



Seroprevalence of leptospirosis in dogs in urban Harare and selected rural communities in Zimbabwe

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A cross-sectional study was conducted to investigate seroprevalence of canine leptospirosis in urban Harare and five selected rural communities in Zimbabwe and to assess public awareness of the disease. Sera from randomly selected dogs were tested for antibodies to the serovars Canicola, Grippotyphosa, Icterohaemorrhagiae and Pomona of *Leptospira interrogans* using an enzyme-linked immunosorbent assay. Clinical chemistry was performed on all seropositive and selected seronegative sera to screen for hepatic and renal insufficiency. A questionnaire-based survey was conducted in Harare to assess dog owners' awareness of leptospirosis and other zoonoses. Overall, 15.6% of sera samples tested (39 out of 250; 95% confidence interval [CI]: 11.0% – 20.2%) were positive for leptospiral antibodies. A significantly higher ($p < 0.05$) seroprevalence was recorded in urban dogs than in rural dogs (25% vs. 11.2%). No significant difference in seroprevalence was observed amongst dogs from different rural communities or between sexes of dogs. There was a significant association between seropositivity and hepatic and/or renal insufficiency ($p < 0.01$), with dogs having hepatic and/or renal insufficiency being approximately twice as likely to be seropositive (relative risk = 1.96; 95% CI: 1.3–3.0). Of the dog owners, 78.8% (119/151) were aware of zoonoses. Except for rabies (92.4%), awareness of leptospirosis (5.0%) and other zoonoses amongst these owners was low. This study showed that leptospirosis was present and represented a risk to dogs from urban Harare and the selected rural communities in Zimbabwe. Availing training programmes for dog owners would be beneficial in improving disease control and reducing the public health risk of pet zoonoses.

Introduction

Canine leptospirosis is a worldwide bacterial zoonosis, caused by pathogenic spirochaetes that are currently classified as a single species, *Leptospira interrogans*, and further subdivided into several serogroups and serovars based on antigenic differences (Ellis 2010; Plesko & Hlavata 1971; Roach, Van Vuuren & Picard 2010). The disease is characterised by septicaemia, renal and hepatic diseases, coagulopathies, abortions and other abnormalities, with a fatality rate of 10% – 20% in dogs (Cullen, Haake & Adler 2004; Grooms 2006). Infected dogs may present with renal failure or be carriers of leptospiral organisms in their proximal convoluted renal tubules for 1–2 years in a sub-clinical form from where they are persistently shed in urine (Levett 2001). Following shedding in urine, these bacteria may survive for some months under appropriate conditions (moist or wet environments); however, survival is very poor in dry or cold environments (Adler & Moctezuma 2010). Transmission generally occurs after a susceptible animal has been exposed directly to leptospires from an infected host's urine or contaminated water, mud or moist soil (Bulach *et al.* 2006). Shedding animals pose a public health risk to humans who get in contact with urine-contaminated environments, particularly water (Sykes *et al.* 2011).

Leptospires are maintained by a wide range of primary reservoir hosts, including dogs, rodents, cattle, pigs and wildlife, but may also occur in many other mammals that act as incidental or accidental hosts. Although dogs are the primary reservoir host to the serovars Canicola and Bataviae, they may also be infected with serovars such as Icterohaemorrhagiae, Grippotyphosa and Pomona. It has been postulated that the re-emergence of leptospirosis and changes in the epidemiology of the infecting serovars may be due to urbanisation of rural areas in the 1980s and 1990s, which provided greater opportunity for contact between domestic animals and wildlife reservoirs (Murray *et al.* 2009). Investigations of the resurgence of canine leptospirosis revealed conflicting findings for risk factors such as age, sex, breed and free-roaming lifestyles of dogs. However, environmental factors such as increased precipitation, warmer temperatures, seasonality of cases, access to raw sewage and drinking from contaminated water sources have been identified fairly consistently as important risk factors for canine leptospirosis (Bulach *et al.* 2006; Duncan *et al.* 2012; Ghneim *et al.* 2007; Sykes *et al.* 2011). Although leptospirosis caused by the serovars Canicola and Icterohaemorrhagiae has been reported in other animals (Dalu & Feresu 1997), the prevalence of these and other serovars in dogs has not been studied in detail in Zimbabwe. Owing to a lack of cross-protection amongst the different serovars and reports of other serovars infecting dogs, conducting a sero-survey of canine leptospirosis in urban Harare and rural



communities in the country was warranted. Furthermore, in spite of the zoonotic importance of the different *Leptospira* serovars, studies on public awareness of leptospirosis have not been conducted. Therefore, this study was conducted to determine not only the seroprevalence of canine leptospirosis in urban Harare and selected rural communities but also to assess public awareness of the disease.

Materials and methods

Study location and collection of serum samples

The study was conducted in urban Harare and five rural communities (Marumani, Machuchuta, Ndhlovu, Kariba and Malipati) in Zimbabwe. In Harare, serum samples were collected from dogs presenting at private veterinary practices for routine elective surgery or ill health. Routine vaccination against leptospirosis is done in most of the urban areas in the country and for the purposes of this study, only dogs with no given history of vaccination were sampled. According to the information obtained from the owners, these dogs were reared in confinement in individual homes.

The Animal and Wildlife Area Research and Rehabilitation trust (AWARE Trust) has been conducting spay and castration campaigns amongst dogs and collected samples in randomly selected rural communities in Zimbabwe. Owing to access to a large number of dog serum samples, the rural communities where the AWARE Trust operates were randomly selected for the study. Hence, serum samples collected by the AWARE Trust just prior to ovariohysterectomy and orchidectomy of apparently healthy dogs with unknown medical histories were used for this study. Currently rural dogs are not vaccinated against leptospirosis and are all considered to be free roaming, which allows for contact with other dogs in the same village.

Testing for canine *Leptospira* antibodies

The canine *Leptospira* antibody test kit (ImmunoComb®, Biogal-Galed Laboratories, Israel), designed to determine dog serum immunoglobulin G (IgG) antibody titres to four different serovars (namely Canicola, Grippotyphosa, Icterohaemorrhagiae and Pomona) of *L. interrogans*, was used in this study. The ImmunoComb® test is a so-called enzyme-labelled 'dot assay', which is a modified enzyme-linked immunosorbent assay (ELISA) (<http://www.biogal.co.il>). Serum samples were tested according to the manufacturer's instructions. Briefly, pooled *L. interrogans* antigens were used to screen for the presence of antibodies to the four *Leptospira* serovars. Before conducting the test, the developing plates were incubated for 22 min at 37 °C. The test was then performed at room temperature (20 °C – 25 °C) in a 72-well developing plate (12 columns × 6 rows). A 5-μL aliquot of the serum was deposited into each well of only the first row, mixed with the antigens adsorbed onto the lower portion of the comb and allowed to stand for 5 min. The comb was transferred to corresponding wells of the second row where unbound antibodies were washed off. The comb was then inserted into the wells of the third row, which contained an

enzyme-labelled anti-dog IgG antibody that binds to the antigen-antibody complex at the test spots, and was allowed to stand for 5 min. After two more washes in the wells of the next two rows, the comb was transferred to the corresponding wells of the last row for 5 min, where a colour developed via an enzymatic reaction. Upon completion of the colour development in cells of the last row, the comb was moved back to the cells of the fifth row for 2 min to facilitate colour fixation. The comb was removed and left to dry for up to 10 min. The threshold for determining seropositivity was based on the manufacturer's recommendations. The bottom spot on the comb represented the result of the reaction between the anti-dog IgG antibody and *Leptospira* serovar IgG antibodies in the samples tested. The colour intensity of the bottom spot, representing the *Leptospira* serovar IgG antibodies, was then compared with that of the upper positive reference spot. A clear purple-grey dot indicated a positive reaction. The results were read with a calibrated (graded from S0 to S6) colour CombScale provided with the kit. A scale of S3, which is equivalent to a positive immune response at a titre of 1:400 by the microscopic agglutination test was considered as the cut-off level of IgG antibodies (<http://www.biogal.co.il>). Hence, in this study serum samples with a CombScale score of ≥ S3 (i.e. ≥ 1:400 titre) were considered as positive for leptospiral antibodies to the tested serovars.

Evaluation for hepatic and renal insufficiency

Since renal and hepatic insufficiency are features suggestive of leptospirosis (Adler & Moctezuma 2010), all the leptospiral seropositive and randomly selected seronegative dog serum samples were evaluated for hepatic and renal insufficiency by testing for elevated liver enzymes and/or urea and creatinine levels. Hepatic insufficiency was determined by measuring the activity of aspartate aminotransferase (AST; reference value < 30 IU/L), alkaline phosphatase (ALP; reference value < 100 IU/L) and alanine aminotransferase (ALT; reference value < 30 IU/L). Renal insufficiency was determined through measuring blood urea nitrogen (BUN; reference value < 6 mmol/L) and serum creatinine (reference value < 150 mmol/L). An automated chemistry analyser (Humastar 180®, Human Diagnostics Worldwide, Wiesbaden, Germany), which was calibrated and run according to the manufacturer's recommendations, was used to measure liver enzyme activity and creatinine and BUN levels. Positive and negative control sera were obtained from Diagnopath Laboratory (Pvt) Ltd, Harare.

Questionnaire survey regarding dog zoonoses

A cross-sectional questionnaire-based study was employed to investigate public awareness of dog zoonoses, including canine leptospirosis. A systematic random sampling technique was used to select dog owners attending private veterinary practices in Harare. Questionnaires with multiple choice and open-ended questions were distributed to at least 10% of dog owners attending each veterinary practice. The questionnaire was designed to obtain information on dog owners' awareness of dog zoonoses, with emphasis on canine leptospirosis and the behavioural practices that may lead to an increased risk of leptospiral transmission.



Data analysis

Statistical analyses were performed using Stata version SE 11.0 (Stata Corp., TX, USA). The total number of seropositive dogs was calculated according to sex and origin by considering the total number of samples tested and expressing it as a percentage. The χ^2 -test was used to measure differences in proportions between generated categories and p -values of < 0.05 were considered significant. Seropositivity was also analysed according to hepatic and renal insufficiency. The association between seropositivity and hepatic and/or renal insufficiency was evaluated by calculating χ^2 , the relative risk (RR) and the 95% confidence interval (CI) using Win Episcope version 2.0® software. For questionnaire data the dog owners' responses were analysed using descriptive statistics (frequencies and proportions) related to awareness of dog zoonoses.

Ethical considerations

Ethical approval for use of dogs and for all protocols in this study was obtained from the Ethical and the Higher Degrees committees of the Faculty of Veterinary Science. The purpose of this study was well explained to the owners of the dogs, who all expressed consent to participate in the study. Standard operating procedures were followed for collection of blood samples and dogs were provided with adequate clean drinking water.

Questionnaire respondents were selected on a voluntary basis from clients visiting veterinary surgeries. Respondents were entitled to withdraw the consent up to a week of data submission. To protect data, questionnaires were submitted in sealed envelopes.

Results

Seroprevalence of canine leptospirosis

The distribution of sampled dogs and their leptospiral seroprevalence according to different categories are shown in Table 1. A total of 250 serum samples were collected and the overall seroprevalence was 15.6% (39 out of 250; 95% CI: 11.0% – 20.2%). Overall, urban dogs from Harare recorded a significantly higher seroprevalence ($\chi^2 = 7.9$, $p < 0.05$) compared to rural dogs. A significantly higher seroprevalence was recorded amongst female urban dogs ($\chi^2 = 9.5$, $p < 0.05$) compared to rural female dogs but there was no significant difference between urban male ($\chi^2 = 0.61$, $p > 0.05$) and rural male dogs. Overall, there was no significant difference ($\chi^2 = 0.149$, $p > 0.05$) in seroprevalence between the sexes (Table 1). For rural dogs, seroprevalence varied from 5.9% – 17.6% but the differences were not significant ($p > 0.05$).

The majority (69.2%) of dogs that tested positive had a titre of 1:400, with 45% of positive urban dogs recording a titre of 1:800 or higher (Table 2). Two of the positive urban dogs had titres of 1:1600 and 1:3200, respectively, whilst none of the positive rural dogs had a titre above 1:800 (Table 2).

Of the dogs tested for hepatic and renal insufficiency, 22.5% (18 of 80) had both hepatic and renal insufficiency, whilst 10% (8 of 80) had hepatic insufficiency only and 2.5% (2 of 80) had renal insufficiency only (Table 3). The median values of serum indicators in these dogs were 25 mmol/L BUN (range = 6 mmol/L – 77 mmol/L), 202 mmol/L creatinine (range = 47 mmol/L – 1309 mmol/L), 72 IU/L AST (range = 36 IU/L – 271 IU/L), 284 IU/L ALP (range = 118 IU/L – 5924 IU/L) and 76 IU/L ALT (range = 38 IU/L – 372 IU/L). Hepatic and/or renal insufficiency presented only in urban seropositive dogs. Of these, 65% (13 of 20) presented with both hepatic and renal insufficiency, 25% presented with hepatic insufficiency only and 10% had renal insufficiency only. The seropositive urban dog for which the highest titre (1:3200) was recorded also presented with the highest ALP value (5924 IU/L). Overall, the results demonstrated a significant association between seropositivity and hepatic and/or renal insufficiency ($\chi^2 = 8.9$; $p < 0.01$) and dogs with hepatic and/or renal insufficiency were approximately twice as likely to be seropositive for leptospirosis (RR = 1.96; 95% CI: 1.3–3.0).

TABLE 1: Distribution of *Leptospira* seroprevalence according to sex and location.

Category	Level	Number tested	Positive	Seroprevalence (%)	95% confidence interval
All animals	Overall	250	39	15.6	11.0–20.2
Urban	Female	42	13	31.0	17.1–44.9
	Male	38	7	18.4	6.1–30.7
	Overall	80	20	25.0	15.6–34.4
Rural	Female	92	9	9.8	3.7–15.9
	Male	78	10	12.8	5.4–20.2
	Overall	170	19	11.2	6.5–15.9
Rural	Marumani	34	2	5.9	–1.9–13.7
	Machuchuta	24	2	8.3	–2.7–19.3
	Ndhlovu	54	5	9.3	1.5–17.1
	Kariba	24	4	16.7	1.0–32.4
	Malipati	34	6	17.6	3.9–31.3

TABLE 2: The distribution of *Leptospira* seroprevalence according to location and titre.

Category	Number of positive samples	Titre							
		1:400		1:800		1:1600		1:3200	
		n	%	n	%	n	%	n	%
Rural	19	16	84.2	3	15.8	0	–	0	–
Urban	20	11	55.0	7	35.0	1	5.0	1	5.0
Total	39	27	69.2	10	25.6	1	2.6	1	2.6

n, number of animals.

TABLE 3: The number and percentage of dogs evaluated for hepatic and renal insufficiency according to seropositivity.

Category	Leptospira seropositive		Leptospira seronegative		Total	
	n	%	n	%	n	%
Hepatic and renal insufficiency	13	33.3	5	12.2	18	22.5
Hepatic insufficiency only	5	12.8	3	7.3	8	10.0
Renal insufficiency only	2	5.2	0	0	2	2.5
No hepatic or renal insufficiency	19	48.7	33	80.5	52	65.0
Total	39	100	41	100	80	100

n, number of animals.



Questionnaire responses

A total of 75.5% (151 of 200) dog owners contacted responded. The gender distribution was roughly equal (52% men vs 48% women) and most respondents (80.8%) were older than 21 years. Most respondents (87.4%) were from non-medical professions, followed by those from the veterinary (8.6%) and human medical (4%) professions. Most respondents (89.4%) had kept dogs for more than a year. The reasons cited for keeping dogs included protection (82.8%), pets (53%) and breeding purposes (4%). The number of dogs owned ranged from 1–16; 78.1% of respondents owned between one and three dogs. Amongst these respondents, 60.3% had been visiting a veterinarian for more than a year. Reasons for veterinary visits included treatment of a sick dog (83.4%), vaccinations and deworming (80.8%) and education and guidance on dog health (45.7%).

When asked about their general awareness regarding dog zoonoses, 78.8% of dog owners answered positively (Table 4). Of these respondents, a higher proportion (92.4%) was aware of rabies as a zoonotic disease in dogs compared with other named zoonoses (Table 4). Other zoonoses mentioned were worms (6.7%), leptospirosis (5%), brucellosis (1.7%), ringworm (0.8%) and toxoplasmosis (0.8%). Those who named leptospirosis as a zoonotic disease in dogs were all from the veterinary profession. A few dog owners responded that tetanus (0.8%), fleas (0.8%) and ticks (0.8%) were zoonoses transmitted by dogs.

Trustworthiness

For the survey on awareness of dog zoonoses, data were collected using a simple, self-completed, structured questionnaire, which was pre-tested to identify difficult and ambiguous questions. Considering that the majority of the respondents kept dogs and have been visiting veterinary surgeries for over a year, we considered the information provided a true reflection of their awareness of dog zoonoses.

Discussion

The reference method for serological diagnosis of leptospirosis is the microscopic agglutination test (Levett 2001). However, because of its complexity, rapid screening tests such as the ImmunoComb® ELISA kit (Biogal-Galed Laboratories, Israel) have been developed for detecting leptospiral IgG antibodies in acute infection. Other studies (e.g. Odontsetseg, Sakado

& Kida 2005) reported this test to show a good concordance with the microscopic agglutination test and was suggested as a potential substitute diagnostic test because it was rapid, sensitive and technically less demanding to perform. Because the microscopic agglutination test relies on the use of live attenuated antigens, which require frequent subculturing, it poses a potential risk of infection to the laboratory personnel.

Neither rural nor urban dogs tested in the present study had a history of vaccination against leptospirosis. Currently only urban dogs are vaccinated in the country, using the bivalent vaccine against serovars Canicola and Icterohaemorrhagiae of *L. interrogans*. Generally, dogs vaccinated against these serovars have negative titres or titres below 1:320, which persist for a few months after vaccination (Hartman *et al.* 1984). Hence, owing to uncertainty with regard to the vaccination status of some of the urban dogs, a more liberal cut-off point of titres ($\geq 1:400$) for *Leptospira*-seropositive dogs was adopted. The ImmunoComb® ELISA kit has a high sensitivity (80%), thus reducing the possibility of false negative reactions (<http://www.biogal.co.il>). Although cross-reactivity between antibodies of *Leptospira* and *Borrelia* spp. is suspected, it has never been confirmed (Shin *et al.* 1993); furthermore, lyme disease has not yet been detected in Zimbabwe. The most commonly indicated serovars in canine leptospirosis have been the Canicola, Icterohaemorrhagiae, Pomona, Bratislava and Grippotyphosa types (Greene, Miller & Brown 1998). Despite its inability to distinguish between the specific serovars, the ImmunoComb® ELISA kit has a mixture of antigens of four of these most common serovars in dogs. Hence, the positive results obtained in the present study are likely to indicate exposure to one or more of these common serovars. However, a lack of serovar-specific data in the present study makes it difficult to conclude on the predominant serovar or serovars and this requires further investigation. The very high titres observed in some of the dogs are likely to indicate acute leptospirosis at or around the time of sampling (Rentko *et al.* 1992). Interestingly, the highest titre (1:3200, CombScale value 6) was detected in an urban dog with a markedly elevated ALP (5924 IU/L), which provided further support for active leptospirosis that was likely accompanied with hepatic damage. This possibly advocates for a review of the vaccination regime against leptospirosis in urban dogs.

In Zimbabwe there is limited information on canine leptospirosis. The first report was from a case amongst dogs in urban Bulawayo in the south-western part of Zimbabwe during the period 1956–1957 (Graf 1965). A survey in the same urban area demonstrated the presence of the disease in two dogs diagnosed serologically and clinically, and a seroprevalence of 13.7% (19/146) against serovar Canicola was reported (Banks & Pigott 1979). The disease was also detected serologically in 2.7% of dogs but details regarding the number and origin of the samples and the infecting serovar or serovars were not given (Feresu 1982). The serological results of the present study using pooled antigens of the serovars Canicola, Grippotyphosa, Icterohaemorrhagiae and Pomona indicated the presence of leptospirosis in both urban and rural dogs.

TABLE 4: Dog owners' awareness of dog zoonoses.

Variable	Number	Percentage
General dog zoonoses	119	78.8
Including:	-	-
Rabies	110	92.4
Worms	8	6.7
Leptospirosis	6	5.0
Brucellosis	2	1.7
Ringworm	1	0.8
Tetanus	1	0.8
Toxoplasmosis	1	0.8

n = 151.



The epidemiology of leptospirosis is mainly influenced by a primary host species that acts as the reservoir for each serovar. *Leptospira interrogans* serovars such as Canicola and Icterohaemorrhagiae have been reported as the most prevalent in causing canine leptospirosis worldwide (Greene & Shotts 1990). Dogs and rats are the reservoir species for the Canicola and Icterohaemorrhagiae serovars, respectively (Greene *et al.* 1998). The widespread use of bivalent vaccines that are specific against only Canicola and Icterohaemorrhagiae has resulted in a decreased prevalence of canine leptospirosis associated with these serovars (Higgins 2004; Prescott *et al.* 2002). In other regions there have been reports of the apparent re-emergence of canine leptospirosis associated with a change in the infecting serovars (Bolin 1996). The serovars commonly reported are Grippotyphosa and Pomona (Ghneim *et al.* 2007; Ward, Glickman & Guptill 2002), with a wide range of wild and domestic animal reservoir species identified (Greene *et al.* 1998). In Zimbabwe, the serovars Canicola, Icterohaemorrhagiae, Grippotyphosa and Pomona have been detected serologically in pigs (Mavenyengwa, Keller & Munyombwe 1999), cattle (Feresu 1987, 1988; Graf 1965; Swanepoel *et al.* 1975) and rodents (Dalu & Feresu 1997). It is therefore likely that these reservoirs, together with dogs, act as sources of infection for other dogs. However, rats in particular are major sources of infection for humans and dogs and it has been suggested that the serovars present in rodents in a given environment are similar to those present in dogs living in the same environment. Given earlier reports of high rodent seroprevalence (62.5%) and high serovar isolation, mostly from *Rattus rattus*, in Harare (Dalu & Feresu 1997), rats could be considered a major source of infection; however, further investigation is required.

As in earlier studies (Adin & Cowgill 2000; Alton *et al.* 2009; Barr 2002), we also observed that seroprevalence of leptospirosis differed between urban and rural dogs, with the former group being at a higher risk for infection. Although these results may be attributable to sampling of dogs with hepatic and/or renal insufficiency presented to private veterinary practitioners, it is likely that leptospirosis in urban dogs may result from contact with infected rodents since a high rodent leptospirosis seroprevalence was previously reported in Harare (Dalu & Feresu 1997). The greater risk of leptospirosis may reflect the higher density of dogs, rodents and veterinary clinics in the studied urban area. A higher population density of infected raccoons in urban areas of Canada has been implicated as a source of the disease amongst domestic dogs (Alton *et al.* 2009). To date, no rural comparative studies on rodent leptospirosis have been conducted in Zimbabwe. There is, therefore, a need for further studies to better understand the epidemiology of leptospirosis in both urban and rural settings. The failure to detect any overall association between the sex of dogs and leptospirosis seropositivity in the current study agrees with published reports of leptospirosis in other regions (Suepaul *et al.* 2010; Ward 2002; Ward *et al.* 2002).

Infection with serovar Icterohaemorrhagiae has classically been associated with either acute haemorrhagic disease or liver failure and uraemia (Wohl 1996). In contrast, patients

with classic infections from serovar Canicola are likely to exhibit acute renal failure associated with less hepatic involvement (Wohl 1996). Infections from serovars Pomona, Grippotyphosa and Bratislava have recently been reported to be predominantly associated with renal involvement and less consistent hepatic involvement (Adin & Cowgill 2000; Birnbaum *et al.* 1998; Brown *et al.* 1996; Okewole & Ayoola 2009). The significant association observed between *Leptospira* seropositivity and hepatic and/or renal insufficiency may further be indicative of infection with the tested serovars. Most of the urban seropositive dogs had both hepatic and renal insufficiency, which could probably be attributed to either Icterohaemorrhagiae and/or Canicola infection. For those that had hepatic insufficiency, serovar Icterohaemorrhagiae could probably be the only causative agent, whilst the Canicola, Grippotyphosa or Pomona serovars may not be ruled out for those with renal insufficiency. However, since the serological test used in this study lacked serovar specificity and no isolation was performed, other causes of hepatic and renal insufficiency could not be ruled out. Currently, routine serodiagnosis of leptospirosis is not performed in the country and it is likely that the disease is missed. In view of the emerging new serovars and zoonotic risks posed by the disease, further epidemiological studies are required to identify the prevailing *L. interrogans* serovars in dogs in Zimbabwe. This will enable formulating appropriate control measures against the disease, such as the use of a polyvalent commercial vaccine that includes the new serovars.

Except for respondents in the veterinary profession, results of the present study concur with earlier observations (Moslagae, Pfukenyi & Matope 2011; Pfukenyi *et al.* 2010) that dog owners in Zimbabwe are more aware of rabies as a zoonotic disease than other diseases (e.g leptospirosis). One weakness of the current study is that no correlation could be made regarding *Leptospira* seropositivity amongst dogs and owners' awareness of zoonoses, since the questionnaires were not administered to the owners of the dogs sampled. However, considering the number of respondents (5%) that were aware of leptospirosis as a zoonosis, it is possible that the general awareness amongst pet owners is low. Hence, awareness, teaching and training programmes for pet owners need to be instituted to improve disease control and reduce the public health risk of pet zoonoses such as leptospirosis.

Conclusion

Although further surveys in other areas of the country still need to be undertaken, the results from this study have shown that leptospirosis was present and represented a risk to dogs from urban Harare and the selected rural communities in Zimbabwe. The significantly higher seroprevalence amongst dogs from Harare compared with those from rural areas may be indicative of differences in area-level risk factors. Sex was not identified as a risk factor for leptospirosis. It is suggested that the use of *Leptospira* vaccines containing the serovars Canicola and Icterohaemorrhagiae should be continued, whilst investigations with regard to other infecting serovars are undertaken, as such data are lacking. It is also



recommended that teaching and training programmes for pet owners need to be instituted to improve disease control and reduce the public health risk of pet zoonoses.

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Competing interests

The authors declare that they had no financial or personal relationships that may have inappropriately influenced them in writing this manuscript.

Authors' contributions

G.M. (University of Zimbabwe) was the project leader and responsible for the study design and drafting the manuscript. D.M.P. (University of Zimbabwe) was the project co-leader and was responsible for the study design and statistical analysis. S.D. (University of Zimbabwe), L.M. (AWARE Trust) and K.D. (AWARE Trust) were responsible for designing the questionnaire, sample collection and testing, literature review and drafting the manuscript.

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