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Parasitic Zoonoses from Dogs: How Common are they in Zambia

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Zoonotic parasitic diseases including helminths and protozoa are common especially in areas with poor living conditions in developing countries. The poor living conditions combined with poor veterinary services and lack of awareness of the zoonotic diseases exacerbates the risks of disease transmission from animals to humans. Dogs serve different purposes, offering several benefits to humans, including companionship, life-saving actions, security as well as hunting and farming. However, dogs have also served as a source of infection for other animals and humans, and remain an important source of infectious diseases. The close relationship between dogs and humans and the fact that dogs live in close proximity to humans makes it possible for parasite/disease transmission to occur either directly or indirectly. This review is aimed at giving an update and creating awareness on the occurrence of some zoonotic infections (*Cryptosporidium*, *Giardia*, *Trypanosoma* spp and helminths) from dogs in Zambia, and highlights the need for epidemiological studies to understand the exact role dogs play in these infections. Information generated from these studies will be used by policy makers and relevant authorities to educate communities and create awareness on these zoonotic diseases which will in turn assist in preventing such infections.

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1. INTRODUCTION

In almost all human societies, dogs are widely used for different purposes, offering several benefits to humans, including companionship, life-saving actions, security as well as hunting and farming [1-2]. The loyalty of the dogs to man has earned them the name "man's best friend". In terms of companionship, dogs, in some homes, replace children who have grown and moved away from home [3]. From a public health perspective, however, dogs have been sources of zoonotic parasites [4-5] and remain an important source of emerging and re-emerging infectious diseases [6]. The importance of dogs in zoonotic diseases is related to the fact that dogs live in close proximity to humans making it possible for parasite or disease transmission to occur through direct contact or indirectly via contamination of water or food by infective stages in dog faeces.

Dogs are hosts to many parasites that may be transmitted to humans. Helminths and protozoa represent some of the important parasites that may/may not have detrimental effects on dogs and but have severe clinical consequences in humans.

Zoonotic parasites from dogs can be transmitted to humans through direct contact with infected animals or exposure to environments contaminated with infected dog faeces or indirectly via vectors. A close contact between dogs and people increases the risk of faecal-oral transmission due to the possibility of direct contact with the infective stages of the parasite. The dogs, often living in the same households with toddler-age children, pass enormous numbers of eggs in the faeces daily for many months. Although the faeces of a small dog will be dissipated in a short time, the eggs of their parasites accumulate in the environment and become a source of infection. Due to increased urbanization, the presence of pets especially dogs has also increased in popularity [7]. In these urban settings, dog faeces represent an important environmental contaminant as they are not regularly removed. Stray and unconfined, free roaming dogs that defecate indiscriminately are a major source of this contamination. Moreover, vehicular traffic can facilitate spread of viable pathogens present in the dog faeces, resulting in contamination of food and/or water which may later be a source of infection for humans. Additionally, parasite eggs can also be carried into human houses if adhered to shoes or dog's paws or fur [8-9]. Other environmental factors, such as water runoff from rain, may also play an important role in the transmission of these pathogens through contamination of water sources [10].

In Zambia, not many studies have been conducted to determine occurrence of most zoonotic infections that are known to be transmissible to humans [5,11-12], with limited data on parasitic infections of dogs. The country has seen an increase in urbanization and keeping of dogs for security as well as pets. Information and knowledge on the occurrence and prevalence of zoonotic infections is important for communities to be well informed and for policy makers to have appropriate intervention measures. This review is aimed at giving an update and creating awareness on the occurrence of some common parasitic zoonotic infections (helminths and protozoa) in dogs and their prevalence in dog populations in Zambia.

2. *Cryptosporidium* spp.

Cryptosporidium species are apicomplexan, protozoan parasites that infect the gastrointestinal tract of a wide range of vertebrates, including humans [13-14]. They are transmitted via the faecal-oral route by environmentally resistant oocysts that are shed in faeces, contaminating soil and water, and thus, providing multiple routes into the food chain [15]. *Cryptosporidium* spp. are common parasites of humans, domestic animals and wild vertebrates. Cryptosporidiosis, the disease caused by *Cryptosporidium* spp. has been considered to be a zoonotic disease for some time due to the wide host range [14].

Populations at increased risk for cryptosporidiosis include household and family contacts and sexual partners of infected patients, health care workers, day-care center personnel, users of communal swimming pools, and travellers to regions of high endemicity [16].

Immuno-compromised individuals such as those with HIV infection and AIDS are at increased risk of infection and may suffer severe clinical consequences. The illness may have a variable presentation namely; transient infection, intermittent relapsing infection, cholera-like

infection or chronic infection [18]. Severe chronic diarrhoea with considerable fluid and weight loss, which may result in death [17] are some of the symptoms associated with infection in these patients. Most infections in humans are due to the human specific *C. hominis* and the zoonotic *C. parvum* [14].

Cryptosporidium canis, in particular, is known to be dog specific (based on molecular analysis and host specificity) but several studies have reported the possibility of zoonotic transmission from dogs to humans. Reports of human infections with *C. canis* have been made in England, Wales, USA, Thailand, Kenya, Venezuela and Peru among others [19-24], though the source of infection is unknown. In the Peruvian study however, *C. canis* was isolated from both dogs and children included in the study from the same household [19]. It is therefore important to consider dogs as possible sources of *Cryptosporidium* infection even if information regarding the exact role of companion animals in the transmission of *Cryptosporidium* species is generally insufficient [25-27] especially in immunocompetent individuals. In Zambia, a number of studies have reported *Cryptosporidium* infections in humans [28-30] but genotypes isolated from these are not known.

Management of cryptosporidiosis is mainly supportive. There is no specific drug that is known to eliminate the infection. However, nitazoxanide has been shown to have some clinical efficacy against *Cryptosporidium* infection. It has been observed to reduce duration of diarrhoea and oocyst shedding [29,31]. In HIV/AIDS patients, chemotherapy and antiretroviral therapy are recommended in addition to supportive therapy. Personal hygiene and often hand washing in this particular group (HIV/AIDS) and in general is paramount in preventing infection; and contact with faeces, be it human or dog should be avoided [31-32].

In dogs, there are many reports of *C. canis* in many countries worldwide [33-35]. Despite the many reports, there is no information on its presence in dogs in Zambia. Only one study is known to have been conducted in dogs to determine the occurrence of *Cryptosporidium* spp and other parasites but no *Cryptosporidium* oocysts were detected in the 20 dogs that were tested [36]. The possibility of zoonotic transmission, highlighted by some studies [19], warrants epidemiological studies in Zambia to determine occurrence and species of *Cryptosporidium* in dogs.

There is no specific drug available for treatment of cryptosporidiosis in dogs, therefore management is mainly supportive. Most infections are however, asymptomatic [37]. In the absence of specific treatment, strict hygienic measures are necessary to prevent spread of infection, especially that *Cryptosporidium* oocysts are already infective when excreted in faeces and are highly resistant to chemical disinfection. The hygienic measures may include daily removal and proper disposal of dog faeces from kennels, home surroundings and play parks; steam cleaning and chemical disinfection (reduces oocyst concentration) of kennels or dog shelters [38].

3. *Giardia*

*Giardia duodenalis (*synonyms *Giardia lamblia, Giardia intestinalis)* is a protozoan parasite that infects the intestinal tract of many animal species including humans. Environmentally resistant cysts are passed in the faeces of infected animals, and are immediately infective if ingested by other susceptible hosts [39-40]. As such, *Giardia* species have been considered zoonotic probably because morphologically similar organisms infect humans and a variety of mammals [41]. However, evidence of the exact role of animals in the transmission of giardiasis is still limited.

There are currently seven genotypic assemblages (assemblages A to F), which are distinct evolutionary lineages, as defined by phylogenetic analysis and enzyme electrophoresis [42-43]. Assemblage A and B are considered to be predominantly for humans while C and D make up the majority of isolates from dogs. Assemblage E is isolated from hooved animals. Cats are hosts or Assemblage F while rats are hosts for Assemblage G [44-45]. Given the distribution of the assemblages between different animal species and humans, the zoonotic transmission of *Giardia* has been a topic of debate for a long time.

Dogs acquire *Giardia* infection via the faecal-oral route. They suffer minimal consequences of the disease, except in young puppies that may develop complications of persistent infection, impairment of growth and development. [39,46]. Even if dogs appear to harbour only the canine oriented assemblage C and D as indicated by Hopkins et al. and Bowman [44-45], recent studies have reported zoonotic forms in pet dogs. A study in the United States reported that 28%

and 41% of client-owned dogs presenting with infection with *Giardia* to veterinary clinics in the western United States had potentially zoonotic assemblages A and B, respectively, while 15% and 16% had host specific assemblages C and D, respectively [47]. Another study in Thailand reported finding assemblages A (79%) and B (21%) in addition to the dog specific assemblages C (12%) and D (31%) from the 104 dogs tested [48] and therefore this area was considered of epidemiologic importance in the dog to human to dog transmission of *Giardia*. This data suggest the possibility of the potential for transmission of non-canine-specific assemblages from owners to their dogs as well as zoonotic transmission from dogs to humans in that study area.

There is very little information on *Giardia* in animals in Zambia. Only a single study by Asha et al. [49] reported the presence of *G. duodenalis* and this was not in dogs but in the African painted dog (*Lycaon pictus*) with both canine specific assemblages C and D as well as the zoonotic assemblages A and B being reported. The zoonotic assemblages were more common compared to the canine host specific C and D, suggesting that these two assemblages have the potential for zoonotic transmission from the captive animals to humans due to close interaction. Another study in domestic dogs reported *Giardia* prevalence of 5% [36].

Giardia infection in dogs can be treated with fenbendazole. A combination of febantel/pyrantel/praziquantel can also be used [38]. Shampooing of dogs with products containing chlorhexidine digluconate at the beginning and the end of treatment, removal of dog faeces and strict personal hygiene may assist in reducing transmission, hence infection and re-infections in animals [50].

In humans, infection occurs through ingestion of *Giardia* cysts directly or indirectly via contaminated water or food. Humans that acquire *Giardia* infections may develop intermittent diarrhoea which is normally associated with chronic infections [51]. The many reports of possible zoonotic transmission of *Giardia* from dogs to humans [47,52-54] stresses the need for further insight into the exact role of domestic animals in the transmission of this parasite. Furthermore, the study by Traub et al. [48] which highlighted the possibility of zoonotic transmission of *Giardia* from dogs to humans and humans to dogs in Temple areas of Bangkok, Thailand should be considered.

As opposed to cryptosporidiosis, effective drugs are available for treatment of giardiasis. In human infections, the drug of choice is metronidazole [55]. However, due to high re-infection rates especially in highly contaminated areas [55], treatment should be accompanied by appropriate education programs designed to prevent faecal-oral transmission and re-infections [50,55-56].

4. *Trypanosoma* species

In tsetse-infested sub-Saharan African countries, pathogenic protozoan trypanosome species are commonly transmitted to a wide range of susceptible mammalian hosts, including dogs. Transmission is through the intermediate host tsetse fly (*Glossina* spp.) bites when taking a blood meal [57]. Dogs are specifically affected by *Trypanosoma evansi*, *Trypanosoma congolense*, and *Trypanosoma brucei brucei* [58] causing Canine African Trypanosomosis (CAT) with varying clinical presentation depending on species. In exotic breeds of dogs, *T. brucei* subspecies tend to cause acute disease [12] while infections due to *T. congolense* appear to be more chronic [12,59]. On the other hand, indigenous dog breeds appear to be more trypanotolerant and do not exhibit any clinical signs [57]. These trypanotolerant dogs therefore may act as a reservoir of infection for other animals as well as humans. Dogs that habour the human infective *T. brucei rhodesiense* and *T. brucei gambiense* and are usually asymptomatic may serve as a reservoir of infection for other dogs as well as humans [61-61].

Although trypanosomosis is commonly reported in farm animals [62-63], Canine African trypanosomosis (CAT) is less frequently reported [59,64]. However, recent studies have actually indicated the significance of the trypanosome parasite in dogs. Affected animals that become clinically ill exhibit clinical signs that may be severe, including lymphadenopathy, oedematous forelimbs, distended abdomen, bilateral corneal opacity, conjunctivitis with mucopurulent discharge, pyrexia, dyspnoea and evidence of anaemia [12,65] with death occurring in some cases.

In Zambia, the first case of *rhodesiense* Human African Trypanosomiasis (rHAT) was reported in 1910 by Stephens and Fantham [66] in the then northern Rhodesia. Since then, a number of cases have been reported; some documented [67-69] while others are not. Mwanakasale et al.

[68] reported two cases of rHAT in two teenagers that had presented with different clinical symptoms (atypical chronic, mild form and typical acute and severe form) and highlighted the possibility of the existence of two strains of *T. b. rhodesiense* in Zambia. Most of the cases of rHAT in Zambia have been related to some national parks in the eastern and northern parts of the country [69]. At risk are people that cohabit with wildlife in game management areas and tourists that visit national parks. With the available data indicating the presence of the infection in humans and the occurrence of the human infective parasites in "man's best friend" [12,70], mechanisms to prevent transmission of trypanosomes in both animals and humans are necessary and cannot be over emphasized. Vector control is the most important aspect in preventing *T. b. rhodesiense* infections. In addition, awareness campaigns and health education activities must be carried out to have well informed communities and prevent infection in humans [58].

5. HELMINTHS

Some helminths impede the successful rearing of dogs if puppies are not treated promptly. The outcome of infection is lowered resistance to infectious diseases, retarded growth, reduced work/activity and feed efficiency and general ill-health [71]. Parasitized animals show a variety of symptoms, depending on the parasite species and density. These signs are attributable to intestinal obstruction, irritation, mal-digestion, malabsorbtion blood loss and protein losing enteropathies [72]. Some of these helminths are of public health importance as zoonotic transmission can occur.

5.1 *Toxocara canis*

Toxocara canis, is a common roundworm of dogs and infection occurs transplacentally, transmammary and through ingestion of an infected paratenic host such as mice, rabbits containing *T. canis* encysted larvae. Infection may also occur through ingestion of embryonated eggs containing the infective second stage larvae (L2) from the environment [71,73-74]. *Toxocara canis* infection is most severe in young puppies and less commonly seen in dogs more than one year of age. Puppies may present with ill thrift, failure to gain weight, a poor hair coat and a pot-bellied appearance. Severe infections in neonatal puppies can result in acute death as a result of large numbers of larvae migrating en route to their establishment in the small intestine [45]. It is important that puppies are treated early to prevent infections and avoid spread of *T. canis* eggs in the environment. Pyrantel pamoate is recommended for puppies aged two weeks while a combination of febantel, praziquantel and pyrantel pamoate is advised for puppies older than three weeks [45]. Pregnant bitches should be treated to prevent transplacental and transmammary transmission of *T. canis* larvae to puppies; and nursing dams should be treated at the same time as the puppies (45).

In humans, toxocariasis is considered one of the most common zoonotic infections especially in disadvantaged communities; and has been reported worldwide [75-77]. Humans get infected by accidentally ingesting embryonated *Toxocara* eggs through soil contaminated with *Toxocara* eggs. In rare cases, infection has also been reported to occur by eating undercooked or raw meat from paratenic hosts containing encapsulated *T. canis* larvae [78].

Infection in humans causes larva migrans syndromes (visceral and ocular larva migrans) and covert toxocariasis [79-80]. Initially only visceral and ocular larval migrans were reported but it is now known that a syndrome known as covert toxocariasis, characterised by abdominal pain, coughing, wheezing and eosinophilia does occur in humans [79,81]. Central nervous system involvement has also been reported which results in neurotoxocariasis. This may present with seizures, mental retardation and developmental delays [82]. Although most human infections are usually asymptomatic, some individuals may develop systemic disease (characterized by fever, lymphadenopathy, coughing, wheezing and eosinophilia) or localized symptoms confined to the eye. The most serious consequence of eye infection is invasion of the retina leading to granuloma formation, heteropia or detachment of the macula. Other clinical consequences are endophthalmitis or papillitis; blindness is also common [83]. The severity and type of disease in humans depend on how many larvae are ingested or number of migrating larvae, the frequency of re-infection, and the age of the host [75,83].

In Zambia, *T. canis* has been reported in domestic dogs several times [5,84-85] with varying prevalence; 7.6%, 14% and 4.8%, respectively. However, it is not known whether

human infections are there because there are no reports or documentation available. Nevertheless, there are reports of *Toxocara* infections in humans in some southern African countries. Recently, Liao et al. [77] reported a 44.6% seroprevalence of *T. canis* in children in Swaziland, highlighting the occurrence of zoonotic infection. Presence of a dog in a household has been reported as the most important risk factor associated with human toxocariasis. The increased urbanization in Zambia has come with an increase in the keeping of dogs for both security and as pets, which may come with a risk of possible zoonotic transmission of *Toxocara* and other helminths if preventive measures are not put in place [6]. Apart from having a dog in the household, geophagy is also an important factor that can significantly contribute to infection in humans especially in heavily contaminated areas [86]. Periodic deworming of dogs and proper disposal of dog faeces, hand washing to prevent faecal-oral transmission, improved sanitation and access to clean water may help in preventing human infections with this parasite [45,87].

5.2 *Ancylostoma caninum*

Infections with *A. caninum* remain common in dogs, with the high prevalences being reported world-wide [85,88-90]. Dogs acquire the infection through skin penetration at hair follicles or sweat glands, especially between the footpads where contact with soil is frequent; and through direct ingestion of the larvae. Clinical consequences include unthriftness and chronic anaemia (which can be fatal in young puppies) in debilitated and malnourished animals [67]. Anorexia, weakness and emaciation usually accompany chronic disease. Diarrhoea with dark, tarry faeces is seen in severe infections. Mature, well-nourished dogs are usually asymptomatic but act as a direct or indirect source of infection for puppies [45]. Development of clinical disease depends on the magnitude of the challenge and host factors.

Humans acquire *A. caninum* infection through contact with moist/wet sand soil containing filariform larvae from the faeces of dogs. This usually occurs in areas where there is heavy soil contamination such as densely populated areas with unsecured or free roaming dogs. Larval invasion of skin in humans produces pruritic papules [91]. Zoonotic infection with *A. caninum* may also occur through ingestion of the larvae in soil or in tissues of paratenic hosts. This may result in enteric disease known as eosinophilic enteritis [88,92]. Skin penetration by larvae may also lead to cutaneous larval migrans (CLM) which may cause pruritus and creeping eruptions which may persist for several months [93-94].

Ancylostoma caninum infections are common in dogs in Zambia [84-85]. Islam and Chizyuka [84] reported a prevalence of 8% in Lusaka district, and years later Bwalya et al. [85] reported a prevalence of 72.9% and 70.6% in dogs from Lusaka and Katete districts, respectively. The amount of disease in people is unknown and this could be due to the fact that infections are either not documented or are not there. However, human infections with *A. caninum* have been reported elsewhere [92]. *Ancylostoma braziliense* is reported to be more frequently involved in CLM than *A. caninum* but *A. caninum* is also an important cause [94]. Periodic deworming of dogs with drugs such as pyrantel pamoate, febantel, fenbendazole helps to prevent infections and reduces environmental contamination by the hookworm eggs [45,87].

5.3 *Dipylidium caninum*

Dipylidium caninum is a zoonotic tapeworm infection which is acquired from dogs when a person accidentally ingests a flea carrying the larval stage of the tapeworm. Infection has been reported in young children (< six months). Symptoms are mild and consist of slight intestinal disturbances, including indigestion and loss of appetite [95-97]. Infection has a characteristic feature of passage of proglottids in faeces in both dogs and infected children [95]. Additionally, dogs tend to scoot to relieve the anal pruritus associated with the infection [98].

In infected dogs, praziquatel is the recommended drug for eliminating of infection [45]. Controlling the fleas (which are carriers of the infective stage of the tapeworm) on the animals would help prevent infections in both dogs and humans.

A number of studies have reported the presence of *D. caninum* in dogs in various districts in Zambia [5,84-85] with varying prevalence, 2.2%, 25% and 3.8%, respectively. Even if human infections are rare, the reported infections especially those occurring in infants [96] are of concern and should stimulate inquiry especially in areas where infections are endemic in dogs. Epidemiological studies are needed to determine the risk *D. caninum* dog infections pose to humans in Zambia.

5.4 *Echinococcus* species

Echinococcus species are parasitic cestodes that affect a number of animal species*. Echinococcus ganulosus* and *E. multilocularis* are of veterinary and public health importance [99]. Although the geographical distribution of *E. granulosus* is considered worldwide, it is higher especially in areas (for example central Asia, China, South America, Northern Africa, Australia, Kenya) where livestock (sheep and cattle) are the major intermediate hosts [100,101]. Different strains of *E. granulosus* exist, but *E. granulosus* "sheep" strain (G l) is generally considered as the most widespread strain worldwide and is endemic in Africa [45,102]. It is the common cause of cystic echinococcosis (hydatidosis or hydatid disease) in humans [103-104].

In dogs, *E. ganulosus* infection is transmitted through ingestion of food contaminated with hydatid cysts while scavenging or when fed infected offals (liver and lung) from domestic animals such as ruminants [105] (http://www.oie.int/doc/ged/D13941.PDF). The disease in dogs causes very minimal effects and is usually asymptomatic. In Zambia, *E. granulosus* has been reported in domestic cattle [106-107], an indication that the parasite maybe present in most villages/areas in Zambia where livestock rearing is common. Pandey and Sharma [108] and Banda et al. [107] reported presence of hydatidosis in cattle from abattoirs in Lusaka and Western provinces, respectively. There is however, very little information available on echinococcosis in dogs. Only two studies have reported the presence of *E. granulosus* in dogs [5,84], with one study reporting a prevalence of 1% [84].

Echinococcus infection in humans occurs as a result of infection by the larval stages of *E. granulosus*, resulting in hydatid disease. Infection occurs through accidental ingestion of eggs [109]. The symptoms and severity of the disease depend on the organ(s) involved, the size, mass and numbers of cysts or metacestode and the location where the cyst develops; immune status of the host, complications related to cyst rupture, spread of protoscoleces, and secondary bacterial infection. The cysts are usually slow growing such that even if infection is acquired early in life, symptoms only manifest in adult patients (except in infection of the brain where symptoms may be seen in children). Additionally, the cyst usually has a layer of fibrous tissue around it and so may only produce symptoms when it has reached a size that exerts pressure on adjacent organs [110]. The liver is the most common site for *Echinococcus* cyst development followed by the lungs and less frequently the spleen, kidneys, heart, bone and brain [110]. Cysts in the liver cause hepatic enlargement, right epigastric pain, nausea and vomiting with complications of jaundice, fever, portal hypertension and cholangitis [110-112]. Lung involvement presents with respiratory symptoms such as chronic cough, dyspnoea, haemoptysis, pneumothorax, pleuritis, lung abscess, eosinophilic pneumonitis [113].

In Zambia, only one study is known to have been conducted in humans on *Echinococcus* infection [114]. The authors reported a prevalence of 0.009%. These reports of *Echinococcus* infections in dogs in Zambia [5, 84], though few, are important because of the role dogs play in human infection especially in rural communities where there is close contact with dogs as well as in other risk groups which include animal handlers, veterinarians and dog owners [113]. Dogs shed eggs in the environment which can easily contaminate fruits, vegetables or water, or can stick to the fur of dog. The eggs can be transferred from the dog to hands and to the mouth. Well planned regular deworming, avoiding feeding dogs uncooked offals (and sanitary disposal of slaughterhouse waste to prevent access by dogs) and destruction of stray dogs in areas of heavy transmission will help prevent environmental contamination and hence further infections in both dogs and humans. Additionally, community public health education to create awareness on the transmission mode and dangers of the infection is a key prevention measure [102].

6. CONCLUSION

Although the potential role of dogs as source of zoonotic infections to humans has been recognized as a significant public health problem, investigations on the prevalence of most parasite infections have not been extensively conducted in Zambia. There is little documentation and the documented data may also not be complete and does not give a clear picture of the situation in the country. There is need to have well-documented country and regional data to have a comprehensive sub-Saharan picture of these zoonotic parasitic diseases.

In all these zoonotic infections, veterinarians need to take a lead as they understand the

potential risks to humans. Client education especially on preventive measures and/or treatment should be part of the services offered, including how to minimize the risk of zoonotic transmission. In addition, awareness campaigns, in conjunction with medical and public health personnel should be carried out on the benefits and risks of keeping dogs.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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