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A cluster of leptospirosis cases associated with crocodile workers in the Northern Territory, Australia, 2022

Astrid M Stark, Michael Nohrenberg, Anthony DK Draper, Kimberley E McMahon, Thalia A Hewitt, Kelly Lomas, Vicki L Krause

Abstract

Leptospirosis is a worldwide zoonotic waterborne disease endemic in tropical and subtropical climates. Outbreaks have been observed in the Northern Territory (NT) of Australia. We briefly described the epidemiology of leptospirosis in the NT between 2012 and 2022, and undertook an investigation of a cluster of three leptospirosis cases observed in crocodile workers between January and December 2022 in the Top End of the NT. A descriptive case series was conducted to investigate the cluster; all three cases were male and non-Aboriginal with a median age of 46.5 years; none took chemoprophylaxis; only one of the three cases reported wearing appropriate protective attire; all reported receiving limited to no education about personal protective measures from their associated workplaces. Higher than average rainfall in both February and December 2022 likely contributed to the increased risk of infection in those months. Changing climate patterns are likely to result in more frequent periods of heavy rain, and risk of contracting leptospirosis in the NT may increase, particularly for those who work in wet and muddy conditions. Promoting the use of protective workplace clothing and equipment, the use of waterproof dressings for skin abrasions, regular hand hygiene, and the consideration of chemoprophylaxis in certain circumstances may prevent future cases.

Keywords: leptospirosis; *Leptospira*; crocodiles; rats; Northern Territory; rainfall; climate change

Background

Leptospirosis is a zoonotic disease of global significance and is considered endemic in the Top End of the Northern Territory (NT). Previously known as ‘rice field jaundice’ and ‘mud fever’,¹ due to transmission from contaminated water in muddy or swampy environments, leptospirosis is endemic in tropical and subtropical climates. Extreme weather, heavy rainfall, flooding, human migration and urbanisation are predicted to contribute to an increase in cases in coming years.^{2,3,4}

Transmission is via direct contact with the spiral-shaped *Leptospira* bacteria (spirochetes) from an infected animal or indirectly through contact with water, wet soil or vegetation that is contaminated with an infected animal’s urine.^{5,6}

The bacteria can enter via the skin (especially where there are cuts and abrasions), or via mucous membranes such as the conjunctiva, oral or genital surfaces. Leptospirosis has a typical incubation period of around 5–14 days, with a range of 2–30 days.⁶

Leptospira spirochetes are found in various domestic and wild animals, including common water rats, feral rodent species, pigs, cattle, dogs, flying foxes and possums.^{6,7} Rats are considered the primary source of infection worldwide.^{1,5} In Australia, *Leptospira interrogans* serovar Australis is associated with rats and bandicoots.⁷

Heavy rains wash *Leptospira* from urine contaminated soil; the bacteria settle in adjacent water bodies.¹ Flooding and heavy rainfall, occurring during the hot and humid wet season

in the Top End of the NT (September to April), creates optimal environmental conditions for the survival and growth of *Leptospira* in water and soil.²

Large leptospirosis outbreaks following excessive rainfall events led to the recognition of leptospirosis as an emerging infectious disease in the mid-1990s.⁵ The disease is now of public health importance due to the increasing frequency and severity of outbreaks in various settings, the changing epidemiology, and the expanding collection of serovars; there are now over 250 known serovars.^{2,8}

Leptospirosis typically presents as a non-specific sudden febrile illness accompanied by fevers, chills, severe myalgia in the lower limbs, lower back pain, conjunctival suffusion, and headache.^{1,5,6} While often self-limiting, 5–10% of cases progress to severe illness with hepatic, cardiac, pulmonary and neurological involvement.⁶ Severe pulmonary involvement is associated with an increased risk of death, especially when antimicrobial therapy is delayed.^{1,6}

Those most at risk of infection include individuals who have close contact with animals that are known carriers, or individuals who are exposed to water, muddy environments, soil or vegetation that may be contaminated with urine from an infected animal.⁶ Several occupations are at higher risk, such as veterinarians, abattoir workers, farm workers, hunters (including crocodile egg collectors)^{9,10} and trappers, animal shelter workers, and those handling animals in laboratories or in fieldwork.^{1,5,6} Those who participate in water sports and other recreational activities in fresh water are also at higher risk.^{1,6}

Leptospirosis is a notifiable disease in the NT, and the NT Centre for Disease Control (CDC) investigates all cases to collect exposure information and to detect potential outbreaks. An outbreak occurred in 2021 amongst cattle workers,¹¹ following higher than usual rainfall. Between January and December 2022, a cluster of cases of leptospirosis in crocodile workers was detected in the greater Darwin region.

We describe the investigation of this cluster as well as briefly describe the epidemiology of leptospirosis in the NT between 2012 and 2022.

Methods

Descriptive epidemiology of leptospirosis in the NT, 2012–2022

We briefly described the epidemiology of all cases of leptospirosis notified to the Northern Territory Notifiable Disease System (NTNDS) between 1 January 2012 and 31 December 2022. Electronic medical records and hard copy case investigation forms were reviewed to cross-reference notifiable disease data. We undertook descriptive analysis of cases by the most likely location of acquisition, and by the time of onset during each year: the ‘wet’ season (September–April) or the ‘dry’ season (May–August). We used Microsoft Excel to undertake descriptive analysis and produce graphs.

Epidemiological cluster investigation

A confirmed cluster case was defined as any person notified with leptospirosis in the NT (as per national case definition – Appendix A)¹² with onset between 1 January 2022 and 31 December 2022 who was involved in crocodile related work. For each case we undertook routine surveillance activities and administered a standardised questionnaire,¹³ by telephone, that collected information including demographics, symptoms, risk factors, co-workers or known others with similar symptoms and the most likely location where the infection was acquired. The most likely location of infection was derived after consideration of the exposure period based on onset dates and responses to the standardised questionnaire.¹³ This included occupational contact including workplace location, recreational exposure and animal exposure risk factors. This information was coupled with the significant rainfall events associated with higher leptospirosis risk during the twelve-month period. Information was stored on a secure Research Electronic Data Capture (REDCap) online database platform.

Laboratory investigation

Notified cases had serum collected for polymerase chain reaction (PCR) testing or for serological testing, dependent on the type of sample requested by the treating clinician. Serological testing measuring immunoglobulin M (IgM) using microscopic agglutination test (MAT), for serovar identification, was performed on acute phase serum as well as repeat serum collected at least two weeks later. Serovars tested were Arborea, Australis, Bataviae, Bulgarica, Canicola, Celledoni, Copenhageni, Cynopteri, Djasiman, Grippotyphosa, Hardjo, Javanica, Kremastos, Mendanensis, Panama, Pomona, Robinsoni, Shermani, Szwajizak, Tarassovi, Zanoni and Topaz.

Environmental and meteorological investigation

The geographical distribution of rodent populations in the NT was confirmed by

literature review. Rainfall patterns of the Top End of the NT during February and December 2022 were reviewed using data from the Bureau of Meteorology (BoM).^{14,15}

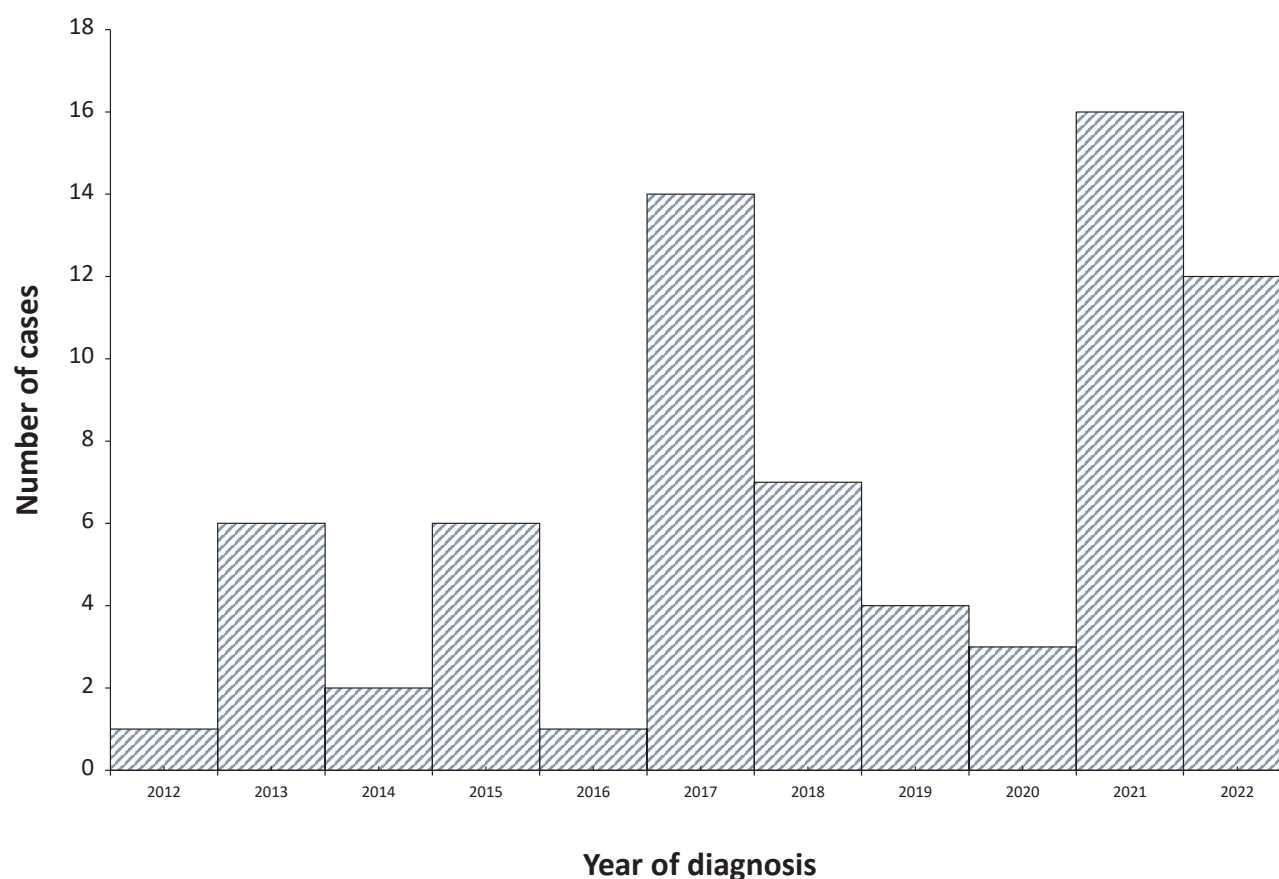
Ethics approval

This project was approved by the Human Research Ethics Committee of the Northern Territory Department of Health and Menzies School of Health Research [HREC 23-4593]. Written informed consent was obtained from all three cluster cases.

Results

During the period 2012–2022, there were 72 cases of leptospirosis notified in the NT, with an average of 6.5 cases per year (Figure 1) and with the peak number of cases occurring in 2021; this peak was associated with a large outbreak among cattle workers.¹¹ The average annual incidence rate in the NT was 2.7 cases

Figure 1: Epidemic curve of leptospirosis cases notified in the Northern Territory, Australia (2012–2022)



per 100,000 population per year, compared to the rest of Australia which had an average incidence rate of 0.5 cases per 100,000 population per year.¹⁶

Most cases (60/72; 83%) were male; most were non-Aboriginal (67/72; 93%); and the median age was 28.5 years (range: 11–64 years) (Table 1). Fever (68/72; 94%), headache (62/72; 86%) and myalgia (53/72; 74%) were the most common symptoms. Of the 40 (56%) who were hospitalised, the median duration of stay was four days (range: 1–13 days). There were no deaths.

L. Hardjo was the most common serovar (27/72; 38%), followed by *Australis* (13/72; 18.1%). Most cases (53/72; 73.6%) were acquired in the Darwin region; 6/72 (8.3%) cases were likely acquired overseas; none were acquired interstate; 43/72 (60%) cases were associated with exposure to cattle, mostly working on cattle stations. The majority of cases (67/72; 93.1%) were notified during the wet season.

Cluster investigation – epidemiological, meteorological and environmental factors

Three cases from 2022 met the cluster definition; all were male and non-Aboriginal and none had comorbidities. Two cases were *L. Australis* and one was *L. Pomona*. All had fever, myalgia, nausea, and vomiting; 2/3 (66.7%) had abdominal pain, diarrhoea, headaches and photophobia. All cases presented to hospital; two were admitted; none required intensive care admission; none died.

Analysis of risk factor information revealed that no cases took chemoprophylaxis; only one of the three cases reported wearing appropriate and full protective attire (that is, long pants, long sleeved shirt, eye protection, gloves and water proof socks); and all reported receiving limited to no education about personal protective measures from their workplaces. Each case was asked, as per standardised questionnaire,¹³ about co-workers or others with similar symptoms; in regard of this, they were all unaware of

others with similar symptoms. There were no additional cases identified when interviewing these individuals.

Further information on cluster cases is presented in Table 2.

The three cases identified in the cluster worked, and likely acquired their infections, in an area less than 50 kilometres apart in the Darwin region. This area, denoted by the yellow circle in Figures 2 and 3, experienced higher than average rainfall for the wet season ending in February 2022 (Figure 2),¹⁴ as well as in December 2022 (Figure 3); rainfall in December 2022 was 109% above the 1961–1990 average¹⁵ and the eighth wettest December since records began in 1900.¹⁵

Native and introduced rats found in the region where the cluster cases were most likely to have acquired their infections, include black footed tree rats, black rats and dusky rats.^{17,18} Native and introduced rats residing in the Top End are known carriers of *L. Australis* as well as *L. Pomona*.⁷ For example, one abundant rodent species in the Top End, the rat *Melomys burtoni*,¹⁹ is a known carrier for *L. Australis*.⁷

Public health response to cluster

The cases and businesses involved were contacted and education on preventative public health measures was provided. Businesses were encouraged to provide regular training to their employees regarding leptospirosis prevention, such as the use of protective clothing and equipment. Written educational resources were distributed to the crocodile industry stakeholders involved in this cluster.

Discussion

Most leptospirosis cases notified in the NT since 2012 have been in cattle workers. Cases most commonly occurred in young non-Aboriginal men, who may be more likely to undertake the type of work required on cattle stations. This work entails repeated long term exposure to this risk factor for leptospirosis.

Table 1: Demographic and clinical characteristics of leptospirosis cases notified in the Northern Territory, Australia, 2012–2022 (n = 72)

Characteristic	Classification	Number of cases	Proportion
Age group in years	≤ 10	0	0%
	11–20	11	15.3%
	21–30	28	38.9%
	31–40	18	25.0%
	41–50	6	8.3%
	51–60	8	11.1%
	> 60	1	1.4%
Demographics	Male	60	83.3%
	Female	12	16.7%
	Non-Aboriginal	67	93.1%
	Aboriginal	5	6.9%
Most likely exposure source	Cattle/cattle farming	43	59.7%
	Hunting	9	12.5%
	Crocodile related	5	6.9%
	Hiking	5	6.9%
	Swimming	3	4.2%
	Fishing	2	2.8%
	Other/unknown	5	6.9%
Likely region of acquisition	Darwin region	53	73.6%
	Big Rivers (Katherine) region	9	12.5%
	Barkly region	3	4.2%
	Top End unspecified ^a	1	1.4%
	Central Australia (Alice Springs region)	0	0%
	East Arnhem region	0	0%
	Imported (overseas acquired)	6	8.3%
Season of onset	Wet	67	93.1%
	Dry	5	6.9%
Serovar	Hardjo	27	37.5%
	Australis	13	18.1%
	Pomona	11	15.3%
	Unknown	10	13.9%
	Topaz	5	6.9%
	Sari	1	1.4%
	Copenhageni	1	1.4%
	Canicola	1	1.4%
	Mendanensis and Szwajizak	1	1.4%
	Djasiman	1	1.4%
	Grippotyphosa	1	1.4%
Robinson	1	1.4%	

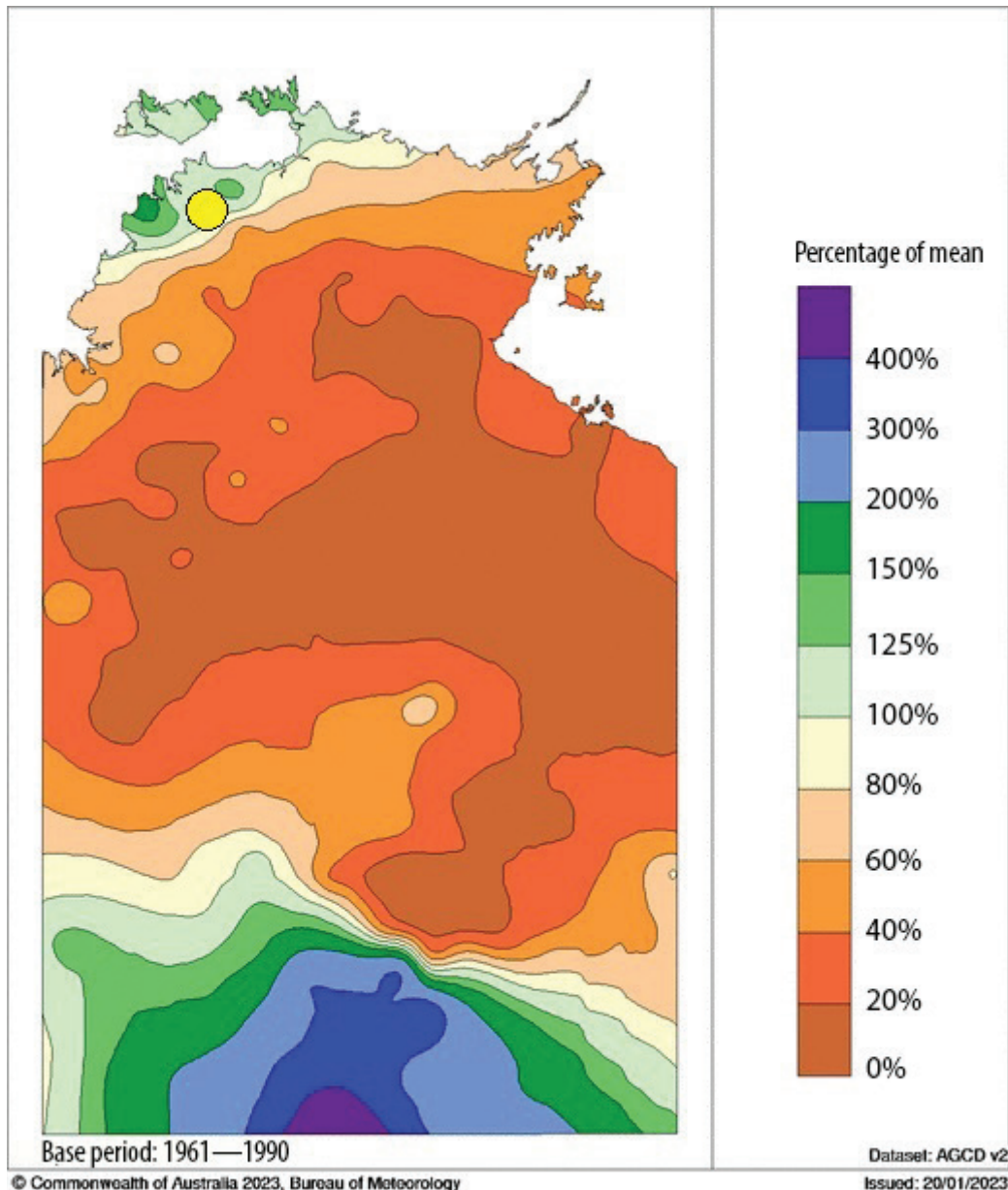
a Acquired either in Darwin region or East Arnhem region – both regions are part of the broader Top End of the Northern Territory.

Table 2: Demographics, testing results, risk factor information and disease severity information for cluster of leptospirosis cases amongst crocodile workers, Northern Territory, Australia, 2022 (n = 3)

Characteristic	Case 1	Case 2	Case 3
Onset date	21 February 2022	25 December 2022	26 December 2022
Test dates and results ^a	2 March 2022: MAT Pomona 400 17 March 2022: MAT Pomona 3200	28 December 2022: PCR positive 12 January 2023: MAT Australis 800	1 January 2023: PCR negative 1 January 2023: MAT Australis 800
Age range	60–70 years	20–30 years	30–40 years
Serovar	Pomona	Australis	Australis
Occupation	Worked on a fish farm; duties included crocodile management including trapping; trapped crocodile in week prior to onset of symptoms	Crocodile egg collector	Crocodile handler at a commercial facility; bitten by crocodile in the week prior to onset of symptoms
Skin integrity	Minor cuts and abrasions to legs	Cuts, insect bites and abrasions to skin on arms and legs	Crocodile bite
Protective equipment utilised	Long sleeve shirt only	Eye protection, rigger gloves (non-waterproof), long sleeved shirt, long pants, waterproof socks, hiking boots	Gum boots, heavy cloth gloves, sun glasses only
Duration of hospitalisation (days)	0	3	1
Days of normal work/activity lost (days)	21	10	1

a MAT: microscope agglutination test; PCR: polymerase chain reaction from blood.

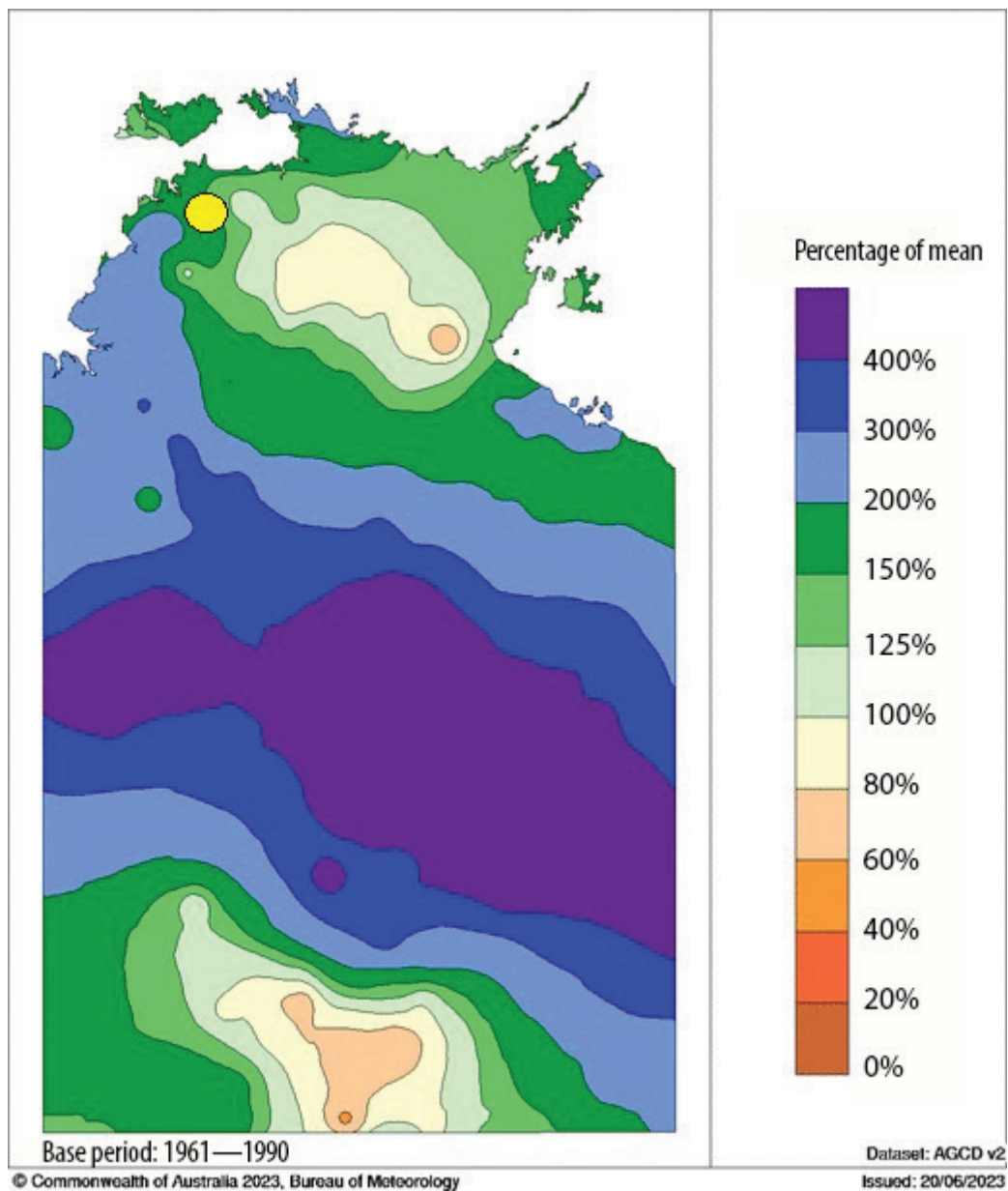
Figure 2: Northern Territory total rainfall compared to mean, February 2022



Other commonly reported activities associated with leptospirosis infection were fishing or hunting, including crocodile workers and egg collectors, and other recreational activities in wetlands. Sporadic hunting of native animals such as magpie geese, fish, and turtles is part of the traditional Aboriginal way of life in the NT and may subsequently place Aboriginal people at risk. However, our review found that the majority of cases were non-Aboriginal in occupations, such as cattle workers, that require a sustained occupational exposure risk.

Although there is some serological evidence of leptospirosis in crocodile species from other countries,²⁰ reptiles are considered unlikely to play an important epidemiological role in human infection.⁵ Rather, the environments that crocodile workers frequent, such as wet swampland, pose a greater risk for transmission. The specific host for *Leptospira* in the Top End of the NT is not established, but rodents are likely an important host. The Collaborating Centre for Reference and Research on Leptospirosis has previously identified rats and bandicoots are associated with *L. Australis* in the Top End;²¹

Figure 3: Northern Territory total rainfall compared to mean, December 2022.



a Yellow circle indicates area in the cases acquired leptospirosis infection

b Map credit: Commonwealth of Australia, Bureau of Meteorology 2023.¹⁴

this was the second most common serovar in cases reported in the Top End from 2012 to 2022.

Though the use of prophylactic antibiotics (chemoprophylaxis) has been considered as a method of preventing leptospirosis infections in other countries,^{3,23,25} Queensland Health—which reports significantly higher numbers

of leptospirosis notifications per year than the NT—does not recommend chemoprophylaxis in its public health guidelines.²⁴ Chemoprophylaxis for those at risk in Queensland may be unfeasible due to prolonged year-long exposure to high-risk environments such as banana farms. There may be a role for chemoprophylaxis in regions which have seasonal outbreaks of leptospirosis.²³

As a result of the cluster described in this paper, several NT crocodile organisations were contacted to ascertain whether chemoprophylaxis has ever been recommended. To date, there has been no local consensus for the routine recommendation of chemoprophylaxis. A previous randomised, double-blind placebo controlled study demonstrated reduced rates of leptospirosis in immune naïve soldiers taking doxycycline chemoprophylaxis in an endemic setting;²² however, subsequent data from further studies have shown conflicting results.^{25,26} A 2010 Cochrane systematic review concluded that doxycycline as a prophylactic agent increased the odds for nausea and vomiting with unclear benefit in reducing *Leptospira* seroconversion or in alleviating clinical consequences of infection.²⁷ However, there remains some evidence for using pre-exposure chemoprophylaxis in certain high-risk endemic environments, and in outbreak or disaster settings.^{22,23}

Education and appropriate personal protective equipment (PPE) may have greater impact in the prevention of leptospirosis than chemoprophylaxis alone. Appropriate protective wear prevents contaminated water or mud coming into contact with skin. Despite the fact that personal protective wear is an established preventative measure for those at risk,^{5,6,7} only one of the cluster cases reported wearing appropriate full protective attire. In order to reduce the risk of infection, employees working in wetlands should utilise rigger gloves, a long sleeve shirt, long pants, and enclosed boots; and this should be promoted by workplaces. Utilising waterproof dressings to cover existing abrasions and cuts on limbs is also recommended, as is showering thoroughly after contact with potentially contaminated water, and regular hand washing.

It is critical that workplaces in endemic areas, with occupational exposure to animals and wetland environments, include education on leptospirosis and its prevention as part of their workplace health and safety programs. Additional awareness campaigns for other high-risk activities, such as hunting and fishing, would also be of potential benefit. These

could be culturally adapted for Aboriginal people in the NT. Medical officers working in endemic areas must also be alert to the signs of a potential leptospirosis infection and should test patients with an undifferentiated febrile illness and occupational or recreational exposure risks.

Both urbanisation and climate change are significant risks in the increasing incidence of leptospirosis cases.^{2,3,4} The three cases identified in the cluster were acquired in the months that saw a higher than average rainfall in the NT.^{14,15} The effect of climate change is already evident in the NT: the current (January 2023) La Niña weather pattern has brought above average rainfall to the NT; the average annual temperature has risen; and wet season (October to April) rainfall has increased over the Top End.²⁸ By mid-century it is projected that the NT will continue to get hotter and extreme rainfall events are predicted to become more intense.²⁸

The strength of this case series is that leptospirosis has long been a notifiable condition in the NT and that core epidemiological data and enhanced data has been systemically collected on leptospirosis cases using standardised case investigation forms; although this information largely remains in hard copy until 2021 where enhanced data was collected electronically. The limitation of our cluster investigation was that it was a descriptive case series; a case control or cohort study was not feasible. Also, there was no environmental sampling undertaken; such sampling is not a feature of routine leptospirosis case investigation, as it is assumed to be widely in the environment.

Conclusion

Leptospirosis may become an increasingly notified disease in the Top End in the future due to changing weather patterns. This risk is amplified for those working or spending time in the Top End's wetlands, such as crocodile workers. It is critical that individuals wading in wetlands for occupational or recreational purposes are

aware of the risks of leptospirosis, and the personal protective practices that they can adopt to avoid infection.

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Appendix A

Leptospirosis: Australian national notifiable disease case definition¹²

Reporting

Both confirmed cases and probable cases should be notified.

Confirmed case

A confirmed case requires laboratory definitive evidence only.

Laboratory definitive evidence

1. Isolation of pathogenic *Leptospira* species

OR

2. A fourfold or greater rise in *Leptospira* agglutination titre between acute and convalescent phase sera obtained at least two weeks apart and preferably conducted at the same laboratory

OR

3. A single *Leptospira* micro agglutination titre greater than or equal to 400 supported by a positive enzyme-linked immunosorbent assay IgM result.

Probable case

A probable case requires laboratory suggestive evidence.

Laboratory suggestive evidence

Detection of pathogenic *Leptospira* species by nucleic acid testing.