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Changing epidemiology of human leptospirosis in New Zealand

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SUMMARY

The objective was to describe the current epidemiology and trends in New Zealand human leptospirosis, using descriptive epidemiology of laboratory surveillance and disease notification data, 1990–8. The annual incidence of human leptospirosis in New Zealand 1990–8 was 4·4 per 100 000. Incidence was highest among meat processing workers (163·5/100 000), livestock farm workers (91·7), and forestry-related workers (24·1). The most commonly detected serovars were *Leptospira borgpetersenii* serovar (sv.) hardjo (hardjobovis) (46·1 %), *L. interrogans* sv. pomona (24·4 %) and *L. borgpetersenii* sv. ballum (11·9 %). The annual incidence of leptospirosis declined from 5·7/100 000 in 1990–2 to 2·9/100 000 in 1996–8. Incidence of *L. borgpetersenii* sv. hardjo and *L. interrogans* sv. pomona infection declined, while incidence of *L. borgpetersenii* sv. ballum infection increased. The incidence of human leptospirosis in New Zealand remains high for a temperate developed country. Increasing *L. borgpetersenii* sv. ballum case numbers suggest changing transmission patterns via direct or indirect exposure to contaminated surface water. Targeted and evaluated disease control programmes should be renewed.

INTRODUCTION

Leptospirosis is an acute generalized infectious disease characterized by extensive vasculitis, caused by *Leptospira* sp. [1]. Leptospirosis is primarily a disease of wild and domestic mammals, and humans are infected through direct or indirect contact with infected urine [2]. Human-to-human transmission is extremely rare, and has not been recorded in New Zealand.

Leptospirosis is New Zealand's most common occupationally acquired infectious disease, and the leptospirosis incidence in New Zealand is high in comparison with other temperate developed countries. First identified in 1951 [3], the annual number of cases peaked at 875 in 1971 [4]. Most were dairy farm workers infected with *Leptospira borgpetersenii* serovar (sv.) *hardjo*. Cattle and pig immunisation against *L. borgpetersenii* sv. *hardjo* and *L. interrogans* sv. *pomona* became widespread following a health promotion campaign in the early 1980s [5]. A study of 1990–2 cases showed that the annual incidence had declined to 6·2 per 100 000 (208 cases) per year [6].

No assessment of human leptospirosis epidemiology in New Zealand has been undertaken since 1993. The objectives of this study were to assess whether observed declining rates of disease have been associated with changes in leptospirosis epidemiology in New Zealand, and to characterize occupation-specific leptospirosis incidence for the first time.

METHODS

Data were combined from case records of acute leptospirosis collected separately by the New Zealand disease notification and laboratory surveillance systems between 1990 and 1998. The disease notification

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system receives acute leptospirosis case reports from medical practitioners, as required by the Health Act 1956. The laboratory surveillance system receives details of positive leptospira tests from all laboratories. Data from both systems were collected from Institute of Environmental Science and Research (ESR) databases. Case records were matched by iteratively comparing combinations of name, date of birth and address, to avoid double counting cases. Cases were included if the laboratory result showed a single serological titre $\geqslant 400$ on the microscopic agglutination test (MAT), a greater than fourfold rise in titres between two sequential specimens, or isolation of leptospires from appropriate clinical specimens. Disease notification case records without matching laboratory records were included if the case report indicated that laboratory confirmation had been obtained. Missing occupation or address information were obtained from electoral rolls with closest publication date to the date of illness onset in each case. Cases who had been overseas shortly before becoming unwell were not excluded. The data were analysed using Epi Info [7] and Microsoft Excel. Analysis was conducted by age, sex, occupation, territorial authority of residence, health district of residence and infecting serovar. Recreational risk factors were not investigated because no notified cases had recreational exposure recorded. Proportions were compared using χ^2 tests. Trends in case numbers were analysed using χ^2 tests for linear trend. Incidence rates were compared using rate ratios, and differences in incidence rates over time were performed by comparing rates in 1990–2 with those in 1996–8. Occupational coding used the 1995 New Zealand Standard Classification of Occupations [8]. Cases with known paid employment were grouped as either livestock farm workers, meat processing workers, forestry-related workers or other workers. Individuals aged younger than 15 or older than 64 years were excluded from occupation analyses. Denominators were drawn from the 1991 and 1996 censuses, and incidence rates were calculated annually. Denominators for intercensal years were calculating by interpolating between the two census years.

RESULTS

Records were obtained on 1397 cases with disease onset between 1990 and 1998, giving an overall annual incidence of 4·4 per 100000 in the New Zealand population (95% confidence interval (CI) 4·1–4·7). Sex was recorded in 98·1% (1370/1397) of case records. The majority of cases were male (1238/1370; 90·4%). The annual incidence among males was 8·0/100000 (CI 7·5–8·4), and 0·8/100000 among females (CI 0·7–1·0). Age was recorded in 91·6% (1281/1397) of case records. Cases were aged between 4 and 80 years, with a median age of 36 years at date of diagnosis. The majority of cases (56·9%, 729/1281) were aged 25–44 years. Peak incidence occurred within the 35–44 year age group among males (14·4/100000) and females (1·7) (Fig. 1).

Information on occupation was obtained for 83·2% (1041/1251) of cases aged between 15 and 64 years. Of those in paid employment, 31·0% (308/992) were meat processing workers. Livestock farming workers made up 51·8% (539/992) of cases in known paid employment, predominantly dairy (212), pig (19), cattle (6) and deer (5) farming. Types of animal farmed were not specified in 273 cases. Remaining cases in known paid employment included forestry-related occupations (17/992; 1·7%) and occupations involving direct animal contact other than meat processing, farming or forestry work (8/992; 0·8%). Individuals with occupations not considered to be at high risk of leptospirosis in New Zealand comprised 12·9% of cases (128/992).

The crude incidence rates for livestock farm workers (91·7/100000), meat processing workers (163·5) and forestry-related workers (24·0) were significantly greater than other workers (1·0) (rate ratio (RR) for livestock farm workers compared to other paid workers with listed occupation 91·2% (95% confidence interval (CI): 75·2–110·6); for meat processing workers 163·5 (133·1–200·1); for forestry-related workers 24·0 (14·5–39·7)). Among livestock farm workers, leptospirosis incidence among males (121·2/100000) was significantly greater than among females (18·4) (rate ratio (RR) for male compared with female livestock workers 6·6 (95% confidence interval (CI): 4·6–9·4)). There were no significant differences between male (164·7/100000) and female (149·5) meat processing workers (RR for male meat processing workers compared with female 1·1 (CI 0·8–1·6)), or between male (23·3) and female (20·1) forestry workers (RR 1·2 (0·2–8·7)).

Geographical distribution of leptospirosis cases was examined by health district and territorial authority area, categorization was possible in 98·9% (1382/1397) of case records. Crude health district incidences ranged from 17·9/100000 in Ruapehu health district to 0·9/100000 in Wellington. Significant positive

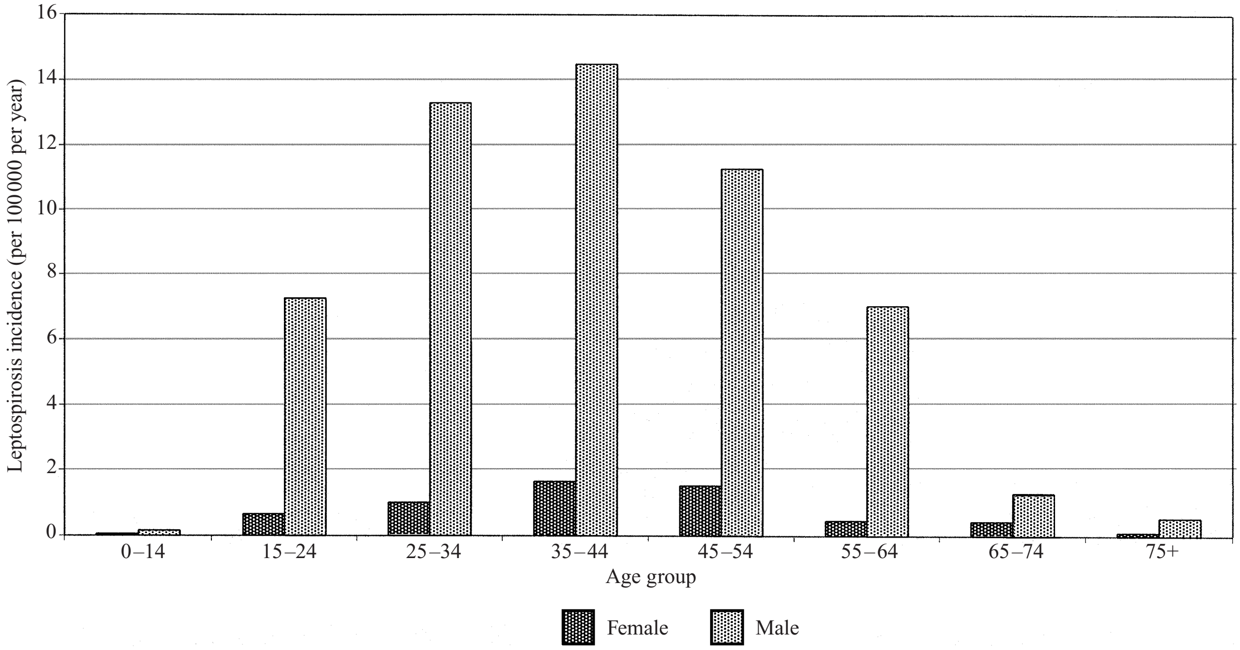

Fig. 1. Age-specific incidence of leptospirosis among New Zealand males and females, average annual rate, 1990–8.

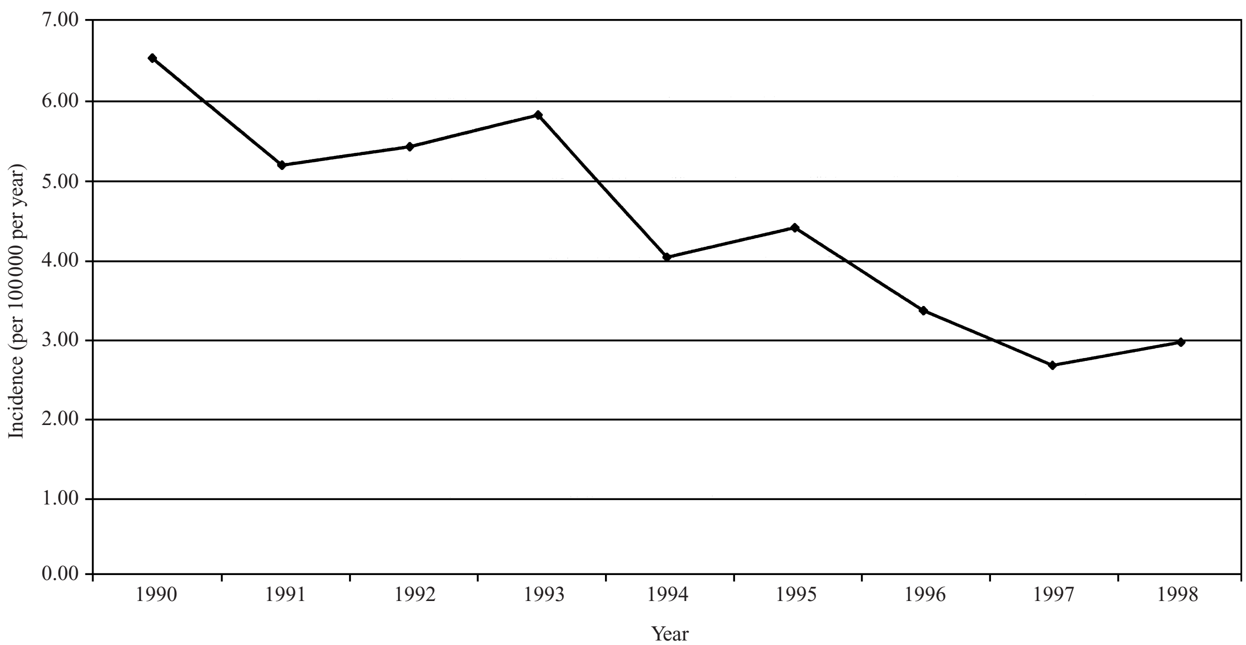

Fig. 2. Annual incidence of human leptospirosis in New Zealand, 1990–8, combined laboratory surveillance and disease notification data.

linear correlation was found between the leptospirosis incidence and the ratio of dairy cattle numbers (obtained from [9]) to human population in each territorial authority area ($R^2 = 0{\cdot}28$; $F = 28{\cdot}0$, $P < 0{\cdot}0001$). Only four cases in the dataset indicated that they had been overseas during the incubation period of their illness. Infecting serovar was recorded in 90·6% (1266/1397) of cases. The most commonly recorded was *L. borgpetersenii* sv. *hardjo* (584/1266, 46·1%), followed by *L. interrogans* sv. *pomona* (309/1266, 24·4%) and *L. borgpetersenii* sv. *ballum* (151/2366, 11·9%). Other serovars detected were *L. interrogans* sv. bratislava (58), *L. borgpetersenii* sv. *tarrassovi* (54), *L. interrogans* sv. *copenhageni* (52), *L. interrogans* sv. *canicola* (11) and *L. interrogans* sv. *australis* (3). The remaining cases (44) reacted to more

Table 1. *Trends in leptospirosis incidence among selected occupational groups, aged 15–64 years, 1990–8*

	Number of cases	Crude annual incidence (per 100 000)	Rate ratio*	95% confidence interval of RR†
Livestock farm workers				
1990–2	227	112·4		
1996–8	134	70·6	0·64	(0·51–0·79)
Meat processing workers				
1990–2	118	176·6		
1996–8	84	144·9	0·82	(0·62–1·09)
Forestry-related workers				
1990–2	5	26·4		
1996–8	4	14·3	0·51	(0·14–2·0)
Other workers				
1990–2	48	1·04		
1996–8	37	1·0	0·63	(0·40–0·97)

* Compared with occupation-specific rate for 1990–2.
† 95% confidence limits for rate ratio.

than one serovar, and could not be assigned to a single serovar group.

The distribution of infecting serovars differed significantly between the main occupational groups ($\chi^2 = 183{\cdot}5$, 9 D.F., $P < 0{\cdot}0001$). Livestock farmers were most commonly diagnosed with *L. borgpetersenii* sv. *hardjo* infection (285/508, 56·1%), meat processing workers were most commonly diagnosed with *L. interrogans* sv. *pomona* infection (130/279, 46·6%), forestry-related were most commonly diagnosed with *L. borgpetersenii* sv. *ballum* infection (8/14, 57·1%), as were other workers (39/113, 34·5%).

Trends in leptospirosis case numbers and incidence, 1990–8

The annual incidence of leptospirosis declined from 5·7/100000 in 1990–2 to 2·9 in 1996–8 (rate ratio for 1996–8 compared with 1990–2: 0·51 (95% CI 0·45–0·59)) (Fig. 2). The overall age and sex distribution of cases was unchanged over the 9-year period (age-group: $\chi^2 = 31{\cdot}1$, 26 D.F., $P = 0{\cdot}23$, sex: $\chi^2 = 9{\cdot}1$, 8 D.F., $P = 0{\cdot}33$).

The number of cases with a 'high-risk' occupation as a proportion of all cases remained static between 1990 and 1998 (χ^2 test for linear trend = 1·95, n.s.). The incidence of leptospirosis in each occupational category fell between 1990–2 and 1996–8 (Table 1). Significant reductions between the two 3-year periods were observed among livestock farm workers and 'other' workers.

The declining leptospirosis incidence trend for New Zealand as a whole was not consistently observed in all health districts. Significant downward trends were observed in Auckland, Waikato, Taranaki, Manawatu and Wellington health districts only.

The overall reduction in leptospirosis cases in New Zealand between 1990 and 1998 is largely due to an absolute reduction in the numbers of cases of *L. borgpetersenii* sv. *hardjo* and *L. interrogans* sv. *pomona* during the time period. The combined number of *L. borgpetersenii* sv. *hardjo* and *L. interrogans* sv. *pomona* cases fell by 55% from 1990–2 to 1996–8, while combined numbers of other serovars, including *L. borgpetersenii* sv. *ballum*, increased by 25% over the same interval. The incidence of *L. borgpetersenii* sv. *ballum* infection increased significantly from 0·2 to 0·6 per 100000 between 1990–2 and 1996–8, while the incidence of *L. borgpetersenii* sv. *hardjo* and *L. interrogans* sv. *pomona* infection declined significantly (Table 2).

The annual number of *L. interrogans* sv. *pomana* cases among livestock farm workers declined from 52 per year in 1990–2 to 14 per year in 1996–8, the annual number of *L. borgpetersenii* sv. *hardjo* cases declined slightly from 96 to 61 per year, and the annual number of cases attributable to *L. borgpetersenii* sv. *ballum* climbed from 13 to 27 per year during the same

Table 2. *Trends in incidence of leptospirosis due to selected serovars, 1990–8*

	Number of cases	Crude annual incidence (per 100000)	Rate ratio*	95% confidence interval of RR†
L. borgpetersenii sv. *ballum*				
1990–2	24	0·2		
1996–8	62	0·6	2·38	(1·48–3·81)
L. borgpetersenii sv. *hardjo*				
1990–2	228	2·3		
1996–8	116	1·1	0·47	(0·37–0·59)
L. interrogans sv. *pomona*				
1990–2	160	1·6		
1996–8	60	0·5	0·35	(0·26–0·46)
Other serovar or mixed infection				
1990–2	78	0·8		
1996–8	66	0·6	0·78	(0·56–1·08)

* Compared with serovar-specific rate for 1990–2.
† 95% confidence limits for rate ratio.

intervals. Among meat processing workers, the annual number of cases due to *L. interrogans* sv. *pomona* declined from 62 per year in 1990–2 to 26 per year in 1996–8, while the annual number of *L. borgpetersenii* sv. *hardjo* cases increased slightly from 23 to 30 per year during the same interval.

DISCUSSION

This study used a combined dataset of leptospirosis notifications and laboratory-reported cases to give a comprehensive assessment of the epidemiology of this disease in New Zealand in the 1990s. By combining data from two surveillance systems, this study mitigated the effect of underreporting of cases to the disease notification system [6].

Descriptive epidemiology

According to this study, the average annual incidence of leptospirosis in New Zealand (4·4/100000) has declined since the last New Zealand estimate of 6·2/100000 reported in 1993 for the 1990–2 period [6], continuing a trend noted previously [4]. At 4·4/100000, the rate of leptospirosis in New Zealand remains higher than that reported for other developed temperate climate countries, such as 0·8–2·2 in Portugal [10], 0·7 in Australia [11] and 1·0 in Ireland [12]. The 1990–2 incidence in the current study was 5·7/100000, lower than that previously reported for the same period [6]. The reason for this discrepancy is not clear, as both estimates combined notifications and laboratory-reported cases. The current study used a systematic approach to preventing double-counting single disease episodes, but the approach used in the 1993 study was not reported.

The higher leptospirosis incidence among males in comparison with females in New Zealand has been documented previously [4, 6]. The male leptospirosis incidence is tenfold that of females. Much of this difference is likely to be due to male predominance within the main occupations at risk of leptospira exposure. There were no differences in gender-specific leptospirosis incidence rates among meat processing workers or forestry-related workers. Gender differences remained among livestock farmers or 'other' workers and suggest gender differentiation of work-tasks or personal hygiene within certain occupational categories leading to differences in leptospira exposure.

The age distribution of cases has not changed appreciably since the 1990–2 study [6] or during the 9-year period analysed in this study. Leptospirosis cases remain concentrated among individuals aged 20–40 years.

This study suggests that the overwhelming majority of cases of leptospirosis in New Zealand occur among livestock farm workers and meat processing workers, as observed previously [6, 13, 14]. Rates of illness among meat processing workers remain very high. Assuming a working career of 30 years and a constant level of exposure throughout, at rates estimated from this study meat processing workers in New Zealand carry a 1:20 risk of contracting leptospirosis of sufficient severity to seek medical attention at some stage during their career. The incidence of leptospirosis among male dairy farm workers aged 15–64 was 115·4/100000. A large proportion of livestock farmers were not differentiated by type of animal farmed. There may have been 199 further cases among male dairy farm workers if the proportion of male dairy farm workers in the undifferentiated group was equivalent to that in the differentiated group. Including these cases suggests that the true incidence of leptospirosis among male dairy farm workers may be as high as 233·8/100000. The career risk of leptospirosis among male dairy farm workers (based on a 30-year career of exposure) ranges between 1:28 and 1:14, using these two incidence estimates.

Analysis was performed on forestry-related workers as a representative occupational group with exposure to surface water but not to livestock animals. Although case numbers among this group were small, forestry-related workers were found in this study to be at increased risk of leptospirosis. Surface water exposure has well-documented association with illness internationally [15–17], but has not been previously documented in New Zealand. Recreational exposure to surface water was not investigated in this study because recreational exposure had not been recorded in notified case reports, despite space to do so. No leptospirosis outbreaks implicating recreational exposure have been reported to the outbreak surveillance system. Systematic collection of recreational risk factor information on notified cases commenced in 1999.

Marked differences in leptospirosis incidence were observed between health districts. These differences were not related to differences in age or sex distribution, and are likely to reflect variation in land use and occupations. Heavy dairy farming areas such as Waikato, Taranaki, Manawatu, Northland and West Coast health districts were all found to have higher leptospirosis incidence than other health districts. Regional differences in leptospirosis incidence in Australia have been associated with variation in types of animals processed [18].

Sources of uncertainty

Despite the improved sensitivity that this dataset represents, several potential sources of bias should be considered. Firstly, many individuals with leptospirosis will not seek medical attention, either because the symptoms are mild and short-lived, or due to difficulties accessing medical services [19]. Such individuals will not be included in this dataset, differentially reducing incidence among individuals with difficulty accessing medical care, such as individuals living in rural areas.

Secondly, recognition of leptospirosis by doctors is poor, even in tropical countries with high rates of the condition [20]. Unrecognized cases will not be tested and therefore would not have been included. Differential bias may be introduced if doctors working in areas with low leptospirosis incidence have a higher threshold for suspecting and investigating cases of leptospirosis. Similarly, doctors may be less likely to suspect the diagnosis in cases lacking a history of exposure to a well known source of infection, creating a bias against detection of atypical or emerging modes of transmission.

Thirdly, it is possible that the ESR Leptospira Reference Laboratory may not have received all regional laboratory cases, and the laboratory surveillance database therefore may not represent a true count of all laboratory-reported cases in New Zealand. Retrospective confirmation that all regional laboratory results had been received was not possible, however the records of returns from each laboratory contained no apparent omissions.

Lastly, any multiple case records (e.g. notification and laboratory record pertaining to an individual case) that remained unmatched would have lead to double-counting, potentially increasing case numbers. The possibility of double-counting is considered to be small because a systematic approach to matching case records was taken.

Changing epidemiology

Analysis of trends over the 9-year period provides some evidence that the epidemiology of leptospirosis in New Zealand is changing. Although leptospirosis cases continue to be concentrated among demographic groups previously associated with high risk (in particular, young male livestock farm workers in heavy dairy farming areas), the predominance of these groups fell during the 9-year period. Rates among livestock farm workers declined significantly during the study period, while rates among other occupational groups showed no significant decline. Similarly, leptospirosis incidence fell in most areas with heavy dairy farming industry, with several exceptions discussed below.

The incidence of *L. borgpetersenii* sv. *hardjo* and *L. interrogans* sv. *pomona* infection, concentrated among livestock farm workers and meat processing workers respectively, declined significantly between 1990–2 and 1996–8. Conversely, the incidence of *L. borgpetersenii* sv. *ballum* infection climbed significantly so that by 1996–8 *L. borgpetersenii* sv. *ballum* had overtaken *L. interrogans* sv. *pomona* as the second most commonly-recognized serovar. *L. borgpetersenii* sv. *ballum* has long been tested for in New Zealand, so the observed increase in this study is not an artefact of changes in testing schedule. *L. borgpetersenii* sv. *ballum* is maintained in rodents and occurs secondarily among livestock animals. The emergence of *L. borgpetersenii* sv. *ballum* as a more frequent cause of human infection suggests a change in the prevalence of *L. borgpetersenii* sv. *ballum* in the zoonotic reservoir, increasing exposure of humans to this serovar either by direct animal contact or through contaminated surface waters. Further clarification of causal pathways underlying this epidemiology shift would require collaboration with veterinary epidemiologists and zoologists.

Recommendations

Collection of accurate information on exposures to potential sources of infection should be encouraged as part of ongoing improvement of the leptospirosis disease notification dataset as collected on the case-report form. Future reviews of leptospirosis epidemiology should make use of exposure data, and a study comparing exposures among leptospirosis cases with those of the population, matched for geographic area of residence, would be necessary to determine the proportion of leptospirosis cases attributable to recreational exposure. The overall decline in cases of leptospirosis among livestock farmers, and hence the decline in cases overall, is likely to be the result of improved prevention of disease in livestock and consequent reduced transmission to farm workers. Several districts have not followed the nationwide trend, but the data presented in this study are insufficient to advance explanations for the failure of these health districts to maintain declining leptospirosis rates. Valuable information could be gained from inclusion of data comparing vaccination rates between health districts, but this information is not currently available. Leptospirosis surveillance in New Zealand would be considerably enhanced by development of an associated hazard-surveillance system that could allow active monitoring of such information.

If rates of vaccination are shown to vary between health districts, then research should be conducted to address reasons for variation. Despite gains made in the last two decades, leptospirosis remains New Zealand's most important occupational infectious disease and is poorly controlled in comparison with other developed countries. Considerable scope remains for further improvement, particularly among meat processing workers. Further gains will require greater investment in targeted and evaluated disease control programmes.

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