investigation could especially follow up on the Grover et al. (2018) study on the spatiotemporal rabies epidemiology conducted in the private reserve at the unfenced western boundary of the KNP in eastern Mpumalanga Province where a large number of rabid dogs were found in a reserve (Grover et al., 2018).

Intimately related to people's behaviors regarding dogs, the ecologies of the different dog categories (e.g., individually owned/stray-collectively owned/wild-feral not owned), which depend on their attributed roles, are also major drivers of the maintenance and transmission patterns of rabies, which once identified spatially would provide a better understanding and control in the specific ecosystem of the studied area. Quantitative data on dog ecology and their epidemiological role (movements, contact networks) would therefore be gathered through participatory protocols with local stakeholders and combined with qualitative data in order to link

social and ecological systems. The management of a dog depends on its roles which in turn will influence its ecology.

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Conflicts of Interest

The authors declare there are no conflicts of interest.

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Notes

1. The datasets used and analyzed during the current study are available from the corresponding author on request.

2. A government-created place with a large tank where livestock can be immersed in an acaricide and used as a weekly meeting point for veterinary monitoring.

3. http://oiegeneralsession.com/en/supporting-the-development-of-national-rabies-control-programmes-in-affected-countries/

4. https://canineraviesblueprint.org/The-GARC-Education-Platform-a

5. www.avma.org/KB/Policies/Pages/Guidelines-for-Responsible- Pet-Ownership.aspx

6. Community Development Forum (CDF) is an internal leadership group that generally represents individuals of all village factions, including traditional leaders, cattle owners, traditional healers, health care workers, and teachers (Berrian et al., 2018).

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