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Neglected tropical diseases of Namibia: Unsolved mysteries

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ABSTRACT

Neglected tropical diseases (NTDs) are diseases most commonly found in settings of poverty and are responsible for the morbidity and/or mortality of millions each year. As an upper-middle income country, Namibia is not normally considered to have many NTDs but published reports indicate the possible presence of over 30. Because much of the data is buried in historical studies published before Independence in 1990, there is a risk of losing valuable information on which to build current and future integrated public health strategies. The purpose of this review, therefore, is to bring together these significant fragments to identify existing knowledge gaps which need to be addressed to build effective control, prevention, and even elimination strategies. The review focuses on intestinal helminthes, schistosomes/snail 'vectors', viruses (Rift Valley Fever, Crimean Congo Hemorrhagic Fever, rabies), protozoa (*Leishmania*, *Toxoplasma*, *Amoeba*, *Giardia*), bacteria (*Rickettsia*, *Ehrlichia*, *Leptospira*, *Coxiella*, *Brucella*, and *Borrelia*), fungi (*Pneumocystis*) and myiasis. Each NTD speaks to the possible need for surveillance and the creation of integrated disease risk maps, linking prevalence of related NTDs with environmental and ecological factors to assist control and prevention efforts. The predominance of zoonotic disease suggests a need to integrate veterinary and public health components as the national public health surveillance system is established.

Contents

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1. Introduction

Neglected Tropical Diseases (NTDs) are diseases most commonly found in settings of poverty. The lists differ by organizational focus, but each disease is responsible for the morbidity and/or mortality of millions each year (Hotez and Kamath, 2009). While important in their own right, they often contribute to the disease burdens caused by the 'big 3': malaria, Tuberculosis, and HIV/AIDS (Nacher, 2011; Noblick et al., 2011). Sixty percent of NTDs are zoonoses meaning that animals are reservoirs for the pathogens and contribute to the spread to and infection of surrounding human populations (Molyneux et al., 2011). Most of these diseases directly impact Sub-Saharan Africa (SSA) and considerable effort is being made to address their prevention and control (Hotez and Kamath, 2009). However, there is not enough epidemiological information to effectively map their prevalence or severity (Hotez and Kamath, 2009). Such is the case in Namibia, an upper middle income country in south-western Africa (World Bank, 2012).

Namibia consists of a large land area (823,290 km^2) with a relatively small population (2,160,000) (CIA, 2012) living in 13 regions (Fig. 1). This means that NTDs impacting other Sub-Saharan African countries with high populations may not be present due only to the sparseness of the human population. As 70% of the population lives in the northern part of the country (Best Country Maps, 2012), NTDs are usually mapped to this hot, humid region which borders Angola, Zambia, and Botswana (Global Atlas, 2011) (Fig. 1). This does not mean, however, that they only exist in the northern regions. Throughout the country, there is a high level of interaction between cattle, goats, and sheep with humans both in 'communal' areas and commercial and hunting farms making it conducive for the transmission of many zoonotic pathogens. To date, NTDs have not been a priority as the principle focus has been to control and prevent malaria ($n = 18$), TB ($n = 7$), and HIV/AIDS ($n = 95$) as is evidenced by the numbers of publications since 1995 (Noden, 2011).

The public health history of Namibia is a fascinating study with a rich history of information locked away in forgotten publications. Attaining independence in 1990, Namibia has been steadily building its health infrastructure and lines of communication as regards infectious disease notification. However, before independence, Namibia (called 'South West Africa') was administered by South Africa and many infectious diseases studies were published within a wider southern Africa focus. As such, past studies may only briefly refer to Namibia as South West Africa and are easily overlooked. Through time, these important studies can become lost to the detriment of public health.

The purpose, then, of this review is to bring together significant fragments of data to identify existing knowledge gaps which need to be addressed so that effective control, prevention and even elimination strategies can be envisioned. As the focus is historic in nature, this review mainly focuses on pre-Independence publications involving NTDs in Namibia with reference to more recent studies, newspaper articles or websites to update what is known. While effort was made to locate relevant publications, it cannot be assumed that every published study was identified. Also, as this review only focuses on published records (in press or online), updated information on one or more of these NTDs may be known to the Ministry of Health and Social Services (MoHSS). That said, however, conversations with those engaged in data management, epidemiology or laboratory testing have not highlighted the availability of such updated information. The course of the review will begin by summarizing what has been published concerning helminths, moving into protozoa, bacteria, viruses, mycoses and a few miscellaneous pathogens, ending with a discussion of future directions.

Neglected tropical diseases in Namibia: Thirty-six NTDs have been published in Namibia since 1959 (Table 1). It is known that some NTDs definitely do not occur in Namibia such as Chagas Disease, guinea-worm, loiasis, onchocerciasis, Japanese encephalitis, yellow fever (CDC, 2012), paracoccidiomycosis and Buruli ulcer (Hotez et al., 2007; WHO, 2009). Through the years, however, various samples have been tested, particularly vector-borne diseases, with positive or questionable results (Table 2). While the positive results are highlighted, lymphatic filariasis has never been identified (Kyronseppa and Goldsmid, 1978) and Human African Trypanosomiasis (HAT) has not been reported in Namibia for over 10 years (Simarro et al., 2011). Tables 1 and 2 include several surprises with briefly mentioned diseases or information hidden in

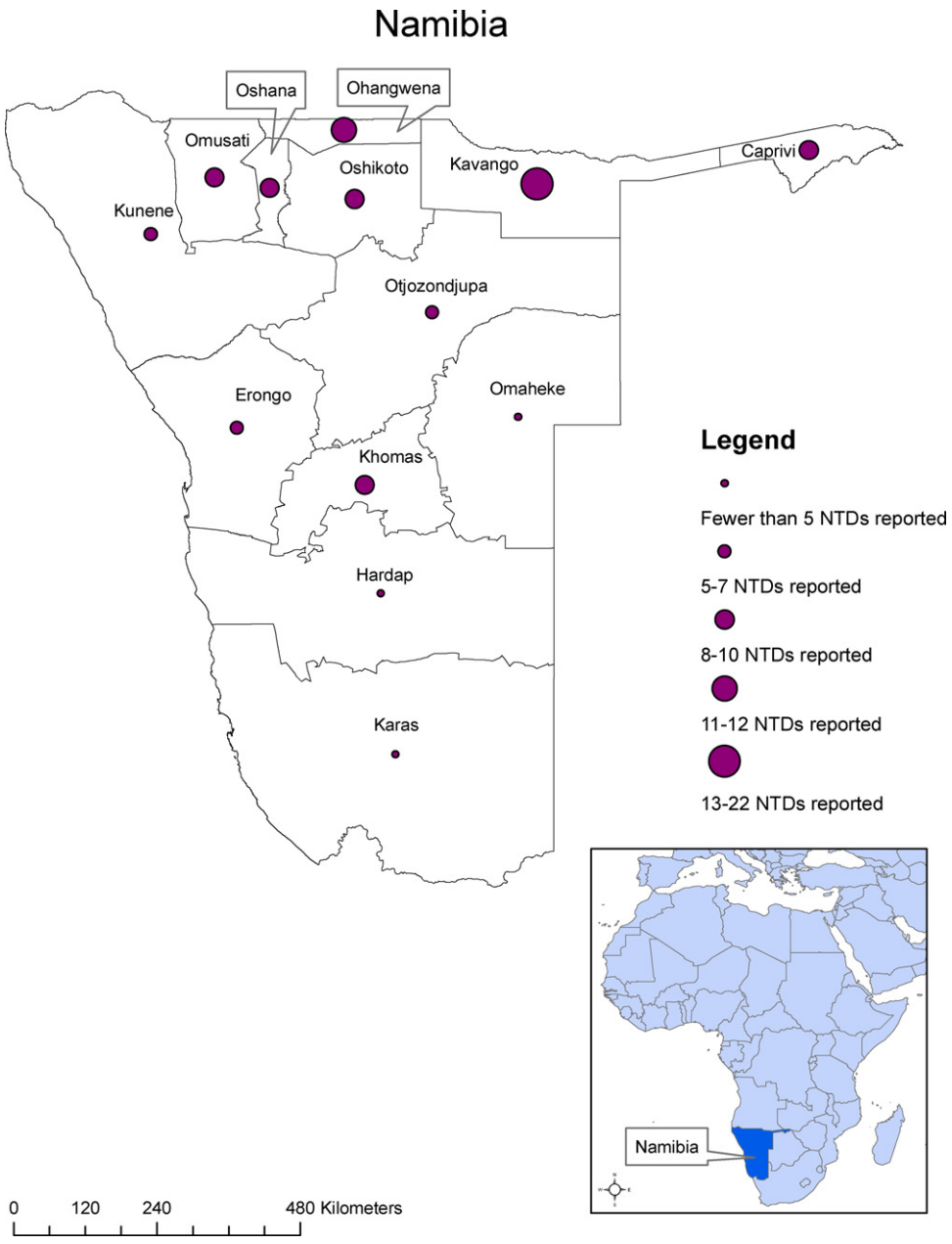

Fig. 1. Concentration of neglected tropical diseases in the 13 regions of Namibia.

studies focused on other pathogens. For example, in a study focused on a hepatitis E outbreak in northern Namibia, Isaäcson et al. (2000) tested 48 serum samples for 17 vector-borne pathogens. From the title and abstract, one would never suspect that testing for other pathogens was included but, through such studies, glimpses are gained into disease systems which may be unexplored. That said, however, it must be stated that the NTDs in Table 1 should only be regarded as historical indicators of possible presence in Namibia with an imperative to further test the current epidemiological status of each NTD.

2. Helminth NTDs

2.1. Soil transmitted nematode infections

Intestinal helminth infections, also called Soil-Transmitted Helminths (STH), dominate the impact of NTDs in Sub-Saharan Africa, accounting for 25–33% of the total burden (Hotez and Kamath, 2009). Five published studies between 1978 and 1995 (Kyronseppa and Goldsmid, 1978; Schutte and van Deventer, 1987; Evans and Joubert, 1989; Evans et al., 1990; Schutte et al., 1995) demonstrate that the major 3 NTD helminths (hookworm, *Ascaris* and *Trichuris*) are present in Namibia (Table 3). Other helminths include *Strongyloides*, *Hymenolepis*, and *Enterobius* (Table 3). All 5 surveys were based in northern Namibia with 4 focused on the Kavango and Caprivi regions in the north-east with only one focused at 3 different hospitals in the north-central regions (Kyronseppa and Goldsmid, 1978). To date, no studies have been published on surveys in central or southern Namibia. It is notable that of the 5 studies, only 2 involved major population surveys (1700–4174 persons) (Evans and Joubert, 1989; Schutte et al., 1995) while the remaining 3 involved small sizes (30–370 persons). The last published helminth survey was carried out between 1987 and 1990 (Schutte et al., 1995) just prior to independence.

Table 1
Neglected tropical diseases in Namibia with the earliest published record.

Pathogen categories	Notable neglected tropical diseases	First published source
Protozoan infections	Amebiasis	Kyronseppa and Goldsmid (1978)
	Giardiasis	Kyronseppa and Goldsmid (1978)
	Balantidiasis	Kyronseppa and Goldsmid (1978)
	Leishmaniasis (cutaneous)	Grove (1978)
	Toxoplasmosis	Jacobs and Mason (1978)
Helminth infections	Schistosomiasis (*S. mansoni* and *S. haematobium*)	Geldenhuys et al. (1967)
	Taeniasis (bovine cysticercosis)	Evans and Joubert (1989)
	Soil-transmitted Helminths	
	Hookworm	Kyronseppa and Goldsmid (1978)
	Ascaris	Schutte and van Deventer (1987)
	Trichuria	Evans et al. (1990)
	Strongyloides	Kyronseppa and Goldsmid (1978)
	Hymenolepis	Kyronseppa and Goldsmid (1978)
	Enterobius	Kyronseppa and Goldsmid (1978)
	Food-borne Trematodiases (*Fasciola*)	Kyronseppa and Goldsmid (1978)
	Larva migrans	Evans and Joubert (1989)
Viral infections	Arboviral infections	
	West Nile	Joubert et al. (1991)
	Chikungunya	Joubert et al. (1985b)
	Rift Valley Fever virus	Joubert et al. (1985b)
	Hemorrhagic fevers	
	Hantaan virus	Joubert et al. (1991)
	Ebola virus	Joubert et al. (1991)
	Crimean-Congo Hemorrhagic Fever virus	Joubert et al. (1991)
	Rabies	Barnard (1979)
Bacterial infections	Cholera	Smith et al. (2008)
	Enteric pathogens (*Salmonella, E. coli*)	Jacobs et al. (1978)
	Trachoma	Burton and Mabey (2009)
	Leptospirosis	Wessels et al. (1986)
	Borrelia relapsing fever	Ordman (1957)
	Treponematoses (syphilis)	Harms et al. (1998)
	Causes of non-malaria febrile illness	
	Rickettsia	Wessels et al. (1986)
	Ehrlichia	DuPlessis and Malan (1987)
	Coxiella	Wessels et al. (1986)
	Brucella	Wessels et al. (1986)
	Leprosy	Smith (2011)
Fungal infections	*Pneumocystis jirovecii*	Nowaseb et al. (2012)
	Mycetoma	Ide et al. (2009)
Ectoparasitic infections	Myiasis	Zumpt (1959)

Summary listing by Medicotrivia (What are the Neglected Tropical diseases (NTD)?) (http://medicotrivia.wordpress.com/2010/08/18/what-are-the-neglected-tropical-diseases-ntd/), includes Public Library of Science (PLoS) list (http://www.plosntds.org/static/scope.action), the World Health Organization list (http://www.who.int/neglected_diseases/diseases/en/), Centers for Disease Control and Prevention (http://www.cdc.gov/globalhealth/ntd/diseases/index.html; http://www.cdc.gov/parasites/npi.html) as well as several Africa-specific NTDs from Hotez and Kamath (2009).

2.1.1. Hookworm

Hookworms are one of the most common roundworm infections, accounting for 33% of total NTD burden in Sub-Saharan Africa (Hotez and Kamath, 2009). In all published helminth studies in Namibia, hookworm has been dominant (Table 3). High infection rates (55–85%) were found in north-east Namibia while slightly lower rates were observed in north-central Namibia (10–60%) (Table 3). The main species of hookworm has yet to be confirmed (Kyronseppa and Goldsmid, 1978) and only one study recorded subclinical loads in 12 patients (Kyronseppa and Goldsmid, 1978). The high occurrence of hookworm in north-east Namibia was identified in females who daily used the river banks and low lying areas along the river for household chores while accompanying children played, swam, and fished. The damp conditions and warmth in summer assisted in the dissemination of hookworms as well as *Strongyloides* (Evans and Joubert, 1989).

2.1.2. Ascaris lumbricoides

Ascaris or 'roundworms' have not historically been common in Namibia with only low infection rates (0.1–0.3%) recorded in three studies (Table 3). While mainly focused on the Kavango and Caprivi regions, these studies involved the most significant numbers tested (total = 12,500 persons). Evans and Joubert (1989), trying to postulate the absence of *Ascaris* in Rundu (Kavango region), mentioned that the arid climatic conditions could have influenced the egg survival and development. However, this hypothesis could not account for the hot and humid Caprivi region where the infection rates were also very low.

2.1.3. Trichuris trichiura

Trichuris, also known as 'whipworm', is also historically uncommon in Namibia where the infection rates were similar to *Ascaris* in 4 of the 5 studies involving the north-east regions (Table 3). Interestingly, Evans et al. (1990) reported a *Trichuris* infection rate of 35% in the Khaudum area (Kavango region). They noted this high infection rate together with the low prevalence of *Ascaris* (they normally co-exist) and hypothesized that this unique condition could be due to climatic and behavioral factors that exist among sparse host populations. The relatively isolated small groups of San in this area of Namibia could preclude the transmission of *Ascaris* and keep the delicate *Trichuris* eggs circulating only within families.

2.1.4. Other STH infections

2.1.4.1. Strongyloides. *Strongyloides* was identified in 4 of the 5 studies in northern Namibian regions which tend to be humid and tropical with moist soil (Table 3). While normally not causing symptoms, *Strongyloides* are reported to cause diarrhea and malnutrition

Table 2
Published test results for specific neglected tropical disease pathogens between 1956 and 2011.

	Pathogen	Tested	Positive result	Place (region)	Reference
Arbovirus	Yellow Fever	X	Not found	Andarai (Caprivi)	Muspratt (1956)
	Chikungunya virus	X	X	Rundu (Kavango) Katima Mulilo (Caprivi)	Joubert et al. (1985b, 1991)
	Middelburg virus	X	Not found	Rundu (Kavango)	Isaäcson et al. (2000)
	Wesselsbron virus	X	Not found	Katima Mulilo (Caprivi)	Joubert et al. (1991)
	Spondweni virus	X	Not found	Rundu (Kavango)	Isaäcson et al. (2000)
	Germiston virus	X	X	Rundu (Kavango)	Joubert et al. (1985b)
	Rift Valley Fever virus	X	X	Rundu (Kavango), Katima Mulilo (Caprivi)	Joubert et al. (1985b, 1991)
	Crimean-Congo Hemorrhagic Fever virus	X	X	Katima Mulilo (Caprivi); Central and Southern Namibia	Joubert et al. (1991), Burt and Swanepoel (2005)
	West Nile virus	X	X	Rundu (Kavango), Katima Mulilo (Caprivi)	Joubert et al. (1985b, 1991)
	Sindbis	X	X	Rundu (Kavango)	Joubert et al. (1985b, 1991)
	Dengue	??	??	Not reported	Amarasinghe et al. (2011)
Hemorrhagic fevers	Hantaan virus	X	X	Katima Mulilo (Caprivi)	Joubert et al. (1991)
	Ebola virus	X	X	Katima Mulilo (Caprivi)	Joubert et al. (1991)
	Lassa virus	X	X	Katima Mulilo (Caprivi)	Joubert et al. (1991)
	Marburg virus	X	X	Katima Mulilo (Caprivi)	Joubert et al. (1991)
Bacteria	*Yersinia pestis* (plague)	X	X (eliminated)	Northern Namibia	Shangula (1998)
	Rickettsia conorii	X	Not found	Rundu (Kavango)	Isaäcson et al. (2000)
	Borrelia duttoni (Relapsing fever)	X	X	Rundu (Kavango)	Dreier et al. (1998)
	Coxiella burnetii (Q fever)	X	X	Rundu (Kavango)	Wessels et al. (1986)
	Typhus-group Rickettsia	X	X	Rundu (Kavango)	Wessels et al. (1986)
	Rickettsia africae	??	??	No published test result	Parola et al. (2005)
	Leptospira	X	X	Rundu (Kavango)	Wessels et al. (1986)
	Brucella	X	X	Rundu (Kavango)	Wessels et al. (1986)
Protozoa	African trypanosomiasis	X	Not found	Rundu (Kavango)	Isaäcson et al. (2000)
	Leishmania (cutaneous)	X	X	Karas and Hardap regions	Grove (1978)
Helminths	Lymphatic filaria	X	Not found	Onandjokwe (Oshikoto)	Kyronseppa and Goldsmid (1978)

in SSA although little is known about their distribution (Hotez and Kamath, 2009). In Namibia, infection rates of *Strongyloides stercoralis* were as high as 21–26% and as low as 0.6% (Table 3). Evans et al. (1990) noted the high prevalence of *Strongyloide*s among the Khaudum population (26%) (Kavango region) as one of highest recorded at the time in Southern Africa. Also, *Strongyloides fuelleborni*, a non-human primate nematode, was identified in 8.2% of Kavango residents (Kyronseppa and Goldsmid, 1978) as well in the Caprivi region (Schutte et al., 1995).

2.1.4.2. Hymenolepis nana. Also known as the 'dwarf tapeworm', *Hymenolepis nana* is common in children (CDC, 2012). Kyronseppa and Goldsmid (1978) recorded a 1.8% prevalence in Engela Hospital (Ohangwena region) and 3.3% ($n = 61$) in Nkurenkuru hospital (Kavango region) (Table 3). Evans and Joubert (1989) also identified *H. nana* in 1% of the 4174 patients tested in Rundu hospital (Kavango region), most commonly in pre-school children.

2.1.4.3. Enterobius vermicularis. In northern Namibia, *E. vermicularis* was reported at a low prevalence (<0.1%) (Kyronseppa and Goldsmid, 1978) but the location was not specified (Table 3).

2.1.4.4. Larval migrans. When the infective larvae of various species of animal hookworms fail to penetrate the skin of humans, they can cause a condition called 'larval migrans' (CDC, 2012). In north-east Namibia, Evans and Joubert (1989) reported that larva migrans was probably due to dog hookworms, *Ancyclostoma braziliense* or *A. caninum*, which were common and mostly likely due to local dogs defecating in common areas along the river bank.

2.2. Cestode infections (Taenia, Echinococcus)

2.2.1. Taenia saginata

Taenia sp. are a group of tapeworms which infect human through the eating of raw or undercooked meat containing cysts. The

Table 3
Intestinal parasites from 5 published surveys in Northern Namibia (1974-1990).

Nematodes	Area in Namibia	Study dates				
		1974–1976 (Kyronseppa and Goldsmid, 1978)	1984 (Schutte and van Deventer, 1987)	1986–1987 (Evans and Joubert, 1989)	1986–1988 (Evans et al., 1990)	1987–1990 (Schutte et al., 1995)
Hookworm	North-central	10–60%				
	North-east	74%	55–67%	7%	63–85%	7–58%
Ascaris lumbricoides	North-east		0.3%	absent		0–1%
Trichuris trichiura	North-east	<1%	0.5%	Absent	1–35%	0–0.4%
Strongyloides stercoralis	North-central	10–21%				
	North-east	7%		3%	25%	0.6–25.7%
Strongyloides fuelleborni	North-east	<1%				Present
Hymenolepis nana	North-east	1.8–3.3%		1%		
Taenia saginata	North-east	<1%		0.9%		
Enterobius vermicularis	North-east	<1%				
Fasciola gigantica	North-central	<1%				

Table 4
Prevalence of *Schistosoma sp.* in northern Namibia between 1965 and 1990.

Area	Hospital/School	# tested	*S. haematobium* (%)	*S. mansoni* (%)	Source
Eastern and Southern Caprivi	9 villages	491	0.0–10.2	0.0–6.7	Geldenhuys et al. (1967)
	3 villages	276	7–47	0–10	Schutte and van Deventer (1987)
	Katima Mulilo	90	21.1	1.1	Geldenhuys et al. (1967)
Western and Northern Caprivi (Cuando river)	3 villages	162	0.0–1.3	0.0–86.1	Geldenhuys et al. (1967)
	3 villages	206	0.0	82–95	Schutte and van Deventer (1987)
	9 villages	8000	0.0	63–96	Schutte et al. (1995)
Kavango – East	7 villages	600	0.0–73.8	0.0–12.5	Geldenhuys et al. (1967)
Kavango – West	Nkurenkuru	101	55.4	0.0	Geldenhuys et al. (1967)
	Nkurenkuru	61	4.9	6.5	Kyronseppa and Goldsmid (1978)
North Central Namibia	Engela, Ongwadiva, Onesi (Ruacana Falls)	441	0.0	0.0	Geldenhuys et al. (1967)
Northwest	Seisfontein	81	0.0	0.0	Geldenhuys et al. (1967)

tapeworms that cause taeniasis (*Taenia saginata* (cattle), *T. solium* (pigs) and *T. asiatica*) are found globally (CDC, 2012). *Taenia* infections were noted in the north-eastern regions of the Namibia (Table 3) (Kyronseppa and Goldsmid, 1978; Evans and Joubert, 1989). As pigs were rare, these infections were due to *T. saginata* which is transmitted by cattle roaming freely along the river banks and around the boreholes in sparsely populated areas (Evans and Joubert, 1989).

Bovine cystercercosis, the larval stage of *Taenia saginata* which forms cysts in cattle, was commonly reported in the north-central regions between 2005 and 2011 (OIE, 2012). Examining records at one abattoir between 2000 and 2004, Shikongo-Kuvare (2007) reported an 8% incidence in 40,373 cattle. Incidence between north-central regions ranged from 5% (Ohangwena) to 12% (Oshikoto) between 2004 and 2005. As records were from managed abattoirs, a principle question involves what transmission is possibly happening via unsupervised meat handling within local communities. Coupled with the incidence study, a KAP survey indicated that 58–96% of persons surveyed had no knowledge of the disease and how it could be controlled (Shikongo-Kuvare, 2007).

2.2.2. Echinococcus/Hydatidosis

Although no human cases have been described in Namibia, the World Organization for Animal Health (OIE, 2012) reports cases of bovine echinococcus infection since 2005.

2.3. Trematode infections (Schistosoma, Fasciola)

2.3.1. Schistosomiasis

Schistosomiasis in Namibia is caused by both *Schistosoma mansoni* and *S. haematobium* (Table 4). Usually found in places with poor sanitation, human infection occurs via cercariae in fresh-water bodies either by swimming, bathing, washing, or fishing (Hotez and Kamath, 2009). *Schistosoma mansoni* can produce bloody diarrhea and ulceritic conditions in the bowel while chronic *S. haematobium* infections can produce bladder wall complications, renal failure, and urogenital schistosomiasis which impacts reproductive health including sexual dysfunction and infertility (Hotez and Kamath, 2009).

Schistosomiasis in Namibia, as indicated by WHO NTD maps (WHO, 2011), has a prevalence less than 10%. However, four historical surveys in northern Namibia reported local infection rates up to 95% (Table 4). Two additional large surveys (Geldenhuys et al., 1967; Brown et al., 1992) focused on the 'vector' snail ecology throughout northern Namibia. In general, *S. haematobium* was found in the eastern part of the Caprivi region and *S. mansoni* was highly prevalent in the western Caprivi region (Table 4). As one moved further west along the Okavango River (Kavango region), the prominent species became *S. haematobium* again.

Historically, the ecology of the *Schistosoma* and their snail hosts was as follows (Geldenhuys et al., 1967):

1. In the Caprivi region, *Bulinus (Physopsis)* sp. were found in the river in the northern villages while *Biomphalaria* sp. were found in the swamps in the south. In the villages in northeastern Caprivi where *Bulinus (Physopsis)* sp. was the principle snail species found in the pools, *S. haematobium* prevalence was variable with low to no *S. mansoni*. In northwest Caprivi region, along the Kwando River, a high prevalence of *S. mansoni* was found in two villages where stagnant pools infested with *Biomphalaria* sp. were the main supply of water (Table 4).
2. Further to the east along the Okavango River (Kavango region), the water was heavily used for pastoral (watering) and domestic purposes. Those who lived along the river spent a lot of time in the water, often knee-deep, tending cattle, trapping fish, and using canoes. It was interesting to note that while *Biomphalaria* sp., *Bulinus (Bulinus)* sp., and *Bulinus (Physopsis)* sp. snails were found throughout the whole length of the Okavango River study area, high *S. haematobium* and low *S. mansoni* rates were only found in those villages in the upper regions (Table 4).
3. In north-central and western Namibia between the Okavango and Kunene rivers, no schistosomes were detected. Notably, *Bulinus forskalii* (a questionable vector species in southern Africa) was found in all permanent waters except in Otavi. In the Kunene region, *Bulinus* (*Physopsis*) sp. was collected below the Ruacana Falls and along the Kunene River as far as Epupa Falls. It was significant to find these snail species in 1967 with a prediction made that they would spread further into the north-central regions. This was confirmed by Uusiku (2009) with a 31% *S. haematobium* infection rate in 400 school children in Outapi health district (Omusati region).

2.3.2. Fasciola gigantica

Fasciola gigantica, a trematode, is a liver fluke which has a lifecycle involving an intermediate snail host in which the fluke develops and releases metacercariae into water. People become infected when eating raw un-washed water plants or vegetables or eating undercooked sheep or goat livers containing immature forms of the parasite (CDC, 2012). In Engela (Ohangwena region), Kyronseppa and Goldsmid (1978) reported *F. gigantica* eggs in the stools of three patients (Table 3). These flukes had a cattle reservoir and the consumption of unwashed greens by humans was most likely the source of infection. It also could have happened via metacercariae in drinking water collected from rain water. *Lymnaea natalensis* snails, prevalent in the Kavango and Caprivi regions, are the intermediate host for this parasite. Notably, this snail was reported in the west near Ruacana Falls (Kunene region) (Geldenhuys et al., 1967) and also in the east (Kavango region) (Schutte et al., 1995).

3. Protozoan NTDs

Protozoan NTDs have not been significantly focused on in Namibia since the 1970s possibly due to the priority of reducing

malaria incidence and controlling anopheline mosquito populations. As such, there are several 'unsolved mysteries' which could potentially impact local populations given a change in climate, rainfall, migration patterns, or grazing areas in the next 5–10 years.

3.1. Leishmania

Cutaneous leishmania (CL) has been reported in Namibia since the 1970s (Grove, 1978) and, although no clinical data has been published since 1989 (total incidence rate of 34 cases between 1970 and 1989), clinical cases involving both canines (OIE, 2012) and humans continue to be reported. Most of the 1970–1989 CL cases were geographically located in the Karas region, specifically clustered on two farms in the Keetmanshoop, Karasburg, and Bethanie area. The rest of the reported cases were distributed across the central and more northern parts of the country and linked with a history of picnicking, camping, or living near hyrax (*Procavia capensis*) colonies.

Isolations of *Leishmania* sp. were obtained from the nose tips of 30 hyrax (*Procavia capensis*) as well as sandflies and skin lesions of infected persons (Grove, 1989). When compared with known *Leishmania* sp. using serological and biochemical tests, the Namibian strains were grouped between *L. tropica* and *L. aethiopica* strains from Africa (Le Blancq et al., 1986). Not only did Namibia's CL strains differ with the rest of the world, the strains isolated from humans and sandflies (*Phlebotomus rossi*) living in close association with hyrax (*Procavia capensis*) were identical but differed considerably from the closely associated hyrax strains (Chance et al., 1978; Le Blancq et al., 1986).

In addition to the Namibian CL mystery strains, there is speculation concerning the responsible vectors. By the time CL was identified in Namibia, nine sandfly species had already been identified (De Meillon and Hardy, 1953). *Plebotomus rossi* was thought to be the primary vector as it was consistently trapped in field studies and was the only species in which parasites were isolated. When that sandfly isolate was found to differ from the hyrax (*Procavia capensis*) isolate, the vector status of *P. rossi* was questioned. Zielke (1971) postulated *P. schwerzi* while *P. grovei*, a new species identified in Namibia in 1971, was also named as a possible vector (Grove, 1989). Like the identity of the parasites, the true vectors of CL in Namibia remain a mystery. Future studies need to update the epidemiology, solve the transmission cycle (probably involving canines), and evaluate the possibility of outbreaks.

3.2. HAT (Trypanosomiasis)

While HAT has not been reported in Namibia for over 10 years (Simarro et al., 2011), a complete assessment may still be warranted (IAEA, 2009; WHO, 2012). When present, van den Bossche et al. (1999) detected a prevalence of 4.5% in 1491 cattle serologically tested in the eastern Caprivi between 1995 and 1997. The vector, *Glossina morsitans centralis*, was only found in a limited area (2,900 km^2) along the Angola and Zambia borders in north Caprivi and along the Kwando and Linyandi rivers on the Botswana border in southern Caprivi (PATTEC, 2005). Krafsur et al. (2001) determined that *Glossina* from the Caprivi were genetically similar to flies from Botswana, mostly likely due to the collapse of *Glossina* populations caused by the rinderpest epizootic of the late 19th and early 20th centuries.

3.3. Toxoplasma

To date, only one study has reported a *Toxoplasma* prevalence using Namibian serum samples (Jacobs and Mason, 1978) from 275 !Kung Tsumkwe San in Rundu (Kavango region); 77 Damara speaking people in the Erongo region and 261 white residents in the Windhoek area (Khomas region). Prevalence rates were 12% in Windhoek, 27% in Erongo region, and 6% in the Rundu area. The prevalence in the San was similar to the Windhoek sample, but both groups were significantly lower than the Erongo region ($P < 0.0001$).

The low prevalence in Namibia was notable and the authors postulated that it may be due to desiccation of the cysts because most of the central and south of Namibia is dry and arid. Differences between cultures were also thought to play a role in differences in prevalence among Namibian groups. The San have been more nomadic or semi nomadic hunter-gatherers and did not have much contact with pastoral people. The Damara are pastoral, keeping large goat herds along with sheep and cattle in north-central Namibia. As goats are known carriers of *Toxoplasma*, they may have played a role in the high prevalence observed in the Erongo region. Both the San and Damara consume meat so if the meat has not been cooked properly, it could lead to ingestion of cysts. With the effects of *Toxoplasma* on pregnant women and the large population of immunocompromised (HIV/AIDS) persons (USAID, 2010), it is a concern that no follow up study has evaluated the prevalence of this pathogen since 1978.

3.4. Water-borne protozoa

Only one study has detailed the prevalence of water-borne protozoa pathogens in a Namibian population, highlighting the presence of *Entamoeba histolytica*, *Giardia lamblia*, and *Balantidium coli*. The population included 501 patients at three hospitals in north-central Namibia and one hospital in the Kavango region (Kyronseppa and Goldsmid, 1978). Only low prevalence rates were recorded for *Entamoeba histolytica* (Nakayale (1.9%) (Omusati region) and Engela (4.5%) (Ohangwena region)), *Giardia lamblia* (Nakayale (2.9%) and Onandjokwe (6.1%) (Oshikoto region)), and *Balantidium coli* (Onandjokwe (0.5%)). No pathogenic protozoan species were detected in the 61 patients from the Kavango region. High rates of non-pathogenic *Entamoeba coli* (35–57%) as well as low prevalence of *Iodamoeba bütschlii* (1.9%) and *Chilomastix mesnili* (1.6%) were detected in several sites. From the data, it was clear that invasive amoebiasis was present in northern Namibia and liver abscesses were diagnosed occasionally. Despite a poor water supply in these areas, the prevalence of *E. histolytica* and *G. lamblia* was quite low.

In 2001, Menge et al. detailed the occurrence of *Giardia* and *Cryptosporidium* in the reclamation plant outside of Windhoek (Khomas region) (Menge et al., 2001). Between 1996 and 1999, *Giardia* crossed into the water supply five times, endangering the health of Windhoek residents. No further studies have since been published. The only recent article involving *Giardia duodenalis* reported a 25% infection rate among wild dogs living in a remote northern region of Namibia (Ash et al., 2010).

4. Bacterial NTDs

4.1. Undetermined causes of febrile illness

With the reduction of malaria in many African countries, bacterial NTDs are increasingly identified as the cause of undetermined febrile illness (Jennings et al., 2007; Ndip et al., 2009; Biggs et al., 2011; Prabhu et al., 2011). Backing up Kamwi (2005), a small study in Onandjokwe Lutheran Hospital (Oshikoto region) identified that 60% of febrile patients treated for malaria were actually blood-smear negative (van Dillen et al., 2007). No other assays were run to determine the local cause of febrile illness. In a country where plague was successfully eliminated (Shangula, 1998) and significant strides are being made towards malaria elimination, it is imperative to determine the causes of fever in local areas.

The possible NTDs involved could be *Rickettsia* (Spotted fever and Typhus groups), *Ehrlichia*, *Borrelia*, *Leptospira*, *Coxiella* and *Brucella*.

4.2. Rickettsia

Past studies indicate that *Rickettsia* sp. could be present in Namibia. Wessels et al. (1986) reported that 59% of San patients tested in Rundu area (Kavango region) produced low agglutination to OX-19 (Weil-Felix test). The only published reference to Weil-Felix results indicative of *Rickettsia* in Namibia, OX-19 agglutination can suggest the presence of typhus group rickettsia (*R. prowazekii*, *R. typhi*) as well as *R. rickettsia* (Amano et al., 1992). The low agglutination reported could indicate waning antibodies after 10 or more years after exposure or cross-reactivity to some other *Rickettsia* species. The poor sensitivity and specificity of the Weil-Felix underscores the need for further testing (La Scola and Raoult, 1997).

Rickettsia africae is reportedly in Namibia (see Parola et al. (2005) for map) but the references cited (Jensenius et al., 2003; Méchaï et al., 2009) are travel studies where the travelers reportedly journeyed through several Southern African countries with no evidence that they were bitten by infected ticks in Namibia. More to the point, Jelinek and Löscher (2001) described the prevalence of *R. africae* infections in a group of 78 German outpatients, many who had been to Southern Africa. While Namibia is not mentioned specifically in the paper, the German-Namibia tourism link is strong which makes it likely that the tourists were infected in Namibia. However, to date, no publication has clearly demonstrated the presence and/or transmission of *R. africae* in Namibia.

While the published presence of *Rickettsia* in Namibia needs confirming, several signs point to the likely presence of more than one species. In addition to *R. africae*, *Rickettsia conorii* and *R. aeschlimannii* have been reported in neighboring South Africa (Pretorius et al., 2004). Also, given the long history of shipping and the ports in Luderitz and Walvis Bay, it is highly likely that the flea-borne, *R. typhi* and *R. felis*, may also be present. *Rickettsia typhi* has already been recorded in nearby Zimbabwe and South Africa (Matthewman et al., 1997). With recent West Africa studies describing the prevalence of many *Rickettsia* species in local tick vectors (Mediannikov et al., 2010a, 2012), it is likely that there may even be undescribed species. Added to this is the presence of eight known *Rickettsia* tick vectors ubiquitously present (Table 6) as well as the cat-flea vector, *Ctenocephalides felis* (Living Namibia, 2003).

4.3. Ehrlichia

4.3.1. Ehrlichia canis

The dog tick, *Rhipicephalus sanguineus* is known to be a vector of canine (*E. canis*) and human (*E. chaffeensis* and *E. ewingii*) *Ehrlichia* in both South Africa (Pretorius and Kelly, 1998; Pretorius et al., 1999) and Cameroon (Ndip et al., 2009, 2010). In Namibia, with *R. sanguineus* being the primary dog tick (Matthee et al., 2010), Noden et al. (2011) demonstrated that 58% of dogs tested in central Namibia were seropositive for *E. canis* with a predominance of cases coming from the low-income areas of Windhoek. If *E. canis* is so prevalent, further testing may also identify *E. chaffeensis* and *E. ewingii*.

4.3.2. Ehrlichia ruminantium

Ehrlichia ruminantium is an emerging zoonotic disease in Southern Africa after three fatal cases were identified by DNA sequencing (Louw et al., 2005). *Ehrlichia* sp. was first reported in Namibia in the mid-1980s when 43 serum samples were taken from cattle on the farm Omatjenne in the Otjiwarongo district (Otjozondjupa region) with an 81% IFA-positive rate (DuPlessis and Malan, 1987). This was considered odd as this area of Namibia was reportedly an *Amblyomma hebraeum*-free region in Southern Africa. Ticks were collected and a still undefined 'Omatjenne agent' was isolated for further characterization (DuPlessis, 1990; DuPlessis et al., 1993; Sumption et al., 2003). Recently, *E. ruminantium* was identified in 3% of ticks obtained from 95 darted buffalo from 6 areas in the Caprivi region (Pascucci et al., 2011). With previous outbreaks reported in cattle populations in the Caprivi region, this pathogen should also be noted for future public health surveillance.

4.4. Borrelia duttoni

Tick-borne relapsing fever (*Borrelia duttoni*) was first reported in Namibia by Ordman (1957) who summarized a 1942 study in which spirochetes were identified in blood smears of mine workers from the Kavango region as well as Angola. Additionally, 7% of 1787 blood smear samples taken between 1952 and 1955 in Ondangwa (Oshikoto Region) were positive. Dreier et al. (1998) picked up the trail between 1986 and 1988 in Rundu (Kavango region) reporting yearly incidence of 45 cases per 10,000 persons using hospital records of 424 bloodfilm positive cases with eight fatal cases between 1980 and 1988. 75% of the patients were under 12 years old and 55% were female. This bacterial NTD is still diagnosed occasionally by personnel at the Namibia Institute of Pathology.

The soft-tick vector, *Ornithodorus moubata* (Table 6), was reported to occur widely in north-central Namibia in the floors of compound huts and in kraals (Ordman, 1957). In 1998, Dreier et al. reported a 2% *Borrelia duttoni* infection rate in100 *O. moubata* obtained from the sand floors of the mud houses at the sleeping or sitting sites in the Rundu area (Kavango region) (Dreier et al., 1998). The ubiquitous presence of these ticks in the Kavango region prompted Joubert et al. (1985a) to even hypothesize that *O. moubata* ticks were involved in the transmission of Hepatitis B virus.

4.5. Leptospira

Leptospira is a zoonotic bacteria spread through the urine of infected animals (cattle, pigs, dogs, wild animals), mainly rodents (CDC, 2012). In 2005, leptospirosis was suspected in animals but was not confirmed (OIE, 2012). Only Wessels et al. (1986) published a 3% seroprevelence among 190 persons tested in the Rundu area (Kavango region).

4.6. Coxiella

Coxiella burnetii, the bacteria causing Q fever, is a zoonoses involving cattle, sheep and goats as the primary reservoirs of infections. *Coxiella* in Namibia has been mentioned 3 times. In 1986, Wessels et al. reported an IgM IFA seroprevelence of 2% and a positive complement fixation titre of $\geq$1:160 in 3% of samples from Rundu (Kavango region). Dupont et al. (1995) hypothesized a significant correlation in Namibia between prevalence of *C. burnetii* antibodies and the high stock-breeding index, but, this hypothesis remains untested. Recently, the World Organization of Animal Health website (OIE, 2012) reported several suspected Q fever animal cases during 2009 and 2010 but no confirmation was made. Notably, five tick known reservoir/carriers of *Coxiella* are also present in Namibia (Table 6) but, to date, the *Coxiella* situation is unknown.

4.7. Brucella

Brucella is the causative agent for Brucellosis, another zoonotic infectious disease passed from animals (sheep, goats, cattle, antelopes, dogs) to humans when they contact an infected animal or consume animal products such as milk, dairy products or meat

which is contaminated (CDC, 2012). There have been several published reports of *Brucella* in Namibia. Wessels et al. (1986) reported one positive antibody test in 190 samples from Rundu (Kavango region). Twenty-six human cases were documented between 1998 and 2003 (OIE, 2012). Since 2005, 24 cases of *Brucella abortus* and 27 cases of *Brucella melitensis* have been reported in Namibian animal populations (OIE, 2012). In 2009, Magwedere et al. reported a seroprevelence of 2.2% for *Brucella melitensis* among slaughterhouse and cutting plant workers at an unspecified small ruminant (sheep and goat) and game (springbok) export abattoir (Magwedere et al., 2009). Finally, Amuthenu and Gummow (2009) reported *Brucella* antibodies were found in 3 of the 7 northern Namibian regions with prevalence between 1.3% and 2.6%. Although still not considered an emerging zoonotic, it would be interesting to investigate whether *Brucella canis* is impacting the immunocompromised populations in Namibia (Lucero et al., 2010).

4.8. Bartonella

No study has evaluated whether *Bartonella* is present in Namibia and how it may be impacting HIV-infected persons as in other African countries (Frean et al., 2002).

4.9. Other bacterial NTDs

In addition to vector-borne species, trachoma, leprosy, syphilis and enteric bacteria have also been reported.

4.9.1. Trachoma

Reportedly 'endemic' in Namibia (see maps in Burton and Mabey (2009) and Hu et al. (2010)), no epidemiological study has been published or data been made publicly available (Polack et al., 2005) from which to know the extent of the problem.

4.9.2. Mycobacterial infections

Leprosy: In the 1980s, Namibia attained 'leprosy elimination' status (less than 1 case/10,000 inhabitants) (Namibia Sun, 2012), but the disease has been reported again in the local media. Leprosy cases increased between 2007 and 2009 so by 2010, 42 cases were reported in 8 of the 13 regions (Namibia Sun, 2012). At the time of writing, local papers reported between 58 (Kavango and Caprivi regions) (Smith, 2011) and 85 persons still struggling with the disease (Haufiku, 2012). The leprosy situation in Namibia, while seemingly well contained, needs clarification. Bovine tuberculosis was last identified in Namibia in 2006 (OIE, 2012) with no quantitative data and no reported human cases.

4.9.3. Cholera

Namibia experienced sporadic outbreaks of cholera between 2006 and 2008, mainly during periods of flooding. In 2006 and 2007, the principal outbreak area was Omusati and Kunene regions (more than 250 cases) (Weiklich, 2007). Another outbreak between March and May 2008 centered mainly in the Ohangwena, Oshana, and Kunene regions (1600 suspected cases/34 deaths) (Shivute, 2008). A third small outbreak occurred in Kunene region in December 2008 involving 29 cases (3 deaths) (Maletsky, 2009). Almost 1900 suspected cases and less than 40 deaths resulted in only one publication focused on the characterization of cholera isolates in the 2006/2007 outbreak (Smith et al., 2008).

4.9.4. Enteric pathogens (Salmonella, E. coli)

Exports of fish and meat are a main source of foreign income for Namibia. One case of bacterial contamination could erode confidence in Namibian products. With a zero-tolerance policy, monitoring is an important component of the food industry. Highlighting this, Mungeyi and Msiska (2009) published on the process used to ensure that hake exports are free of *E. coli* and *Salmonella*.

Evaluation of human *Salmonella* has occurred via two studies. In 1978, Jacobs et al. summarized 6 isolated cases of *Salmonella paratyphi* C variant East Africa isolated from northern Namibian patients (Oshakati (Oshana region), Nkurenkuru, Tondoro, Rundu (Kavango regions)) (Jacobs et al., 1978). Two patients had enteric fever while the other four were asymptomatic, with 3 having urinary tract infections. Schrire et al. (1987) followed up by comparing *Salmonella* isolates from Namibia with other Southern Africa isolates, reporting that 6% were subspecies II which is not normally linked to human infections. Sixteen cases of human *Salmonella* reported in 2009 (OIE, 2012) indicate a possible lack of understanding of hygienic meat handling practices in local communities.

4.9.5. Treponematoses (syphilis)

While published results are few, Namibia has done well to ensure that all pregnant women are screened for syphilis. The national syphilis prevalence (via RPR test) among women ranged between 0.0% and 17.9% (MoHSS, 2008). The only publication reporting syphilis prevalence rates (6%) involved 97 patients from Engela District Hospital (Ohangwena region) (Harms et al., 1998).

5. Viral infections (Arboviruses, rabies)

Arboviral infections and rabies have dominated the viral infection publications out of Namibia in the past 30 years. While focused mainly on Rift Valley Fever and Crimean-Congo Hemorrhagic Fever, seroprevalence studies have demonstrated antibodies to other arboviruses as well (Table 2) including West Nile, Chikungunya, and, possibly, Dengue. Rabies has historically been a concern with relatively constant human cases reported since 1998 (OIE, 2012).

5.1. Mosquito-borne virus

5.1.1. Rift Valley Fever virus

The first published reference to Rift Valley Fever virus (RVFV) in Namibia was in 1985 which affected cattle, sheep and goats with no record of human cases (OIE, 2012). Following this, low prevalence rates were published from small cohort studies in the Kavango (2%) (Joubert et al., 1985b) and Caprivi (4%) regions (Joubert et al., 1991). After 25 years, Rift Valley Fever virus returned again in May/June 2010, affecting farms in the Hardap ($n=6$) and Karas ($n=3$) regions (Kisting, 2010a). By July 2010, RVFV had moved north to an Omaruru farm in the Erongo region. In total, 80 sheep and goats became ill with 38 deaths (OIE, 2012). Three farmers were suspected to have contracted the virus by September 2010 (Kisting, 2010b). By April to June 2011, RVFV had jumped to the northern region of Oshikoto where it affected 73 goats, killing 31 (OIE, 2012). By June 2011 (Kisting, 2011), *The Namibian* newspaper reported that two Erongo farmers had RVFV infections – confirmed in South Africa. While recent RVFV outbreaks have only been reported through contact with sick animals, the presence of known mosquito vectors (*Culex*, *Aedes*, *Anopheles*, and *Mansonia*) (Table 5) together with the large populations of sheep, goats, and cattle in the flood-prone northern regions amplifies the outbreak potential. The impact of a future outbreak could have substantial effects on the agriculture (meat exportation) and tourism economic sectors. A vigorous epidemiological/entomological analysis is imperative to evaluate the parameters of this new outbreak and revise strategies for control and prevention.

5.1.2. Other mosquito-borne arboviruses

Other mosquito borne arboviruses such as Chikungunya, West Nile, Sindbis and Germiston have been serologically identified in small cohorts of Namibian patients in Kavango (Joubert et al.,

Table 5
Mosquito vector species of Namibia (Living Namibia, 2003), their published collection locations and reported human pathogens transmitted in Namibia and other Sub-Saharan African countries.

AEDES	Published collection locations in Namibia (North to South regions)	Human pathogens transmitted by particular species in SSA countries
Aedes aegypti	Kunene region: Fransfontein (Muspratt, 1956) Oshikoto region: Tsumeb (De Meillon, 1943; Muspratt, 1956) Otjozondjupa region: Otjiwarongo, Grootfontein (Muspratt, 1956) Erongo region: Okombahe, Usakos, Karibib (Muspratt, 1956) Khomas region: Windhoek (De Meillon, 1943; Muspratt, 1956)	Chikungunya, Dengue (Weaver and Reisen, 2010)
Aedes caballus Theobald 1912	Not reported	Rift Valley Fever virus (RVFV), West Nile virus (WNV) (Mcintosh, 1973)
Aedes circumluteolus Theobald 1908	Not reported	RVFV (Sang et al., 2010); WNV
Aedes fowleri D'Emmerez de Charmoy 1908	The North Central regions (Edwards, 1941) Erongo region: Okombahe (Muspratt, 1956)	RVFV (Turell, 1989)
Aedes fulgens Edwards 1917	Not reported	Chikungunya (Jupp et al., 1981)
Aedes lineatopennis Ludlow 1905	Not reported	RVFV (Linthicum et al., 1985)
Aedes luteocephalus Newstead	Not reported	Chikungunya, yellow fever (Diallo et al., 1999), dengue 2 (WRSU, 2011)
Aedes metallicus Edwards	Kunene region: Fransfontein, Outjo (Muspratt, 1956) Otjozondjupa region: Otjiwarongo, Grootfontein, Okahandja (Muspratt, 1956) Erongo region: Omatjette, Okombahe, Usakos, Karibib (Muspratt, 1956) Khomas region: Windhoek (Muspratt, 1956)	Yellow fever (Muspratt, 1956)
Aedes ochraceus Theobald 1901	Not reported	RVFV (Ba et al., 2006)
Aedes simpsoni Theobald 1910	Not reported	Yellow fever (Trpis et al., 1971)
Aedes taylori Edwards 1936	Erongo region: Okombahe (Muspratt, 1956)	Yellow fever, dengue 2, Chikungunya (WRSU, 2011)
Aedes vittatus Bogot	Kunene region: Outjo (Muspratt, 1956) Otjozondjupa region: Okahandja (Muspratt, 1956) Erongo region: Omatjette, Okombahe, Omaruru, Usakos, Karibib, Otjimbingwe (Muspratt, 1956) Khomas region: Windhoek (Muspratt, 1956)	Yellow fever, Dengue (Guindo-Coulibaly et al., 2010)
Anopheles		
Anopheles arabiensis (reported originally as *Anopheles gambiae s.l.* Patton 1905 but most likely *An. arabiensis*)	Kunene region: Fransfontein, Outjo, Ohopuho (De Meillon, 1951) Oshana region: Ondangwa (De Meillon, 1951) Otjozondjupa region: Otjiwarongo, Waterberg Reserve, Otavi, Ovitoto, Grootfontein, Otjituo Reserve, Maria Bronn, Kanovlei, Okahandja (De Meillon, 1951) Oshikoto region: Tsumeb, Namutoni (Etosha) (De Meillon, 1951) Ohangwena region: Oshikango (De Meillon, 1951) Okavango region: Rundu and at many points along the Okavango River (De Meillon, 1951) Erongo region: Swakopmund, Omatjette, Okombahe, Otjimbingwe, Omaruru, Usakos, Karibib (De Meillon, 1951) Omaheke region: Gobabis, Aminuis Reserve, Epukiro Reserve, Farm Harnas (Gobabis), Khomas region: Windhoek (De Meillon, 1951) Not found south of latitude 23 South. (De Meillon, 1951)	Principal malaria vector in Namibia (Kamwi, 2005; Ntomwa et al., 2006)
Anopheles cinereus Theobald 1901	Khomas region: Windhoek - probably more widely distributed (De Meillon, 1951)	RVFV (Moutailler et al., 2009)
Anopheles coustani Laveran 1910	Oshana region: Ondangwa; 58 miles (93 km) Namutoni-Ondangwa road – confined to the north (De Meillon, 1951) Otjozondjupa region: Otjiwarongo (De Meillon, 1951) Okavango region: Musese (De Meillon, 1951)	RVFV (Ratovonjato et al., 2011) Secondary malaria vector (Taye et al., 2006)
Anopheles demeilloni Evans 1933	Khomas region: Windhoek - probably more widely distributed (De Meillon, 1951)	Secondary malaria vector (Taye et al., 2006)
Anopheles funestus Giles 1910	Okavango region: Musese and along the Okavango river (De Meillon, 1951) Ohangwena Region: Oshikango (De Meillon, 1951)	Main malaria vector in Namibia (Kamwi, 2005; Ntomwa et al., 2006) O'Nyong-Nyong fever virus (Lutwama et al., 1999)

Table 5 (*Continued*)

AEDES	Published collection locations in Namibia (North to South regions)	Human pathogens transmitted by particular species in SSA countries
Anopheles marshallii (Theobald 1903)	Otjozondjupa region: Grootfontein – widespread (De Meillon, 1951)	Secondary malaria vector (Antonio-Nkondjio et al., 2006)
Anopheles nili (Theobald 1904)	Caprivi region: Andara Only along the Okavango and Kunene rivers (De Meillon, 1951)	Possible secondary malaria vector (Gillies and De Meillon, 1968; Taye et al., 2006). Not important in presence of *An gambiae and An funestus*
Anopheles pharoensis Theobald	Okavango region: Musese – restricted to the extreme north of the Namibia (De Meillon, 1951)	Secondary vector of malaria (Gillies, 1964; Gillies and De Meillon, 1968; Taye et al., 2006; Antonio-Nkondjio et al., 2006; WRBU, 2011)
Anopheles pretoriensis (Theobald 1903)	Otjozondjupa region: Grootfontein Kunene region: Outjo, Ohopuho-Tshimhaka road at several points, Seisfontein, Fransfontein Erongo region: Brandberg Khomas region: Windhoek Karas region: Warmbad (De Meillon, 1951)	Possible secondary malaria vector (South Africa) (Swellengrebel et al., 1931) – hardly significant because of lack of contact with man
Anopheles rufipes (Gough 1910)	Otjozondjupa region: Tsumeb, Grootfontein, Maria Bronn, Okavango region: Nyangana widespread (De Meillon, 1951)	Possible secondary malaria vector (Gelfand, 1947)
Anopheles squamosus Theobald 1901	Oshikoto region: Namutoni (Etosha) (De Meillon, 1951) Okavango region: Rundu and generally along the Okavango, (De Meillon, 1951) Otjozondjupa region: Kanovlei, Otjituo Reserve, Waterberg Reserve (De Meillon, 1951) Oshana region: Ondangwa (De Meillon, 1951) Ohangwena region: Oshikango (De Meillon, 1951) Kunene region: Ugab-Fransfontein Road (De Meillon, 1951) widespread (De Meillon, 1951)	RVFV (Ratovonjato et al., 2011) Secondary malaria vector (Gillies, 1964)
Anopheles wellcomei Theobald 1904	Not reported	Secondary malaria vector (Antonio-Nkondjio et al., 2006)
Anopheles ziemanni Grünberg 1902	Okavango River (De Meillon, 1951)	Secondary malaria vector (Antonio-Nkondjio et al., 2006)
Culex		
Culex antennatus Becker 1903	Not reported	WNV, RVFV (WRBU, 2011)
Culex decens Theobald 1901	Not reported	Moussa virus (Quan et al., 2010)
Culex duttoni Theobald 1901	Erongo region: Omaruru (De Meillon and Hardy, 1953).	Wesselbron virus (Grard et al., 2010)
Culex ethiopicus Edwards 1912 – *Culex bitaeniorhynchus*	Not reported	Chikungunya (Diallo et al., 1999)
Culex pipiens Linnaeus	Erongo region: Usakos, Swakopmund and Walvis Bay (De Meillon and Hardy, 1953).	WNV (Weaver and Reisen, 2010), RVFV (Turell et al., 2008)
Culex poicilipes Theobald 1903	Not reported	WNV (Diallo et al., 2000); RVFV (Sang et al., 2010)
Culex quinquefasciatus Say	Khomas region: Windhoek (Noden and Musuuo, unpublished data)	WNV (Weaver and Reisen, 2010); RVFV (Sang et al., 2010)
Culex univittatus Theobald 1901	Otjozondjupa region: Okahandja (Edwards, 1941); widely distributed in Northern Namibia (De Meillon and Hardy, 1953).	WNV (WRBU, 2011); RVFV (Sang et al., 2010)
Mansonia		
Mansonia africana Theobald 1901	Not reported	RVFV (Sang et al., 2010)
Mansonia uniformis Theobald 1901	Not reported	RVFV (Sang et al., 2010)

1985a,b) and Caprivi (Joubert et al., 1991) (Table 2). Exposure to West Nile was highest in the Caprivi with a prevalence of 29% which increased from 13% in 1983–a dramatic increase in one year (Joubert et al., 1991). This is most likely due to an outbreak passing through Southern Africa in the early 1980s (Jupp, 2001; Weaver and Reisen, 2010). Chikungunya, with very low evidence of exposure (<0.1%) (Joubert et al., 1985b, 1991), also occurred in Southern Africa since the mid-1950s (Weaver and Reisen, 2010) so it is likely that persons in Caprivi and Kavango regions were exposed during a regional epidemic. Interestingly, dengue virus has not been historically identified in Namibia but a recent review (Amarasinghe et al., 2011), including a map, reported that dengue was identified in travellers to Namibia between 1999 and 2002 as well as 2006, citing reports on the TropNet Europ Network (www.tropnet.net) and ProMED mail (www.promedmail.org). Attempts were made to verify but the authors were only able to find one paper citing the aforementioned references (Wichmann et al., 2003). Much like the *Rickettsia africae* cited earlier, this dengue reference appears to be another traveller-related report without local confirmation. More effort needs to be made to determine whether these traveller reports have any credibility within local populations. Currently, while arboviruses do not seem to be much of a threat, the presence of known mosquito vectors, especially *A. aegypti*, throughout Namibia (Table 5) increases the outbreak potential of any mosquito-borne virus which may come across the border or enter via an infectious traveller.

5.2. Tick-borne viruses: Crimean-Congo Hemorrhagic Fever virus (CCHRV)

One of the unsolved mysteries of Namibia, CCHFV was first reported in Namibia in 1986. Between 1986 and 2006, HPA (2010) reported 15 'outbreaks' in various locations. Even before an outbreak occurred, Joubert et al. (1991) reported one sero-positive sample from 621 patients in Caprivi region in 1984. To date, six NIH GenBank codes for samples described by Burt and Swanepoel (2005) provide the only published records of its existence and epidemiology in Namibia. The infections mainly occurred in the eastern half of the country – one in Grootfontein (Otjozondjupa region), two in Windhoek (Khomas region), two in Gobabis (Omaheke region) and one in Karasburg (Karas region). Three of the cases occurred in 1986, 1 in 1998, and 2 in 2001. Four of the 6 cases came from known tick bites with a 50% survival rate (Burt and Swanepoel, 2005).

Occurrences of CCHFV in Namibia occur on a regular basis ('once every 5 years' (ProMED, 2001). One particular case in 2001 involved a well-known farmer from a game farm near Gobabis (Omaheke region) which rehabilitates wild cats who died of CCHFV through a tick bite while transporting cattle to his guest lodge. Another case was diagnosed in January 2002 when a man from Katatura, the low-income area of Windhoek, the capital, had become infected in the Mangetti area (Kavango region) (ProMED, 2002).

In 2010, after an 8 year hiatus, three human cases of CCHFV cases occurred in the Karas region (OIE, 2012). The principle case was a cattle and sheep farmer from an area close to the South African border. When he wasn't improving, the farmer and his wife went immediately across the border for treatment at a private hospital in Upington, South Africa. While CCHFV is a notifiable infection in Namibia, the fact that this farmer went into South Africa with an active infection prompts questions about what would happen if a full-blown outbreak would have occurred. From what was reported in The Namibian (2010), these infections were due primarily to handling dead carcasses and not due to tick bites.

The low human/high animal density in areas where CCHFV has been contracted by humans may lower the priority to address this pathogen in Namibia. However, the presence of 3 known vectors (Table 6), principally *Hyalomma marginatum rufipes*, as well as the repetitive cycle already mentioned (every 5 years), suggests the feasibility of creating disease risk maps involving tick species distribution, case detection in animals and humans, and environmental parameters to better understand the transmission dynamics, reservoirs of infection during the non-transmission periods, and potential for climate-induced outbreaks.

5.3. Hemorrhagic fever viruses

Two studies evaluated hemorrhagic fever virus exposure using serology in Rundu (Kavango) ($n = 48$) (Isaäcson et al., 2000) and Katima Mulilo (Caprivi) ($n = 621$) (Joubert et al., 1991). Only Joubert et al. (1991) reported prevalence for Hantaan (2.6%), Ebola (2.2%), Lassa (0.8%), and Marburg (0.3%) viruses. The cross-border transmission potential for any of these viruses must be suspected. There have been no published reports since the mid-1980s.

5.4. Rabies

Rabies continues to be a significant zoonotic problem in Namibia (OIE, 2012). A variety of studies have reported rabies in animal populations (Barnard, 1979; Laurenson et al., 1997a,b; Courtin et al., 2000) with several focusing on the unique transmission cycles involving kudu (*Tragelaphus strepsiceros*) (Barnard and Hassel, 1981; Hubschle, 1998; Mansfield et al., 2006). The only reports of human cases (OIE, 2012) have varied between 5 and 26 cases (average of 17 cases per year) between 1998 and 2010 with high mortality rates. As Namibia has already demonstrated how community-based participation can assist in the elimination of plague (Shangula, 1998), priority needs to be given to educate and prevent in communities where rabies is a problem.

6. Fungal infections

Fungal infections, in general, are not well studied in SSA (Hodgson and Rachanis, 2002; Morris et al., 2004) and Namibia is no exception. Three studies since 2009 indicate that fungal infections are present. Ide et al. (2009) gave an account of a Namibian diagnosed with mycetoma in Belgium, 30 years after falling into an acacia tree as a teenager in northern Namibia. Zaigraykina et al. (2010) described a *Fusarium* infection in the eye of a volunteer who travelled to Namibia for work in a carnivore wildlife conservation center. Focused on mycoses affecting the HIV/AIDS patients, Nowaseb et al. (2012) molecularly tested HIV- and TB-infected patients for infection with *Pneumocystis jirovecii* in central Namibia and reported a minimal frequency of PcP of 3.6%.

7. Ectoparasites (myiasis)

In 1959, Zumpt reported the presence of the Tumbu fly, the most common cause of myiasis in Africa, throughout central and northern Namibia in 6 sites, namely Ondangwa (Oshana region), Outjo (Kunene region), Epukiro, Omitara (Omaheke Region), Okahandja (Otjozondjupa Region), and Ondekaremba (Khomas region). Two samples were obtained directly from people. Fujisaki et al. (2008) presented a case of a Namibian living in Japan who was infested when visiting a hunting farm close to the Etosha National Park. Upon return to Japan, he was diagnosed (PCR) with 19 Tumbu fly (*Cordylobia anthropophagi*) maggots (blowfly) which had parasitized his back and upper shoulder region. These reports indicate that myiasis could be more of a problem in Namibia than previously thought.

Table 6
Tick vector species of Namibia (Living Namibia, 2003), their published collection locations and reported human pathogens transmitted in other Sub-Saharan African countries.

IXODID species	Published collection locations in Namibia	Reported human pathogens transmitted in other Sub-Saharan African countries
Amblyomma hebraeum Koch 1844	Not reported	*Rickettsia conorii* (Walker, 1991) *R. africae* (Portillo et al., 2007) *Ehrlichia ruminantium* (Walker, 1991)
Amblyomma variegatum Fabricius 1794	Caprivi region (Walker et al., 2007)	*Rickettsia conorii*, (Walker, 1991) *Rickettsia africae* (Mediannikov et al., 2012) *Ehrlichia ruminantium* (Walker, 1991) *Coxiella* (Mediannikov et al., 2010b)
Hyalomma turanicum Pomerantsev, 1946	Not reported	Crimean-Congo haemorrhagic fever virus (Walker et al., 2007)
Hyalomma truncatum Koch 1844	Kunene Region: Otjovasandu; Oshikoto Region: Okaukuejo (Etosha National Park); north-east of Windhoek (Biggs and Langenhoven, 1984); Southern Namibia (Matthee et al., 2010) – Hardap region (Horak et al., 1992)	*Rickettsia aeschlimannii* and *Rickettsia sibirica mongolitimonae* (Mediannikov et al., 2010a) *Coxiella* (Mediannikov et al., 2010b)
Hyalomma marginatum rufipes Koch 1844	Kunene Region: Otjovasandu, Oshikoto Region: Okaukuejo (Etosha National Park); north-east of Windhoek (Biggs and Langenhoven, 1984); Southern Namibia (Matthee et al., 2010) – Hardap region (Horak et al., 1992)	*Rickettsia aeschlimannii* (Mediannikov et al., 2010a) *Rickettsia africae* (Mediannikov et al., 2012) Crimean-Congo haemorrhagic fever virus (Tekin et al., 2011) *Coxiella* (Mediannikov et al., 2010b)
Rhipicephalus (*Boophilus*) *decoloratus* Koch, 1844	Northeast of Windhoek (Biggs and Langenhoven, 1984)	*Rickettsia africae* (Portillo et al., 2007; Mediannikov et al., 2012) *Coxiella* (Mediannikov et al., 2010b)
Rhipicephalus evertsi evertsi Neumann, 1897	Common in the moist northern regions of Namibia and throughout the Caprivi region (Walker, 1991; Walker et al., 2007)	*Rickettsia aeschlimannii* (Mediannikov et al., 2010a) *R. conorii conorii* and *Rickettsia africae* (Mediannikov et al., 2010a) *Coxiella* (Mediannikov et al., 2010b)
Rhipicephalus sanguineus Latreille 1806	Southern and Central Namibia (Matthee et al., 2010)	*R. conorii* (Levin et al., 2012) *Rickettsia africae* (Ogo et al., 2012) *Ehrlichia canis*, *E. chaffeensis*, and *E. ewingii* (Ndip et al., 2007)
Rhipicephalus turanicus Pomerantsev, 1936	Otjozondjupa region: Grootfontein Etosha National Park (Walker et al., 2007)	*Rickettsia massiliae* (Keysary et al., 2011) Crimean-Congo haemorrhagic fever virus (Tekin et al., 2011)
Argasid species		
Ornithodoros moubata (Murray 1877)	Okavango region: Rundu (Dreier et al., 1998); North Omusati, Ohangwena, Oshana and Oshikoto regions (Ordman, 1957).	*Borrelia duttoni* (Dreier et al.,1998)

8. Discussion

As Namibia develops an integrated public health system, this is an opportune time to implement creative strategies to address the gaps in knowledge addressed in this review. It is significant to note that most of the published information covered in this review was from before Independence (1990) and focused on the catchments of 1 or 2 hospitals or regions in the northern parts of the country (Fig. 1). Because of this, the epidemiology of each NTD listed in Table 1 (Fig. 1) is most likely not representative of the situation and needs to be updated on a national level. Given the high prevalence of undefined febrile illness in recent reports (Kamwi, 2005; van Dillen et al., 2007) and the outbreak potential of many identified NTDs (ex. RVFV, CCHFV, West Nile virus, Chikungunya, Leptospirosis, Q fever, and Rickettsia) with the ubiquitous presence of mosquito, flea and tick vectors, the first step would be to create disease risk maps for each NTD using environmental (e.g. climate, temperature, rain, humidity, water catchment), and ecological (e.g. animal-human distribution, land use, land cover) parameters so that baselines could be established on which to build future prevention and control strategies. With many NTDs also found in bordering countries with similar climate zones and seasons (Angola (Filipe et al., 1975), Zambia (Simuunza et al., 2011), Zimbabwe (Kelly et al., 1993), Botswana (Appleton et al., 2008; Alexander et al., 2012), and South Africa (Pretorius et al., 2004; Louw et al., 2005), it is critical to evaluate how the volume of cross-border movement of animals and humans affects regional control and prevention strategies.

A second step would be to develop an active vector-borne disease training program to jump-start the involvement of tertiary institutions in this vital task for the country. The tertiary institutions of Namibia (UNAM and the Polytechnic of Namibia) need to be tasked with mapping the NTDs in Namibia. Although only 8% of biomedical publications from Namibia between 1995 and 2009 were from Namibian universities (Noden, 2011), there are positive movements which will alter this scenario in the near future. First, newly established biomedical science programs including medicine, pharmacy, veterinary science, master's level microbiology (UNAM) and biomedical laboratory sciences and environmental health (epidemiology) (Polytechnic), each with integrated research priorities, will join already established programs in nursing and public health (UNAM). With the capacity building and research focus of each of these programs, it will be possible to develop research foci for NTDs. Secondly, since 2008, the Ministry of Health and Social Services (MoHSS) has fast-tracked the development of an Integrated Health Information Management System to enable large scale data management of patient data from the public systems. Finally, the developing priority to develop a public health surveillance network (including the developing FELTP program) will significantly improve understandings of all NTDs in the country. Once all these systems are in place and working together in the next 3–5 years, it will be possible to establish new diagnostic algorithms for local districts in regards to undefined causes of febrile diseases as well as track the outbreak potential of various pathogens before they cause a problem. The five travel studies reporting NTDs in this review, including dengue, *Rickettsia*, and fungal infections, continues to point to the need for a broad epidemiological surveillance program to monitor NTDs involved in both animal and human health. Due to the zoonotic nature of many of NTDs, future directions should consider a 'One Health' approach

in which resources for both animal and human health programs can be pooled to create a collaborative, cross-sectional strategy to evaluate the ecological and environmental drivers of specific NTDs in Namibia.

9. Conclusions

In conclusion, the historical record of NTDs in Namibia provides an urgent call to discovery, especially by Namibia's nascent biomedical programs. While the main focus is on STHs and schistosomiasis, the involvement of *Rickettsia*, *Leptospira*, *Coxiella*, and *Brucella* on the non-malaria causes of febrile illness needs special attention. While apparent that recent studies have strategically addressed human populations which would most be a risk for these bacterial infections, they are only small in comparison with what needs to be done. While arguable that the historical record of each NTD may not indicate current presence, the timing is good for collaboration and capacity building to occur in order to improve NTD surveillance and create integrated disease risk maps of the critical NTDs which are impacting the Namibian people.

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References

Alexander, K.A., Blackburn, J.K., Vandewalle, M.E., Pesapane, R., Baipoledi, E.K., Elzer, P.H., 2012. Buffalo, bush meat, and the zoonotic threat of brucellosis in Botswana. PLoS One 7 (3), e32842.

Amano, K., Suzuki, N., Hatakeyama, H., Kasahara, Y., Fujii, S., Fukushi, K., Suto, T., Mahara, F., 1992. The reactivity between rickettsiae and Weil-Felix test antigens against sera of rickettsial disease patients. Acta Virologica 36 (1), 67–72.

Amarasinghe, A., Kuritsk, J.N., Letson, G.W., Margolis, H.S., 2011. Dengue virus infection in Africa. Emerging Infectious Disease 17 (8), 1349–1354.

Amuthenu, N., Gummow, B., 2009. A seroprevalence study of foot-and-mouth disease and brucellosis in the Northern Communal Area of Namibia. International Symposia on Veterinary Epidemiology and Economics (ISVEE) proceedings, ISVEE 12. Proceedings of the 12th Symposium of the International Society for Veterinary Epidemiology and Economics, Durban, South Africa, Theme 1 – Surveillance and disease control: FMD, Disease monitoring & control, Evaluation of animal disease. http://www.sciquest.org.nz/node/68287

Antonio-Nkondjio, C., Kerah, C.H., Simard, F., Awono-Ambene, P., Chouaibou, M., Tchuinkam, T., Fontenille, D., 2006. Complexity of the malaria vectorial system in Cameroon: contribution of secondary vectors to malaria transmission. Journal of Medical Entomology 43 (6), 1215–1221.

Appleton, C.C., Ellery, W.N., Byskov, J., Mogkweetsinyana, S.S., 2008. Epidemic transmission of intestinal schistosomiasis in the seasonal part of the Okavango Delta, Botswana. Annals of Tropical Medicine and Parasitology 102 (7), 611–623.

Ash, A., Lymbery, A., Lemon, J., Vitali, S., Thompson, R.C., 2010. Molecular epidemiology of *Giardia duodenalis* in an endangered carnivore: the African painted dog. Veterinary Parasitology 174 (3–4), 206–212.

Ba, Y., Diallo, D., Dia, I., Diallo, M., 2006. Feeding pattern of Rift Valley Fever virus vectors in Senegal. Implications in the disease epidemiology. Bulletin de la Société de Pathologie Exotique 99 (4), 283–289.

Barnard, B.J., 1979. The role played by wildlife in the epizootiology of rabies in South Africa and South-West Africa. Onderstepoort Journal of Veterinary Research 46 (3), 155–163.

Barnard, B.J., Hassel, R.H., 1981. Rabies in kudus (*Tragelaphus strepsiceros*) in South West Africa/Namibia. Journal of the South African Veterinary Association 52 (4), 309–314.

Best Country Maps, 2012. Population Density Map of Namibia. http://www.bestcountryreports.com/Population_Map_Namibia.php

Biggs, H.C., Langenhoven, J.W., 1984. Seasonal prevalence of ixodid ticks on cattle in the Windhoek District of South West Africa/Namibia. Onderstepoort Journal of Veterinary Research 51 (3), 175–182.

Biggs, H.M., Bui, D.M., Galloway, R.L., Stoddard, R.A., Shadomy, S.V., Morrissey, A.B., Bartlett, J.A., Onyango, J.J., Kinabo, G.D., Saganda, W., Crump, J.A., 2011. Leptospirosis among hospitalized febrile patients in northern Tanzania. American Journal of Tropical Medicine and Hygiene 85 (2), 275–281.

Brown, C.B.A., Bethune, S., Appleton, C.C., 1992. Freshwater snails of East Caprivi and the lower Okavango River Basin in Namibia and Botswana. Hydrobiologia 246, 9–40.

Burt, F.J., Swanepoel, R., 2005. Molecular epidemiology of African and Asian Crimean-Congo haemorrhagic fever isolates. Epidemiology and Infection 133 (4), 659–666.

Burton, M.J., Mabey, D.C., 2009. The global burden of trachoma: a review. PLOS Neglected Tropical Diseases 3 (10), e460.

CDC, 2012. Parasites. http://www.cdc.gov/parasites/

Chance, M.L., Schnur, L.F., Thomas, S.C., Peters, W., 1978. The biochemical and serological taxonomy of *Leishmania* from the Aethiopian zoogeographical region of Africa. Annals of Tropical Medicine and Parasitology 72 (6), 533–542.

CIA, 2012. World Fact Book: Africa: Namibia. https://www.cia.gov/library/publications/the-world-factbook/geos/wa.html

Courtin, F., Carpenter, T.E., Paskin, R.D., Chomel, B.B., 2000. Temporal patterns of domestic and wildlife rabies in central Namibia stock-ranching area, 1986–1996. Preventive Veterinary Medicine 43 (1), 13–28.

De Meillon, B., 1943. New records and new species of Nematocera (Diptera) from the Ethiopian Region. Journal of the Entomological Society of Southern Africa 6, 90–113.

De Meillon, B., 1951. Malaria survey of Southwest Africa. Bulletin of World Health Organization, 4, 333–417. http://whqlibdoc.who.int/bulletin/1951/Vol4/Vol4-No3/bulletin_1951_4(3)_333-417.pdf

De Meillon, B., Hardy, F., 1953. New records and species of biting insects from the Ethiopian region: IV. Journal of the Entomological Society of Southern Africa 16 (1), 17–35.

Diallo, M., Lochouarn, L., Ba, K., Sall, A.A., Mondo, M., Girault, L., Mathiot, C., 2000. First isolation of the Rift Valley fever virus from *Culex poicilipes* (Diptera: Culicidae) in nature. American Journal of Tropical Medicine and Hygiene 62 (6), 702–704.

Diallo, M., Thonnon, J., Traore-Lamizana, M., Fontenille, D., 1999. Vectors of Chikungunya virus in Senegal: current data and transmission cycles. American Journal of Tropical Medicine and Hygiene 60 (2), 281–286.

Dreier, M., Rohl, S., Potschka, B., 1998. Epidemiology of relapsing fever (*Borrelia duttoni*) in Northeast Namibia. Meeting abstract. Tropical Medicine and Parasitology 40 (4), 504.

DuPlessis, J.L., 1990. Increased pathogenicity of an *Ehrlichia*-like agent after passage through *Amblyomma hebraeum*. A preliminary report. Onderstepoort Journal of Veterinary Research 57, 233–237.

DuPlessis, J.L., Bezuidenhout, J.D., Brett, M.S., Camus, E., Jongejan, F., Mahan, S.M., Martinez, D., 1993. The serodiagnosis of heartwater: a comparison of five tests. Revue D'elevage et de Medecine Veterinaire des Pays Tropicaux 46 (1–2), 123–129.

DuPlessis, J.L., Malan, L., 1987. The application of the indirect fluorescent antibody test in research on heartwater. Onderstepoort Journal of Veterinary Research 54, 319–325.

Dupont, H.T., Brouqui, P., Faugere, B., Raoult, D., 1995. Prevalence of antibodies to *Coxiella burnetti*, *Rickettsia conorii*, and *Rickettsia typhi* in seven African countries. Clinical Infectious Diseases 21 (5), 1126–1133.

Edwards, F.W., 1941. Mosquitoes of the Ethiopian Region, 3.Culicine adults and pupae. London: Brit. Museum (Nat. Hist.).

Evans, A.C., Joubert, J.J., 1989. Intestinal helminthes of hospital patients in Kavango territory, Namibia. Transactions of the Royal Society of Tropical Medicine and Hygiene 83, 681–683.

Evans, A.C., Markus, M.B., Steyn, E., 1990. A survey of the intestinal nematodes of Bushmen in Namibia. American Journal of Tropical Medicine and Hygiene 42 (3), 243–247.

Filipe, A.R., De Carvalho, R.G., Relvas, A., Casaca, V., 1975. Arbovirus studies in Angola: serological survey for antibodies to arboviruses. American Journal of Tropical Medicine and Hygiene 24 (3), 516–520.

Frean, J., Arndt, S., Spencer, D., 2002. High rate of *Bartonella henselae* infection in HIV-positive outpatients in Johannesburg, South Africa. Transactions of the Royal Society of Tropical Medicine and Hygiene 96 (5), 549–550.

Fujisaki, R., Makimura, K., Hayashi, T., Yamamura, M., Yamaoka, T., Shiraishi, K., Ishibashi, S., Kawakami, S., Kurihara, T., Nishiya, H., 2008. Exotic myiasis caused by 19 larvae of *Cordylobia anthropophaga* in Namibia and identified using molecular methods in Japan. Transactions of the Royal Society of Tropical Medicine and Hygiene 102 (6), 599–601.

Gelfand, H.M., 1947. Natural malaria infection in *Anopheles rufipes* (Gough). Journal of Tropical Medicine and Hygiene 50 (8), 159.

Geldenhuys, P.J., Hallett, A.F., Visser, P.S., Malcolm, A.C., 1967. Bilharzia survey in the eastern Caprivi, northern Bechuanaland and northern South West Africa. South African Medical Journal 41 (31), 767–771.

Gillies, M.T., 1964. The role of secondary vectors of malaria in north-east Tanganyika. Transactions of the Royal Society of Tropical Medicine and Hygiene 58, 154–158.

Gillies, M.T., De Meillon, B., 1968. The Anophelinae of Africa South of the Sahara. Publications of the South African Institute for Medical Research 54, 343.

Global atlas of helminth infections, 2011. http://www.thiswormyworld.org/

Grard, G., Moureau, G., Charrel, R.N., Holmes, E.C., Gould, E.A., de Lamballerie, X., 2010. Genomics and evolution of *Aedes*-borne flaviviruses. Journal of General Virology 91 (Pt 1), 87–94.

Grove, S.S., 1978. The clinical and histological features of South West African cutaneous Leishmaniasis. South African Medical Journal 53, 712–715.

Grove, S.S., 1989. Leishmaniasis in South West Africa/Namibia to date. South African Medical Journal 75, 290–292.

Guindo-Coulibaly, N., Adja, A.M., Koudou, B.G., Konan, Y.L., Diallo, M., Koné, A.B., Hervé, J.P., N'Goran, K.E., 2010. Distribution and Seasonal Variation of *Aedes*

aegypti in the Health District of Abidjan (Côte d'Ivoire). European Journal of Scientific Research, 40(4), 522–530. http://www.eurojournals.com/ejsr_40_4_05.pdf

Harms, G., Iyambo, S.N., Corea, A., Radebe, F., Fehler, H.G., Ballard, R.C., 1998. Perceptions and patterns of reproductive tract infections in a young rural population in North-West Namibia. International Journal of STD & AIDS 9 (12), 744–750.

Haufiku, M., 2012. Leprosy sufferers appeal for help. http://www.newera.com.na/articles/43832/Leprosy-sufferers-appeal-for-help (accessed 27.03.12).

HPA (Health Protection Agency), (2010). Historical cases and outbreaks of CCHF. http://www.hpa.org.uk/Topics/InfectiousDiseases/InfectionsAZ/CCHF/EpidemiologicalData/cchfoutbreaks/#four

Hodgson, T.A., Rachanis, C.C., 2002. Oral fungal and bacterial infections in HIV-infected individuals: an overview in Africa. Oral Diseases 8 (Suppl 2), 80–87.

Horak, I.G., Anthonissen, M., Krecek, R.C., Boomker, J., 1992. Arthropod parasites of springbok, gemsbok, kudus, giraffes and Burchell's and Hartmann's zebras in the Etosha and Hardap Nature Reserves, Namibia. Onderstepoort Journal of Veterinary Research 59 (4), 253–257.

Hotez, P.J., Kamath, A., 2009. Neglected tropical diseases in sub-Saharan Africa: review of their prevalence, distribution, and disease burden. PLOS Neglected Tropical Diseases 3 (8), e412.

Hotez, P.J., Molyneux, D.H., Fenwick, A., Kumaresan, J., Sachs, S.E., Sachs, J.D., Savioli, L., 2007. Control of neglected tropical diseases. New England Journal of Medicine 357 (10), 1018–1027.

Hu, V.H., Harding-Esch, E.M., Burton, M.J., Bailey, R.L., Kadimpeul, J., Mabey, D.C., 2010. Epidemiology and control of trachoma: systematic review. Tropical Medicine & International Health 15 (6), 673–691.

Hubschle, O.J.B., 1998. Rabies in the Kudu Antelope (*Tragelaphuss trepsiceros*). Reviews of Infectious Diseases 10 (S4), S629–S633.

IAEA, 2009. IAEA and African Union Commission Agree to Cooperate in Tsetse Fly Eradication. http://www.iaea.org/newscenter/pressreleases/2009/prn200916.html

Ide, L., Knol, J., Op De Beeck, L., Surmont, I., 2009. Subcutaneous nodules, some 20 years after a fall in Namibia, diagnosed in Belgium: imported pathology may take a long time before diagnosis. Journal of Clinical Pathology 62, 765.

Isaäcson, M., Frean, J., He, J., Seriwatana, J., Innis, B.L., 2000. An outbreak of hepatitis E in Northern Namibia. American Journal of Tropical Medicine and Hygiene 62 (5), 619–625.

Jacobs, M.R., Koornhof, H.J., Crisp, S.I., Palmhert, H.L., Fitzstephens, A., 1978. Enteric fever caused by *Salmonella paratyphi* C in South and South West Africa. South African Medical Journal 54 (11), 434–438.

Jacobs, M.R., Mason, P.R., 1978. Prevalence of *Toxoplasma* antibodies in Southern Africa. South African Medical Journal 53, 619–621.

Jelinek, T., Löscher, T., 2001. Clinical features and epidemiology of tick typhus in travellers. Journal of Travel Medicine 8 (2), 57–59.

Jennings, G.J., Hajjeh, R.A., Girgis, F.Y., Fadeel, M.A., Maksoud, M.A., Wasfy, M.O., El-Sayed, N., Srikantiah, P., Luby, S.P., Earhart, K., Mahoney, F.J., 2007. Brucellosis as a cause of acute febrile illness in Egypt. Transactions of the Royal Society of Tropical Medicine and Hygiene 101 (7), 707–713.

Jensenius, M., Fournier, P.E., Vene, S., Hoel, T., Hasle, G., Henriksen, A.Z., Hellum, K.B., Raoult, D., Myrvang, B., Norwegian African Tick Bite Fever Study Group, 2003. African tick bite fever in travelers to rural sub-Equatorial Africa. Clinical Infectious Diseases 36 (11), 1411–1417.

Joubert, J.J., Jupp, P.G., Prozesky, O.W., Lourens, J.G.H., 1985a. Infection of wild populations of the tampan, *Ornithodoros moubata* Murray, with hepatitis B virus in the Kavango, Northern Namibia. South African Journal of Science 81, 167–168.

Joubert, J.J., Prozesky, O.W., Lourens, J.G., van Straten, A.M., Theron, J.W., Swanevelder, C., Meenehan, G.M., van der Merwe, C.A., 1985b. Prevalence of hepatitis virus and some arbovirus infections in Kavango, northern SWA/Namibia. South African Medical Journal 67 (13), 500–502.

Joubert, J.J., van der Merwe, C.A., Lourens, J.H., Lecatsas, G., Siegrühn, C., 1991. Serological markers of Hepatitis B virus and certain other viruses in the population of eastern Caprivi, Namibia. Transactions of the Royal Society of Tropical Medicine and Hygiene 85 (1), 101–103.

Jupp, P.G., 2001. The ecology of West Nile virus in South Africa and the occurrence of outbreaks in humans. Annals of the New York Academy of Sciences 951, 143–152.

Jupp, P.G., McIntosh, B.M., Dos Santos, I., DeMoor, P., 1981. Laboratory vector studies on six mosquito and one tick species with chikungunya virus. Transactions of the Royal Society of Tropical Medicine and Hygiene 75 (1), 15–19.

Kamwi, R.N. 2005. Malaria situation in Namibia: a study of vector species and effectiveness of the past and current control strategies in selected parts of Namibia [PhD]. University of Namibia. http://wwwisis.unam.na/cgi-bin/wwwi32.exe/%5Bin=genisis2.in%5D/

Kelly, P.J., Matthewman, L.A., Mason, P.R., Raoult, D., 1993. Q fever in Zimbabwe. A review of the disease and the results of a serosurvey of humans, cattle, goats and dogs. South African Medical Journal 83 (1), 21–25.

Keysary, A., Eremeeva, M.E., Leitner, M., Din, A.B., Wikswo, M.E., Mumcuoglu, K.Y., Inbar, M., Wallach, A.D., Shanas, U., King, R., Waner, T., 2011. Spotted fever group rickettsiae in ticks collected from wild animals in Israel. American Journal of Tropical Medicine and Hygiene 85 (5), 919–923.

Krafsur, E.S., Endsley, M.A., Wohlford, D.L., Griffiths, N.T., Allsopp, R., 2001. Genetic differentiation of *Glossina morsitans centralis* populations. Insect Molecular Biology 10 (4), 387–395.

Kisting, D., 2010. Rift Valley outbreak confirmed. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=68004&no_cache=1] (accessed 19.05.10).

Kisting, D., 2010. 3 suspected cases of RVF reported http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=72046&no_cache=1] (accessed 03.09.10).

Kisting, D., 2011. Farmer 'has Rift Valley Fever'. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=82744&no_cache=1] (accessed 09.06.11).

Kyronseppa, H.J.P., Goldsmid, J.M., 1978. Studies on the intestinal parasites in African patients in Owamboland, South West Africa. Transactions of the Royal Society of Tropical Medicine and Hygiene 72 (1), 16–21.

La Scola, B., Raoult, D., 1997. Laboratory diagnosis of rickettsioses: current approaches to diagnosis of old and new rickettsial diseases. Clinical Microbiology 35 (11), 2715–2727.

Laurenson, K., Esterhuysen, J., Stander, P., Van Heerden, J., 1997a. Aspects of rabies epidemiology in Tsumkwe District, Namibia. Onderstepoort Journal of Veterinary Research 64 (1), 39–45.

Laurenson, K., Van Heerden, J., Stander, P., Van Vuuren, M.J., 1997b. Seroepidemiological survey of sympatric domestic and wild dogs (*Lycaon pictus*) in Tsumkwe District, north-eastern Namibia. Onderstepoort Journal of Veterinary Research 64 (4), 313–316.

Le Blancq, S.M., Cibulskis, R.E., Peters, W., 1986. Leishmania in the Old World: 5. Numerical analysis of isoenzyme data. Transactions of the Royal Society of Tropical Medicine and Hygiene 80 (4), 517–524.

Levin, M.L., Killmaster, L.F., Zemtsova, G.E., 2012. Domestic dogs (*Canis familiaris*) as reservoir hosts for *Rickettsia conorii*. Vector Borne and Zoonotic Diseases 12 (1), 28–33.

Linthicum, K.J., Bailey, C.L., Davies, F.G., Kairo, A., 1985. Observations on the dispersal and survival of a population of *Aedes lineatopennis* (Ludlow) (Diptera Culicidae) in Kenya. Bulletin of Entomological Research 75, 661–670.

Living Namibia Namibian Biodiversity Database, 2003. Phylum Arthropoda. http://oldsite.biodiversity.org.na/scripts/taxondisplay.php?taxonlevel=Phylum&taxonnr=2

Louw, M., Allsopp, T.E.P., Meyer, E.C., 2005. Ehrlichia ruminantium, an emerging human pathogen–a further report. South African Medical Journal 95, 948–949.

Lucero, N.E., Maldonado, P.I., Kaufman, S., Escobar, G.I., Boeri, E., Jacob, N.R., 2010. Brucella canis causing infection in an HIV-infected patient. Vector Borne and Zoonotic Diseases 10 (5), 527–529.

Lutwama, J.J., Kayondo, J., Savage, H.M., Burkot, T.R., Miller, B.R., 1999. Epidemic O'Nyong-Nyong fever in southcentral Uganda, 1996–1997: entomologic studies in Bbaale village, Rakai District. American Journal of Tropical Medicine and Hygiene 61 (1), 158–162.

Magwedere, K., Hoffman, L.C., Van Schalkwyk, D., 2009. Seroprevalence of *Brucella melitensis* at a small ruminant export abattoir. International Symposia on Veterinary Epidemiology and Economics (ISVEE) proceedings, ISVEE 12. Proceedings of the 12th Symposium of the International Society for Veterinary Epidemiology and Econo]mics, Durban, South Africa, Theme 3 – Zoonoses and emerging diseases: Poster session, Emergingdiseases, Public health, p. 786. http://www.sciquest.org.nz/node/68277

Maletsky, C., 2009. Cholera under control, officials remain on alert. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=1757&no_cache=1] (accessed 05.01.09).

Mansfield, K., McElhinney, L., Hübschle, O., Mettler, F., Sabeta, C., Nel, L.H., Fooks, A.R., 2006. A molecular epidemiological study of rabies epizootics in kudu (*Tragelaphus strepsiceros*) in Namibia. BMC Veterinary Research 2, 2.

Matthee, S., Lovely, C., Gaugler, A., Beeker, R., Venter, H.R., Horak, I.G., 2010. Ixodid ticks on domestic dogs in the Northern Cape Province of South Africa and in Namibia. Journal of the South African Veterinary Association 81 (2), 126–128.

Matthewman, L., Kelly, P., Hayter, D., Downie, S., Wray, K., Bryson, N., Rycroft, A., Raoult, D., 1997. Domestic cats as indicators of the presence of spotted fever and typhus group rickettsiae. European Journal of Epidemiology 13 (1), 109–111.

Mcintosh, B.M., 1973. A taxonomic re-assessment of *Aedes* (*Ochlerotatus*) *caballus* (Theobald) (Diptera: Culicidae) including a description of a new species of *Ochlerotatus*. Journal of the Entomological Society of Southern Africa 36 (2), 261–269.

Méchaï, F., Han, Y., Gachot, B., Consigny, P.H., Viard, J.P., Lecuit, M., Lortholary, O., 2009. Pristinamycin for *Rickettsia africae* infection. Journal of Travel Medicine 16 (2), 136–137.

Mediannikov, O., Diatta, G., Fenollar, F., Sokhna, C., Trape, J.F., Raoult, D., 2010a. Tick-borne rickettsioses, neglected emerging diseases in rural Senegal. PLOS Neglected Tropical Diseases 4 (9), e821.

Mediannikov, O., Fenollar, F., Socolovschi, C., Diatta, G., Bassene, H., Molez, J.F., Sokhna, C., Trape, J.F., Raoult, D., 2010b. *Coxiella burnetii* in humans and ticks in rural Senegal. PLOS Neglected Tropical Diseases 4 (4), e654.

Mediannikov, O., Diatta, G., Zolia, Y., Balde, M.C., Kohar, H., Trape, J.F., Raoult, D., 2012. Tick-borne rickettsiae in Guinea and Liberia. Ticks and Tick-borne Diseases 3 (1), 43–48.

Menge, J.G., Haarhoff, J., König, E., Mertens, R., van der Merwe, B., 2001. Occurrence and removal of *Giardia* and *Cryptosporidium* at the Goreangab Reclamation Plant. Water Science and Technology: Water Supply 1, 97–106. http://www.environmental-expert.com/Files%5C5302%5Carticles%5C5892%5Cart12.pdf

MoHSS (Ministry of Health and Social Services), 2008. Report on the 2008 National HIV Sentinel Survey. Directorate of Special Programmes. http://www.healthnet.org.na/documents/reports/2008%20National%20HIV%20Sentinel%20Survey%20Report.pdf

Molyneux, Hallaj, D., Keusch, Z., McManus, G.T., Ngowi, D.P., Cleaveland, H., Ramos-Jimenez, S., Gotuzzo, P., Kar, E., Sanchez, K., Garba, A., Carabin, A., Bassili, H., Chaignat, A., Meslin, C.L., Abushama, F.X., Willingham, H.M., KioyD., A.L., 2011. Zoonoses and marginalised infectious diseases of poverty: where do we stand? Parasites & Vectors 4, 106.

Morris, A., Lundgren, J.D., Masur, H., Walzer, P.D., Hanson, D.L., Frederick, T., Huang, L., Beard, C.B., Kaplan, J.E., 2004. Current epidemiology of *Pneumocystis* pneumonia. Emerging Infectious Diseases 10 (10), 1713–1720.

Moutailler, S., Bouloy, M., Failloux, A.B., 2009. Potential vectors of Rift Valley fever virus in the Mediterranean region: 2009. Molecular Genetics of Bunyavirus. http://www.arbo-zoo.net/_data/Anna_Bella_Failloux_2009.pdf

Mungeyi, P., Msiska, O.V., 2009. Incidences of *Escherichia coli* and *Salmonella spp*. in processed hake from companies based at Walvis Bay, Namibia. Malawi Journal of Aquaculture Fisheries 1(1), 13–18. http://www.cabi.org/gara/FullTextPDF/2009/20093200505.pdf

Muspratt, J., 1956. The Stegomyia mosquitoes of South Africa and some neighboring territories: Including chapters on the mosquito-borne virus diseases of the Ethiopian zoo-geographical region of Africa. Memoirs of the Entomological Society of Southern Africa 4, 1–138.

Nacher, M., 2011. Interactions between worms and malaria: good worms or bad worms? Malaria Journal 10, 259.

Namibia Sun, 2012. Namibia free of leprosy. http://sun.com.na/content/healthy-living/namibia-free-leprosy (accessed 03.02.12).

Ndip, L.M., Ndip, R.N., Ndive, V.E., Awuh, J.A., Walker, D.H., McBride, J.W., 2007. Ehrlichia species in *Rhipicephalus sanguineus* ticks in Cameroon. Vector Borne and Zoonotic Diseases 7 (2), 221–227.

Ndip, L.M., Labruna, M., Ndip, R.N., Walker, D.H., McBride, J.W., 2009. Molecular and clinical evidence of *Ehrlichia chaffeensis* infection in Cameroonian patients with undifferentiated febrile illness. Annals of Tropical Medicine and Parasitology 103 (8), 719–725.

Ndip, L.M., Ndip, R.N., Esemu, S.N., Walker, D.H., McBride, J.W., 2010. Predominance of *Ehrlichia chaffeensis* in *Rhipicephalus sanguineus* ticks from kennel-confined dogs in Limbe, Cameroon. Experimental and Applied Acarology 50 (2), 163–168.

Noblick, J., Skolnik, R., Hotez, P.J., 2011. Linking global HIV/AIDS treatments with national programs for the control and elimination of the neglected tropical diseases. PLOS Neglected Tropical Diseases 5 (7), e1022.

Noden, B.H., 2011. Biomedically-focused research productivity by Namibian authors and institutions 1995-2010. PROGRESS Multidisciplinary Research Journal 1(1), 1–17. http://ir.polytechnic.edu.na/bitstream/10628/282/1/Noden.pdf

Noden, B.H., Morkel, C., Manyarara, R., Tubbesing, U., Soni, M., 2011. Emerging zoonotic diseases of companion animals in Namibia. Poster presented at American Society of Tropical Medicine and Hygiene meeting, Philadelphia, PA, USA, Dec 4–8, 2011.

Nowaseb, V., Gaeb, E., Fraczek, M., Richardson, M., Denning, D.W., 2012. The frequency of *Pneumocystis jirovecii* in sputum samples of HIV and TB patients received at the Central Reference Laboratory in Windhoek, Namibia [meeting abstract]. Mycoses 55 (SI sup 4), 296.

Ntomwa, B.N., Usuku, P., Govere, J.N., Manga, L., Koekemoer, L.L., Hunt, R.H., Coetzee, M., 2006. Distribution of *An gambiae* complex in Namibia and susceptibility to insecticides. African Entomology 14 (2), 404–406.

OIE (World Organization for Animal Health), 2012. Namibia reports. http://web.oie.int/wahis/public.php?page=country_reporting&this_country_code=NAM&detailed=1

Ogo, N.I., de Mera, I.G., Galindo, R.C., Okubanjo, O.O., Inuwa, H.M., Agbede, R.I., Torina, A., Alongi, A., Vicente, J., Gortázar, C., de la Fuente, J., 2012. Molecular identification of tick-borne pathogens in Nigerian ticks, Veterinary Parasitology, in press, http://dx.doi.org/10.1016/j.vetpar.2012.01.029

Ordman, D., 1957. Relapsing Fever in Africa. The Central African Journal of Medicine 3 (9), 347–356.

Parola, P., Paddock, C.D., Raoult, D., 2005. Tick-borne rickettsioses around the world: emerging diseases challenging old concepts. Clinical Microbiology Reviews 18 (4), 719–756.

Pascucci, I., Dondona, A.C., Cammà, C., Marcacci, M., Di Domenico, M., Lelli, R., Scacchia, M., Jago, M., Khaiseb, S., Hager, A.L., Tjipura-Zaire, G., Caporale, V., 2011. Survey of ixodid ticks and two tick-borne pathogens in African buffaloes, *Syncerus caffer*, from the Caprivi Strip, Namibia. Journal of Zoo and Wildlife Medicine 42 (4), 634–640.

PATTEC (Pan African Tsetse and Trypanosomaiasis Eradication Campaign), 2005. Report of the Regional Planning Workshop for Tsetse Eradication in the countries of the Kwando/Zambezi River Region (Angola, Botswana, Namibia and Zambia). http://www.africa-union.org/PATTEC/PATTEC%20REPORT-ANGOLA%20WORKSHOPvffinal.doc

Polack, S., Brooker, S., Kuper, H., Mariotti, S., Mabey, D., Foster, A., 2005. Mapping the global distribution of trachoma. Bulletin of World Health Organization 83 (12), 913–919.

Portillo, A., Pérez-Martínez, L., Santibáñez, S., Blanco, J.R., Ibarra, V., Oteo, J.A., 2007. Detection of *Rickettsia africae* in *Rhipicephalus* (*Boophilus*) *decoloratus* ticks from the Republic of Botswana, South Africa. American Journal of Tropical Medicine and Hygiene 77 (2), 376–377.

Prabhu, M., Nicholson, W.L., Roche, A.J., Kersh, G.J., Fitzpatrick, K.A., Oliver, L.D., Massung, R.F., Morrissey, A.B., Bartlett, J.A., Onyango, J.J., Maro, V.P., Kinabo, G.D., Saganda, W., Crump, J.A., 2011. Q fever, spotted fever group, and typhus group rickettsioses among hospitalized febrile patients in northern Tanzania. Clinical Infectious Diseases 53 (4), e8–e15.

Pretorius, A.M., Jensenius, M., Birtles, R.J., 2004. Update on spotted fever group Rickettsiae in South Africa. Vector Borne and Zoonotic Diseases 4 (3), 249–260.

Pretorius, A.M., Kelly, P.J., 1998. Serological survey for antibodies reactive with *Ehrlichia canis* and *E. chaffeensis* in dogs from the Bloemfontein area, South Africa. Journal of the South African Veterinary Association 69 (4), 126–128.

Pretorius, A.M., Venter, T.P., van der Ryst, E., Kelly, P.J., 1999. Possible human ehrlichiosis in the Free State. South African Medical Journal 89 (9), 961.

ProMED-mail, 2001. Crimean–Congo hemorrhagic fever – Namibia (Omaheke). 25 January 2001: Accessed on10 April 2012 at 20010125.0179; http://www.promedmail.org

ProMED-mail, 2002. Crimean–Congo hemorrhagic fever – Namibia. 18 January 2002: Accessed on 10 April 2012 at 20020120.332; http://www.promedmail.org

Quan, P.L., Junglen, S., Tashmukhamedova, A., Conlan, S., Hutchison, S.K., Kurth, A., Ellerbrok, H., Egholm, M., Briese, T., Leendertz, F.H., Lipkin, W.I., 2010. Moussa virus: a new member of the Rhabdoviridae family isolated from *Culex decens* mosquitoes in Côte d'Ivoire. Virus Research 147 (1), 17–24.

Ratovonjato, J., Olive, M.M., Tantely, L.M., Andrianaivolambo, L., Tata, E., Razainirina, J., Jeanmaire, E., Reynes, J.M., Elissa, N., 2011. Detection, isolation, and genetic characterization of Rift Valley fever virus from *Anopheles* (*Anopheles*) *coustani*, *Anopheles* (*Anopheles*)*squamosus*, and *Culex* (*Culex*) *antennatus* of the Haute Matsiatra region, Madagascar. Vector Borne and Zoonotic Diseases 11 (6), 753–759.

Sang, R., Kioko, E., Lutomiah, J., Warigia, M., Ochieng, C., O'Guinn, M., Lee, J.S., Koka, H., Godsey, M., Hoel, D., Hanafi, H., Miller, B., Schnabel, D., Breiman, R.F., Richardson, J., 2010. Rift Valley fever virus epidemic in Kenya, 2006/2007: the entomologic investigations. American Journal of Tropical Medicine and Hygiene 83 (2 Suppl), 28–37.

Schrire, L., Crisp, S., Bear, N., McStay, G., Koornhof, H.J., 1987. The prevalence of human isolates of *Salmonella* subspecies II in southern Africa. Epidemiology and Infection 98, 25–31.

Schutte, C.H.J., van Deventer, J.M.G., 1987. Schistosomiasis in eastern Caprivi Part I. The prevalence of *Schistosoma* species and other parasite infections in school children. Southern African Journal of Epidemiology and Infection 2, 71–75.

Schutte, C.H., Evans, A.C., Pammenter, M.D., Cooppan, R.M., Pretorius, S.J., Joubert, P.H., Gouws, E., Jooste, P.L., Badenhorst, C.J., Joubert, J.J., 1995. Epidemiology and control of *Schistosomiasis mansoni* in communities living on the Cuando River floodplain of East Caprivi, Namibia. Annals of Tropical Medicine and Parasitology 89 (6), 631–644.

Shangula, K., 1998. Successful plague control in Namibia. South African Medical Journal 88 (11), 1428–1430.

Shikongo-Kuvare, L.T., 2007. Development of risk communication strategies to improve control of Cysticercosis bovis in North Central Namibia.[Master's], University of Pretoria. http://upetd.up.ac.za/thesis/available/etd-04112008-150144/unrestricted/dissertation.pdf

Shivute, O., 2008. Cholera toll hits 34. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=49245&no_cache=1] (06.05.08).

Simarro, P.P., Diarra, A., Ruiz Postigo, J.A., Franco, J.R., Jannin, J.G., 2011. The human African trypanosomiasis control and surveillance programme of the World Health Organization 2000–2009: the way forward. PLOS Neglected Tropical Diseases 5 (2), e1007.

Simuunza, M., Weir, W., Courcier, E., Tait, A., Shiels, B., 2011. Epidemiological analysis of tick-borne diseases in Zambia. Veterinary Parasitology 175 (3–4), 331–342.

Smith, A.M., Keddy, K.H., De Wee, L., 2008. Characterization of cholera outbreak isolates from Namibia, December 2006 to February 2007. Epidemiology and Infection 136 (9), 1207–1209.

Smith, J-M., 2011. Leprosy: the reality in Namibia. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=79929&no_cache=1]

Sumption, K.J., Paxton, E.A., Bell-Sakyi, L., 2003. Development of a polyclonal competitive enzyme-linked immunosorbent assay for detection of antibodies to *Ehrlichia ruminantium*. Clinical and Diagnostic Laboratory Immunology 10 (5), 910–916.

Swellengrebel, N.H., Annecke, S., De Meillon, B., 1931. Malaria investigations in some parts of the Transvaal and Zululand. JAMA 97 (25), 1916.

Taye, A., Hadis, M., Adugna, N., Tilahun, D., Wirtz, R.A., 2006. Biting behavior and *Plasmodium* infection rates of *Anopheles arabiensis* from Sille, Ethiopia. Acta Tropica 97 (1), 50–54.

Tekin, S., Bursali, A., Mutluay, N., Keskin, A., Dundar, E., 2011. Crimean-Congo hemorrhagic fever virus in various ixodid tick species from a highly endemic area. Veterinary Parasitology 186 (3–4), 546–552.

The Namibian, 2010. Southern Farmer has Congo Fever. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news=70544&no_cache=1]

Trpis, M., Hartberg, W.K., Teesdale, C., McClelland, G.A., 1971. *Aedes aegypti* and *Aedes simpsoni* breeding in coral rock holes on the coast of Tanzania. Bulletin of World Health Organization 45(4), 529–31. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2427944/pdf/bullwho00197-0118.pdf

Turell, M.J., 1989. Effect of environmental temperature on the vector competence of *Aedes fowleri* for Rift Valley fever virus. Research in Virology 140 (2), 147–154.

Turell, M.J., Linthicum, K.J., Patrican, L.A., Davies, F.G., Kairo, A., Bailey, C.L., 2008. Vector competence of selected African mosquito (Diptera: Culicidae) species for Rift Valley fever virus. Journal of Medical Entomology 45 (1), 102–108.

Uusiku, L.A. 2009. A study of Schistosomiasis among school children between the ages of 6–17 years in the Outapi Health District in Namibia [Masters], University of Namibia. http://www.isis.unam.na/theses/uusiku2009.pdf

USAID, 2010. Namibia HIV/AIDS Health Profile. http://www.usaid.gov/our_work/global_health/aids/Countries/africa/namibia.pdf

van den Bossche, P., Mudenge, D., Mubanga, J., Norval, A., 1999. The parasitological and serological prevalence of tsetse-transmitted bovine trypanosomosis in the Eastern Caprivi (Caprivi District, Namibia). Onderstepoort Journal of Veterinary Research 66 (2), 103–110.

van Dillen, J., DeJager, A.J., DeJong, I., Wendte, J.F., 2007. Overdiagnosis of malaria in hospitalized patients in Namibia. Tropical Doctor 37 (3), 185–186.
Walker, J.B., 1991. A review of *Ixodid* ticks occurring in Southern Africa. Onderstepoort Journal of Veterinary Research 58, 81–1053.
Walker, A.R., Bouattour, A., Camicas, J.-L., Estrada-Peña, A., Horak, I.G., Latif, A.A., Pegram, R.G., Preston, P.M., 2007. Ticks of Domestic Animals in Africa: a Guide to Identification of Species. Bioscience Reports, Edinburgh.
Weaver, S.C., Reisen, W.K., 2010. Present and future arboviral threats. Antiviral Research 85 (2), 328–345.
Weiklich, B., 2007. 50 new cholera cases reported at Outapi – Death toll up to 7. http://www.namibian.com.na/index.php?id=28&tx_ttnews[tt_news]=33695&no_cache=1 (accessed 13.02.07).
Wessels, G., Hesseling, P.B., Cooper, R.C., 1986. Q fever, OX19, OX2 and leptospirosis antibodies in patients with onyalai and in negroid, bushman and white inhabitants of Kavango, Namibia. Transactions of the Royal Society of Tropical Medicine and Hygiene 80 (5), 847–848.
WHO, 2009. Neglected Tropical Disease Country Report. http://www.who.int/neglected_diseases/preventive_chemotherapy/databank/CP_2009_Namibia.pdf
WHO, 2011. Global health observatory: Map gallery. http://gamapserver.who.int/mapLibrary/app/searchResults.aspx
WHO, 2012. Fact sheet N#259: African trypanosomiasis (sleeping sickness). http://www.who.int/mediacentre/factsheets/fs259/en/
Wichmann, O., Mühlberger, N., Jelinek, T., 2003. Dengue – the underestimated risk in travelers. Dengue Bulletin 27, 126–137.
World Bank, 2012. Namibia. http://data.worldbank.org/country/namibia
WRBU (Walter Reed Biosystematics Unit), 2011. Medically Important Mosquitoes: AFRICOM Species. http://wrbu.si.edu/africom_MQ.html
Zaigraykina, N., Tomkins, O., Garzozi, H.J., Potasman, I., 2010. Fusarium keratitis acquired during travel to Namibia. Journal of Travel Medicine 17 (3), 209–211.
Zielke, E., 1971. Notes on the Phlebotomes in South Africa and South West Africa (*Diptera: Psychodidae*). Zeitschrift fur Angewandte Entomologie 68, 102–110.
Zumpt, F., 1959. The Tumbu fly, *Cordylobia anthropophage* (Blanchard), in Southern Africa. S. Afr. Journal of Medical Sciences 33, 862–865.