A review of national legionellosis surveillance in Australia, 1991 to 2000

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Abstract

A study was undertaken to analyse legionellosis notifications for the period 1991 to 2000 to establish the distribution of legionellosis in Australia with the aim of identifying risk factors amenable to public health intervention. Legionellosis notification rates ranged from 0.6 cases per 100,000 population in 1991 to 2.5 cases per 100,000 population in 2000. Notifications were highest in autumn (March to May). Sixty-nine per cent of cases were males. At-risk population included those aged over 50 years. The upward trend in notification rates of legionellosis indicated that this disease remains a significant public health problem particularly among older people. Seasonal differences in notification rates require further investigation to develop appropriate prevention and control strategies. To have a better understanding of the epidemiology of legionellosis, further information is needed on smoking history, chronic illnesses, whether the notification is outbreak-related and the species of *Legionella* isolated. *Commun Dis Intell* 2002;26:462-470.

Introduction

Legionellosis is a collective name for the clinical syndromes caused by members of the genus, *Legionella*. It was first recognised after an outbreak of pneumonia in Philadelphia in 1976.[1] In 1978, the first Australian case was described.[2]

Legionellosis is an environmentally acquired bacterial pneumonia with no person-to-person spread. It is caused by members of the genus, *Legionella,*[3] which are aquatic organisms, widely distributed in natural and man-made habitats.[4] Transmission of the disease may, in susceptible people, follow inhalation of aerosol contaminated with pathogenic *Legionellae*. Known sources of infective aerosols include evaporative cooling towers, showers, water taps, nebulisers and whirlpool spas.[3] Outbreaks have mostly been associated with exposure to aerosols from evaporative cooling towers and complex domestic water systems.[3] However, many cases are sporadic[5,6] and for these the source of infection is seldom found.[7,8]

Legionnaires' disease is the most severe form of legionellosis and it is an important cause of community-acquired pneumonia. European and North American studies have estimated that *Legionella* species may cause between 2 and 15 per cent of all community-acquired pneumonia requiring hospitalisation.[9] The case fatality rate has been reported as ranging from 5 to 30 per cent, depending on the underlying risk factors of the patients.[10]

This paper presents an overview of the frequency and distribution of notified cases of legionellosis in Australia for the period 1991 to 2000, with the objective of identifying demographic characteristics of the disease.

Methods

Notification data of legionellosis received by the National Notifiable Diseases Surveillance System (NNDSS) between 1 January 1991 and 31 December 2000 were collated. Data were analysed using Stata statistical software (version 6).

Collection of notification data of legionellosis

Legionellosis is a notifiable disease under the public health legislation of each state and territory. All states and territories require medical practitioners to notify legionellosis and all except

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Western Australia also require laboratories to do so. Nationally, notifications of legionellosis have only been routinely collected since 1991.

The NNDSS receives de-identified notification data from each state and territory. These data include fields for sex, age in years, postcode, species details, date of onset and date of notification to the relevant health authority.[11]

Case definition

Legionellosis can be identified on clinical grounds and through laboratory diagnosis. Most states and territories use the National Health and Medical Research Council case definition,[12] a clinically compatible illness (fever, cough or pneumonia) and at least one of the following:

- isolation of *Legionella* species from lung tissues, respiratory tissue, respiratory secretions, blood or other tissues; or

- demonstration of *Legionella* species antigens in lung tissue, respiratory secretions or pleural fluid; or

- a fourfold or greater rise in indirect immunofluorescent antibody titre against *Legionella* species, to at least 128, between acute and convalescent phase sera; or

- a stable high *Legionella* titre (at least 512) in convalescent phase serum.

Notifications related to legionellosis outbreaks

To estimate the number of notifications related to outbreaks, legionellosis outbreaks reported in the literatures in Australia during the study period were identified by searching the Medline database. However, many outbreaks may have been unpublished. To address this issue alternative data sources that included state and territory public health bulletins, environmental health bulletins, annual surveillance reports, Master of Applied Epidemiology theses of the Australian National University and personal communication with individual departments of health were used. The number of cases by year, month of onset, season of onset, place of outbreak, putative sources and causative species from each identified report were extracted.

Statistical analyses

Calculations of crude notification rates were made using the Australian Bureau of Statistics (ABS) estimates of mid-year populations as the denominator. The trend of the crude notification rates, with and without the inclusion of the outbreak cases, over the 10-year period were examined using Poisson regression. The data were analysed to investigate differences in the incidence of legionellosis notifications according to period (year of notification) after allowing for the different population sizes. The ABS 1996 population figures were used as the denominator to calculate the age and gender-specific notification rates during the study period. To examine seasonal changes in notifications between 1996 and 2000, the number of notifications by season of onset were combined. Unpaired t-tests were used to compare the mean number of notifications in autumn versus other seasons. Degrees of freedom of seasonal comparisons were equal to n_1+n_2-2 where n_1 was the number of observations in one season, and n_2 was the number of observations in the comparing season. Sub-analyses of comparisons of seasons in *Legionella longbeachae* species and *Legionella pneumophila* species were also carried out.

The study explored the impact of the outbreak that occurred at the Melbourne Aquarium as the large number of cases may have affected the dynamics of the seasonal comparison. To fulfil this objective the number of cases of this outbreak were removed from the data set and the sub-analysis of seasonal comparison in *Legionella pneumophila* was repeated.

Results

Trend analysis

There were 2,170 notifications of legionellosis to the NNDSS with an onset date in the study period. The trend in the period from 1991 to 1997 was flat, with the crude notification rate ranging from 0.6 to 1.1 cases per 100,000 population (Rate 1 in Figure 1). The crude notification rate raised to approximately 1.4 cases per 100,000 population in 1998 and 1999 (Rate 1 in Figure 1). The highest crude notification rate was recorded as 2.5 cases per 100,000 population in 2000 (Rate 1 in Figure 1). After excluding cases related to outbreaks, the trend remained unchanged between 1991 and 1999 except that the crude rate in 2000 dropped to 1.8 cases per 100,000 population (Rate 2 in Figure 1). The upward trend of Rate 1 (Regression coefficient of incidence rate ratio (IRR)=0.11 (95%CI: 0.10-0.13); IRR=1.12 (95%CI: 1.10-1.13); p<0.0005)) and Rate 2 (Regression coefficient of incidence rate ratio (IRR)=0.08 (95%CI: 0.07-0.10); IRR=1.09 (95%CI: 1.07-1.11); p<0.0005)) were statistically significant.

Figure 1. Crude notification rates of legionellosis, Australia, 1991 to 2000, by year
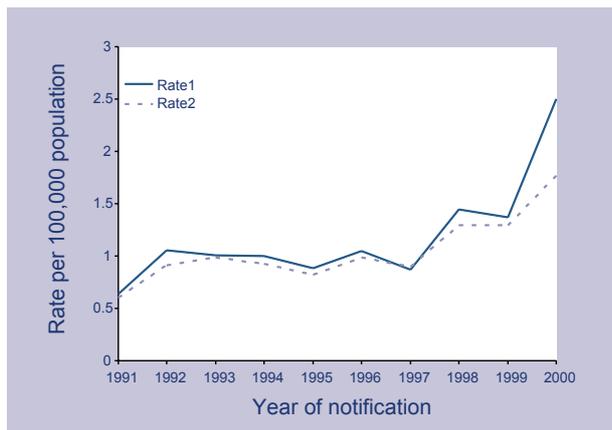

Rate1. Crude rate derived by including all legionellosis notifications during the study period.

Rate2. Crude rate derived by excluding cases related to outbreaks from legionellosis notifications during the study period.

Distribution by age and gender

There was a clear over-representation of males and elderly in notifications for legionellosis. During this period, 69 per cent of notifications were for males and 73 per cent of notifications were for people older than 50 years. The largest proportion of notifications was for males in the 75–79 years age group (Figure 2). The notification rate for males increased gradually over the adult years while the notification rate for females started to increase for those aged over 50 years, however the magnitude was much smaller than that observed in males.

Figure 2. Notification rates for legionellosis, Australia, 1991 to 2000, by age and sex
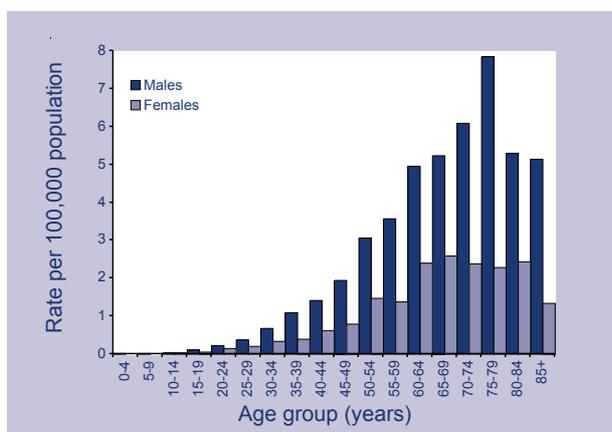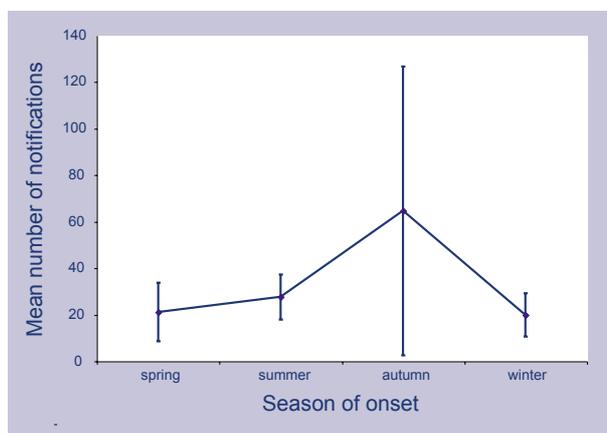

Seasonality

There was a seasonal pattern of legionellosis notifications between 1996 and 2000, with the mean number of notifications peaking in autumn (March to May) (Figure 3). The mean number of notifications in autumn was higher than for all other seasons however, the seasonal differences of notifications between autumn and each of the other seasons were not significant.

Figure 3. Mean number of legionellosis notifications, Australia, 1996 to 2000, by season of onset
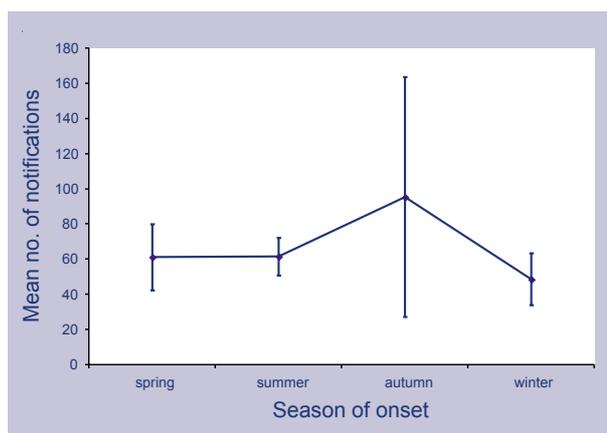
The sub-analysis of seasonal difference of notifications in *Legionella pneumophila* species showed a similar peak in autumn (Figure 4). The difference between autumn (mean=65) and spring (mean=21) in *Legionella pneumophila* species was not significant (t_8=1.6, p=0.09). Similarly the difference between autumn (mean=65) and winter (mean=20) was also not significant (t_8=1.4, p=0.09).

Figure 4. Mean number of *Legionella pneumophila* notifications, Australia, 1996 to 2000, by season of onset

The repetition of the sub-analysis of the a seasonal comparison in *Legionella pneumophila* which excluded the cases related to the Melbourne Aquarium outbreak increased the precision of the comparison. The difference between autumn (mean=42) and spring (mean=21) was significant (t_8=3.4, p=0.01), as was the difference between autumn and summer (mean=27.6) (t_8=2.5, p=0.03), and between autumn and winter (mean=19.8) (t_8=3.2, p=0.02).

The sub-analysis of the seasonal difference of notifications in *Legionella longbeachae* species showed a peak in spring (Figure 5). The differences between spring and summer (t_8=1.8, p=0.05), and between spring and winter (t_8=1.8, p=0.05) were significant whereas the difference between spring and autumn was not significant (t_8=1.6, p=0.07).

Figure 5. Mean number of *Legionella longbeachae* notifications, Australia, 1996 to 2000, by season of onset
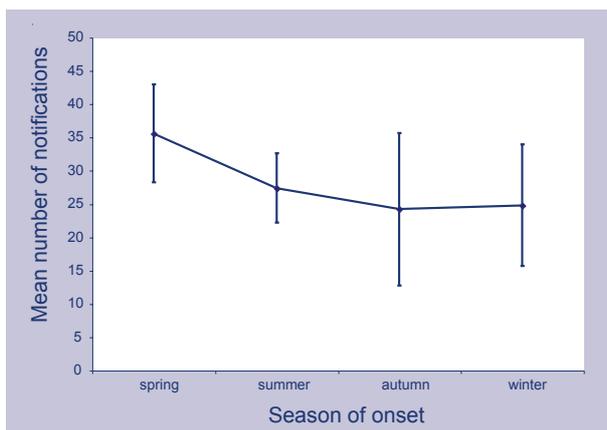
Species types

Speciation of *Legionella* has only been recorded in the NNDSS since 1996. For this reason, only information on species types between 1996 and 2000 were examined. Species type data in the NNDSS were incomplete with 52 per cent of records not including this information. The NNDSS data were supplemented with data sources from individual states and territories and the results showed that *Legionella pneumophila* was the most common species (51%), followed by *Legionella longbeachae* (42%), unspecified species (4%), *Legionella bozemanii* (1%), and *Legionella micdadei* (1%).

Notifications related to legionellosis outbreaks

A total of 22 outbreaks of legionellosis were identified (Table). *L. pneumophila* serogroup 1 was the most likely cause of all of the outbreaks. These outbreaks included at least 246 cases during the 10-year period. Eight outbreaks occurred in autumn, six in summer, five in winter and one in spring. Contaminated cooling towers were suspected to be the source for 15 outbreaks while spa pools were suspected to be the source for 4 outbreaks.

Discussion

The trend of crude annual notification rates

There has been an upward trend in the number of reports of legionellosis since 1997 (Figure 1). There were several factors which contributed to this increase. Firstly, the continued increase in case ascertainment of legionellosis was partly attributable to continuing publicity about the disease and the increasing use of the urinary antigen test (UAT) since mid 1990s. The use of UAT has made the diagnosis of Legionnaires' disease caused by *L. pneumophila* serogroup 1 easier for mild cases. Nevertheless, the increased use of UAT was not solely responsible for the upward trend of notifications since 1997, but without any sign of a change in the virulence of *Legionella*,[13] it can be speculated that rapid diagnosis and increased case ascertainment were major contributors to the upward trend. Secondly, the increased notification rates in 1998 and 2000 were affected by the size of outbreaks during the period. Two *L. pneumophila* 1 related outbreaks in 1998[14] and 2000[15] accounted for 7 per cent and 24 per cent respectively, of total notifications for those years.

Distribution by age and gender

There was a marked association between age, gender and legionellosis. Overall, the ratio of disease in men to women was 2:1. Only 4 per cent of patients were 30 years or under and 73 per cent of patients were aged over 50 years. The patterns in age and sex distribution were consistent with the generally recognised epidemiology for the disease.[14,16] Males are normally regarded to be at greater risk of legionellosis, partly because they are more likely to be heavier smokers[17] and therefore may tend to have inferior respiratory and general health. Ultimately, the sex ratio of the notified cases depends upon the demography of the exposed population.[18] Also, advancing age leads to the deterioration of general health, which makes the elderly more vulnerable to the disease when exposed to *Legionellae* during gardening and shopping.

Table. Notable outbreaks of legionellosis, Australia, 1991 to 2000

No.	Year	Month	Season	Place	Area	Likely source	Species	No. of cases	Ref
1	1992	Apr	Autumn	Fairfield, Sydney	Shopping centre	*	LPsg1	26	22
2	1993	Apr	Autumn	Paramatta, Sydney	Hotel	*	LPsg1	4	23
3	1994	Apr	Autumn	Western Sydney	Hotel car park	*	LPsg1	4	19
4	1994	Jun	Winter	Western Sydney	A club	*	LPsg1	7	34
5	1994	Aug	Winter	Sunshine coast, Queenland	Holiday apartment unit	Private spa pool	LPsg1	3	35
6	1995	Jan	Summer	Sydney	Shopping centre	*	LPsg1	11	36
7	1996	Apr	Autumn	Melbourne	Metropolitan area	Not identified	LPsg1	7	37
8	1996	May	Autumn	Kangaroo Island, South Australia	Tourist resort	Spa pool	LPsg1	4	38
9	1998	Jun	Winter	Moonee Valley, Victoria	Suburban shopping district	*	LPsg1	4	39
10	1998	Oct	Spring	Thomstown, Victoria	Industrial area	*	LPsg1	18	39
11	1998	Nov	Summer	Western Sydney	Work place	*	LPsg1	3	40
12	1998	Not reported	Not	Victoria	Supported accommodation hostel	Not identified	LPsg1	2	39
13	1998	Not reported	Not reported	Victoria	Hospital	*	LPsg1	3	39
14	1999	Jan	Summer	Melbourne	Community	*	LPsg1	3	41
15	1999	Feb	Summer	Wentworth & Western Sydney	Source unclear	Not identified	LPsg1	7	42
16	1999	Jun	Winter	Melbourne	Social club	Spa pool	LPsg1	2	41
17	2000	Feb	Summer	Carlton-Fitzroy, Victoria	Community	*	LPsg1	6	15
18	2000	Mar	Autumn	Melbourne	Metropolitan area	*	LPsg1	5	15
19	2000	Apr	Autumn	Melbourne	Aquarium	*	LPsg1	125	15
20	2000	May	Autumn	Cobram, Victoria	Community	*	LPsg1	6	15
21	2000	Jun	Winter	Collingwood, Victoria	Football club	Spa pool & shower	LPsg1	4	15
22	2000	Dec	Summer	Melbourne	Private hospital	*	LPsg1	5	15

* Small cooling tower

LPsg1 *Legionella pneumophila* serogroup 1

Seasonality

Peak seasons for onset of disease appeared to be autumn followed by summer. This seasonal peak of notifications coincided with outbreaks related to small cooling towers in Australia.[15,19-23] In this study 64 per cent (14/22) of the outbreaks in the 10-year period occurred between summer and autumn. Colbourne and Dennis reported a summer to early autumn prevalence of sporadic cases of the disease in the United Kingdom.[24] Bhopal and Fallon reported an autumn peak in incidence of cooling tower-associated outbreaks in Scotland,[25] and outbreaks in the United States of America have also generally occurred in the late summer to autumn period and were generally related to small cooling towers.[24,26-28]

The effect of one autumn outbreak (the Melbourne Aquarium) on the results of the seasonal analysis of *L. pneumophila* species merits discussion because the large size of this outbreak may exaggerate the seasonal importance of autumn (n=125, with 113 of these notified in Victoria).[15] By removing this outbreak from the seasonal analysis of *L. pneumophila* the autumn peak reduced only in magnitude. The statistical significance of the comparison between autumn and other seasons were improved. It is clear that autumn had a significantly higher number of *L. pneumophila* notifications than other seasons.

Interestingly, *Legionella* colonisation of cooling towers also appears to vary seasonally.[29,30] A 12-month field study of more than 30 cooling towers in Adelaide showed that 80 per cent of towers were colonised in summer.[30] A 21-month study of 9,904 cooling tower water samples collected from New South Wales, Queensland and the Northern Territory showed a similar seasonal trend.[31] The isolation rate of *Legionellae* from these water samples peaked in the summer and autumn months.

The autumn coincidence of *Legionella* counts in tower water, outbreaks related to small cooling towers and peak notification of legionellosis merits further discussion. A model to explain this autumn coincidence has been proposed.[32] In autumn, *Legionella* populations in cooling towers are likely to be well established after the summer period. If towers are shut down, as ambient temperatures fall below 20°C, *Legionella* populations will decline until temperatures rise again in spring. However, if systems are put back into service in autumn after a short period of inactivity in response to a period of warm weather ('Indian summer'), a sudden and very rapid increase in *Legionellae* count could be expected. The increased relative humidity and reduced sunlight intensity in autumn would prolong the viability of *Legionellae* entrained in aerosols.[33] This may explain outbreak occurrence in autumn in states with a temperate climate, such as New South Wales and Victoria, but not in jurisdicitons with a tropical climate, such as the Northern Territory. During the 10-year period the Northern Territory reported between zero and 5 cases per year.

Measuring the association between the risk level of cooling towers (*Legionella* count and level of cleanliness) and onset of illness caused by *Legionella pneumophila* 1 may validate this autumn hypothesis of legionellosis. Time series data of maintenance records from a representative sample of cooling towers and information including species type, of every notification would need to be collected for this analysis.

Limitations of notification data

The epidemic potential of *Legionella pneumophila* 1 is well known, but outbreaks contribute to only a moderate proportion of all legionellosis notifications. Relatively little is known about the risk factors for sporadically occurring legionellosis. The current study cannot add to our understanding of sporadic cases.

Only larger outbreaks are likely to be published. The study was unable to account for those notifications associated with outbreaks that were not published in the literature and the number of notifications associated with outbreaks is probably higher than reported in literature.

To understand the epidemiology of sporadic legionellosis, information is needed on age, sex, onset date, causative organism, smoking history and chronic illnesses of non-outbreak related cases. The NNDSS cannot currently distinguish between outbreak-related and other notifications. Enhanced surveillance data for *Legionella* cases could include information on whether the notification was outbreak-related and whether the persons notified are smokers or have a history of chronic illnesses. Moreover, all states and territories should be encouraged to complete the data field of *Legionella* species in the NNDSS as 52 per cent of notifications had no information on reporting causative species. It is difficult to design appropriate prevention strategies for different regions since adequate information is not available to estimate which species is more prevalent in a particular region.

Conclusions and implications

Legionellosis may be an increasing public health concern in Australia. Contamination of cooling towers was a putative source for 69 per cent (15/22) of all of the outbreaks, and 36 per cent (8/22) of the outbreaks related to cooling towers in the 10-year period, occurred in autumn. While outbreak-related cases represent only a small proportion of all notifications, it is important that prompt identification and control of the sources occurs. Alerts to building managers to ensure the proper maintenance of cooling towers could also help prevent outbreaks. Since the ecology of legionellosis varies by type of infection, i.e. whether outbreak-related; travel-associated; nosocomial; occupationally-acquired; or community-acquired, national surveillance data could be improved by accurately recording such information along with the species type so that there can be a better understanding of the epidemiology of legionellosis. Future research should focus on identifying the factors contributing to the peak notification in autumn and in furthering the development of effective preventive measures.

Acknowledgments

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