Investigation and control of a cluster of cases of Legionnaires disease in western Sydney

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Abstract

Three cases of *Legionella pneumophila* infection were identified in Sydney's west in November 1998. Epidemiological investigations identified an association with one workplace. Environmental sampling revealed that the cooling towers in the workplace, and at 2 other premises within a 1 km radius of the workplace, were positive for *L. pneumophila* serogroup 1 (LP1) which was indistinguishable from clinical isolates of 2 of the cases on DNA fingerprinting. Our report highlights limitations of the current control program for *Legionella* in cooling towers, including the finding of unregistered cooling towers, cooling towers positive for LP1 despite satisfactory results on inspection, and cooling towers potentially linked to disease with counts of LP1 below the current protocol requirements for immediate decontamination. *Commun Dis Intell* 2001;25:63-66.

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Introduction

Legionnaires' disease was first identified in 1976 after an outbreak occurred at an American Legion convention.[1] Legionnaires' disease is generally caused by the environmental pathogen *Legionella pneumophila* serogroup 1 (LP1) or *Legionella longbeachae*.[2] Outbreaks of LP1 have been associated with cooling towers,[3-9] evaporative condensers,[10] domestic hot water systems,[11,12] and excavation and construction activity.[13] On average one LP1 outbreak is reported annually in Australia.[2]

In western Sydney outbreaks of Legionnaires' disease occurred in 1992,[14] 1993,[8] 1994[15] and 1995.[15] We report here on a cluster of cases of Legionnaires' disease associated with a cooling tower in a workplace in Sydney's west.

Methods

Epidemiological investigation

Two cases of Legionnaires' disease[16] were notified by laboratories to the Western Sector Public Health Unit on 12 November 1998. Both cases satisfied definitions of confirmed cases in the NSW Health Department Infectious Diseases Manual.[16] When initial investigations revealed that the 2 cases were employed in the same workplace (Premises A) an outbreak was suspected and active surveillance was initiated and continued for a 10-day period. All emergency departments and intensive care units were contacted daily to ascertain whether there were any probable cases of Legionnaires' disease. Laboratories were also contacted daily to ensure test results were available as soon as possible. Additionally, we requested that the workplace alert us of staff members suffering prolonged respiratory illness.

All cases were interviewed by Public Health Unit staff using a standard questionnaire.[17] Information on the case's movements, including potential exposures to *Legionella*, during the 10-day period prior to onset of illness was obtained for each case. Where the case was unconscious, proxies were interviewed and electronic work diaries and time sheets were used as sources of information. Clinical specimens were processed using standard microbiological techniques. Putative isolates were identified as *L. pneumophila* by growth, colony characteristics and serogrouping.

Environmental investigation

Environmental investigations commenced immediately on receipt of notifications, which was between 3 and 5 weeks after the likely exposure. Potential environmental sources of *Legionella*, such as cooling towers, at or near sites of exposure reported by cases, were identified from registers held by local government authorities.

These sources were then inspected and sampled in sequence, commencing at locations of common exposure to more than 1 case, and progressing to those where only 1 case reported potential exposure. At sites of common exposure, potential sources up to 500 m from the site were investigated. When a third case was reported with exposure 800 m from Premises A, the radius of investigation around Premises A was increased to 1 km. The Environmental Health Officers made efforts to identify any unregistered

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premises or cooling towers within that radius by visual inspection from suitable vantage points.

Molecular investigations

Environmental samples were tested for the presence of *Legionella* by the Legionella Reference Laboratory of the Division of Analytical Laboratories (DAL), Lidcombe, New South Wales. This testing involved the use of standard culture procedure, using heat treatment at 50 C for 30 minutes and Glycine-Vancomycin-Polymixin D-Cyclohexamide agar. Cultural confirmation involved the use of Buffer-charcoal-yeast extract and Tryptocase-soya broth agar, Gram staining and serological characterisation.

Molecular investigations were carried out by the Molecular Microbiology Laboratory of the DAL. Isolates were sent for molecular testing from cooling towers which tested positive for LP1 at premises where there was an epidemiological link to the cases. In situations where more than 1 cooling tower at the premises tested positive for LP1, samples from the cooling tower with highest count were examined. At least 2 different isolates from each cooling tower and all available clinical isolates were subjected to molecular testing. Isolates were characterised by two methods – randomly amplified polymorphic DNA[18] and restriction fragment lengths polymorphism.[19] The DNA fingerprint profiles were then visually compared.

Results

Epidemiological investigation

Three cases with onset dates 6 days apart were notified to the Public Health Unit and characterised as confirmed cases (Table 1). Active surveillance identified a fourth case that met initial probable case definition criteria, but was subsequently excluded on the basis of negative *Legionella* antibody tests in acute and convalescent sera.

All cases survived. One case developed acute renal failure. In-depth interviews (via proxy in Cases 1 and 2) revealed 3 epidemiological links between the cases. These were as follows: Cases 1 and 3 were employed at the same premises, (Premises A); Case 2 lived 800 m south of Premises A; and Cases 1 and 3 attended a day long seminar in the same premises during their incubation periods, which was 6 km north of Premises A.

Environmental investigation

Intensive investigation identified 8 premises with 30 cooling towers within 1 km of Premises A, including 3 premises with a total of 6 cooling towers which had not been registered with the local government authority. Four cooling towers in premises within 500 m of Premises A were found to be positive for LP1; 2 of these towers were in Premises A, and the remaining 2 were at Premises B located within 100 m of Premises A. All of these cooling towers had been registered and were satisfactory on inspection. (Table 2)

A further 5 cooling towers in 2 premises © and D) between 500 and 1000 m of Premises A were found to be positive for LP1. Four of these towers were at one of the unregistered premises (Premises D) and were unsatisfactory on inspection. The remaining towers, including those at Premises C and the other unregistered premises, were satisfactory on inspection. (Table 2)

Outside this range, only cooling towers at sites reported as visited by cases were inspected and sampled. LP1 was isolated from a further 4 cooling towers at 3 premises at sites from 2 km to 20 km from Premises A; this did not include the premises attended by 2 of the cases for a seminar.

Overall 72 cooling towers at 25 premises were inspected and sampled during the investigation, and 13 cooling towers were found to be positive for LP1.

Table 1. Cases by date of onset, age, case criteria and risk factors

Case number	Date of onset	Age (years)	Case criteria	Risk factor
Case 1	23/10/98	44	Urine positive for *Legionella pneumophila* antigen	smoking
Case 2	25/10/98	60	*L. pneumophila* serogroup 1 isolated	smoking
Case 3	29/10/98	66	*L. pneumophila* serogroup 1 isolated	smoking

Table 2. Summary of *Legionella pneumophila* 1 (LP1) counts by the number of premises and cooling towers in each distance range

Distance from Premises 1 (metres)	Number of premises	Number of registered premises	Number of premises LP1 positive	Number of cooling towers	Number of registered cooling towers	Inspection satisfactory	Number of cooling towers LP1 positive
< 500	5	4	2	21	20	19	4
500-1000	3	1	2	9	4	5	5
1000 – 2000 *	6	6	0	10	10	8	0
> 2000 *	11	11	3	32	32	32	4
Total	25	22	7	72	66	64	13

* Only premises linked to case exposures were investigated at these ranges

Following inspection and sampling, immediate decontamination was undertaken for all cooling towers in Premises A and B between 13 and 15 November, which was 2 and a half weeks after the onset of the last case. At other premises, action was taken in accordance with the New South Wales Code of Practice for the control of Legionnaires' disease.[20] All cooling towers that were positive for *L. pneumophila* were re-tested following decontamination.

Molecular typing was undertaken on LP1 isolates from 4 cooling towers from the 4 LP1 positive premises within 1 km of Premises A and compared with clinical isolates obtained from 2 patients (Cases 2 and 3). The DNA profiles of the 2 clinical isolates were identical and matched at least 1 isolate from 3 of the cooling towers (at Premises A, B and C, Table 3).

Discussion

We identified 3 cases of Legionnaires' disease, which we viewed as a sentinel to initiate active surveillance and a comprehensive environmental investigation. The epidemiological links among the 3 cases were supported by the finding of indistinguishable DNA profiles in the 2 cases where clinical specimens were available.

Environmental investigation identified cooling towers positive for LP1 in 4 premises which were potentially linked to the cases. Molecular typing was unable to distinguish between LP1 isolates from cooling towers at 3 premises and clinical samples from 2 cases. However, the lack of information on the frequency with which this particular DNA profile of LP1 is found in cooling towers prevents a definite conclusion on the source of the cluster.

The environmental investigation identified that 50 per cent (4/8) of the premises and 30 per cent of the cooling towers (9/30) within 1 km of Premises A were positive for LP1 on sampling. This proportion is higher than that found in a survey of registered New South Wales clubs in 1997 (6% of 126 clubs tested were positive for *Legionella* spp)[21] and higher than that found among the premises and cooling towers investigated which were distant from Premises A.

This could be due to the more intensive investigation within the 1 km radius of Premises A, which identified 3 premises and 6 cooling towers which had not been registered. Four of these cooling towers were positive for LP1 and were unsatisfactory on inspection. This suggests that action by cooling tower owners to register towers with their local councils may be associated with improved cooling tower maintenance and reduced detection of LP1. However, even if the unregistered towers are not included, the rate of isolation of LP1 in this area is high and other factors, such as the preponderance of industrial rather than commercial premises, and the time of the year, need to be considered. (Our Environmental Health Officers anecdotally report that production schedules in some industrial premises have created difficulties in adhering to regular maintenance regimes for cooling towers).

The New South Wales Code of Practice has a response protocol based on stratified counts of *L. pneumophila* and it recommends immediate shutdown and decontamination where counts of *L. pneumophila* in cooling tower water exceed 1000cfu/mL.[20] For counts between 100 and 999 cfu/mL a re-evaluation of maintenance procedures, including the current disinfection process is recommended.[20] None of the premises within a 1 km radius of Premises A had counts over 370 cfu/mL. Although these samples were taken 2 to 3 weeks after the onset dates for the cases, these cooling towers were associated with disease.

The response protocol based on stratified counts of *L. pneumophila* first appeared in an internal Department of Housing and Construction report in 1987.[22] The report suggested that the use of stratified *Legionella* counts should only be used as a guide and as an interim tool. The evidence for the stratified counts was based on the consensus of experts, primarily from the United States of America, rather than specific quantitative studies (personal communication,

Table 3. Cooling towers where LP1 was isolated and results of molecular typing

Location	Cooling tower*	On register	Inspection satisfactory	Legionella count†		Molecular typing done	DNA fingerprint match
		Y/N	Y/N	LP 1	Other		
< 500m	A.1	Y	Y	330	70	Y	Case 2, 3
	A.2	Y	Y	40	0	N	
	B.1	Y	Y	130	50	Y	Case 2,3
	B.2	Y	Y	40	0	N	
500 – 1000m	C.1	Y	Y	370	0	Y	Case 2,3
	D.1	N	N	40	30	Y	None
	D.2	N	N	10	0	N	
	D.3	N	N	30	10	N	
	D.4	N	N	10	0	N	
> 2000m	E	Y	Y	150	70	N	
	F.1	Y	Y	20	0	N	
	F.2	Y	Y	10	0	N	
	G	Y	Y	100	0	N	

* Cooling tower notation as premises cooling tower number.

† Colony forming units per millilitre (cfu/mL).

Mr Clive Broadbent (AM), Legionella Consultant, Canberra, 20 December 2000). These stratified counts were then adopted into the New South Wales Code of Practice in 1991, based on the 1987 internal Department of Housing and Construction report (personal communication, Mr Tony Burns, Senior Environmental Health Officer, Wagga Wagga, 21 December 2000). The findings of this investigation, and results of recent research in South Australia[23] which indicate that health risks from cooling towers cannot be reliably based upon single or infrequent *Legionella* tests, suggest that a review of the response protocol is required.

Seventy percent (9/13) of *L. pneumophila* positive cooling towers were assessed as compliant with the *Public Health Act 1991* at the time of inspection and sampling. The questionnaire includes a visual assessment of cleanliness, water turbidity, presence of slime, type of biocide used and recent cleaning history. We suggest that a broader questionnaire may be needed, as legislative compliance is a proxy for risk of *Legionella* contamination. The emphasis in the Code of Practice is on correct maintenance of cooling towers and occupiers are not required to sample cooling towers and test for *Legionella*.[20] Our findings suggest that either the questionnaire does not reflect the true maintenance of cooling towers or current maintenance procedures do not ensure the elimination of *Legionella* from cooling towers.

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References

1. Collee JG, Watt B. Bacterial infections of the respiratory tract. In: Parker MT, Collier LH, editors. Topley and Wilson's Principles of Bacteriology, Virology and Immunity. 8th ed. Melbourne: Hodder and Stoughton; 1990.p.130-3.
2. Heath TC, Roberts C, Jalaludin B, Goldthorpe I, Capon A. Environmental investigation of a legionellosis outbreak in western Sydney: the role of molecular profiling. *Aust NZ J Public Health* 1998;22:428-31.
3. Friedman S, Spitalny K, Barbaree J, Faur Y, McKinney R. Pontiac fever outbreak associated with a cooling tower. *Am J Public Health* 1987;77:568-72.
4. Addiss D, Davis J, LaVenture M, Wand P, Hutchinson M, McKinney R. Community acquired Legionnaires' disease associated with a cooling tower: evidence for longer distance transport of *Legionella pneumophila. Am J Epidemiol* 1989;130:557-67.
5. Keller DW, Hajjeh R, DeMaria A, Fields BS, Pruckler JM, Benson RS, et al. Community outbreak of Legionnaires' disease: an investigation confirming the potential for cooling towers to transmit *Legionella* species. *Clin Infect Dis* 1996;22:257-61.
6. Hunt DA, Cartwright KA, Smith MC, Middleton J, Bartlett CL, Lee JV, et al. An outbreak of Legionnaires' disease in Gloucester. *Epidemiol Infect* 1991;107:133-41.
7. O'Mahony MC, Stanwell Smith-RE, Tillett HE, Harper D, Hutchison JG, Farrell ID, et al. The Stafford outbreak of Legionnaires' disease. *Epidemiol Infect* 1990;104:361-80.
8. Bell JC, Jorm LR, Williamson M, Shaw NH, Kazandjian DL, Chiew R, et al. Legionellosis linked with a hotel car park-how many were infected? *Epidemiol Infect* 1996; 116: 185-92.
9. Watson JM, Mitchell E, Gabbay J, Maguire H, Boyle M, Bruce J, et al. Piccadilly Circus Legionnaires' disease outbreak. *J Public Health Med* 1994;16:341-7.
10. Breiman RF, Cozen W, Fields BS, Mastro TD, Carr SJ, Spika JS, et al. Role of air sampling in investigation of an outbreak of Legionnaires' disease associated with exposure to aerosols from an evaporative condenser. *J Infect Dis* 1990;161:1257-61.
11. Colville A, Crowley J, Dearden D, Slack RC, Lee JV. Outbreak of Legionnaires' disease at University Hospital, Nottingham. Epidemiology, microbiology and control. *Epidemiol Infect* 1993;110:105-16.
12. Farrell LD, Barker JE, Miles EP, Hutchinson J. A field study of the survival of *Legionella pneumophila* in a hospital hot-water system. *Epidemiol Infect* 1990;104:381-7.
13. Redd SC, Lin-FY, Fields BS, Biscoe J, Plikaytis BB, Powers P, et al. A rural outbreak of Legionnaires' disease linked to visiting a retail store. *Am J Public Health* 1990;80:431-4.
14. Levy M, Wesley-Wise V, Frommer M, Lyle D, Blummer C, Rubin G, et al. Report on Legionnaires' disease in South Western Sydney, April 1992. North Sydney: NSW Health Department; 1992.
15. Jalaludin B, Goldthorpe I, Chow C, Liddle J, Shaw N, Capon A. Legionnaires' disease outbreak in Western Sydney. *Comm Dis Intell* 1995;19:114-115.
16. NSW Health Department. Infectious Diseases Manual. Sydney. NSW Health. 1995.
17. NSW Health Department. Legionnaires' disease emergency management plan. Sydney: NSW Health; 1992.
18. Bansal N and McDonell F. Identification and DNA fingerprinting of *Legionella* strains by Randomly Amplified Polymorphic DNA Analysis. J. Clin. Microbiol. 1997;35:2310-2314.
19. Lanser J., Adam M, Doyle R, Hewitt P and Sangster N. Genetic characterisation of *Legionella pneumophila* serogroup 1 associated with respiratory disease in Australia. *Appl Environ Microbiol* 1992;58:706-708.
20. NSW Health Department. New South Wales code of practice for the control of Legionnaires' disease. State Health Publication No SWRO91-08. Sydney: NSW Health. 1991.
21. Lloyd G. Legionella and institutionalised recreation: A survey of cooling towers in NSW Registered Clubs. Sydney: NSW Health. 1998.
22. Broadbent C, Bubb C. Measures to control Legionnaires' Disease hazards in buildings. First Issue. Canberra: Central Office Department of Housing and Construction, Technical Information Mechanical Branch; 1987 April. Report number TI 178 ME. Central Office File Number D86/1418.
23. Bentham, RH. Routine sampling and the control of Legionella spp. in cooling tower water systems. *Current Microbiology* 2000;41: 271-275