Epidem. Inf. (1989), **103**, 285–292
Printed in Great Britain

Legionnaires' disease and the sick-building syndrome

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(*Accepted 30 April 1989*)

SUMMARY

In October 1985, six cases of legionnaires' disease were associated with a police headquarters building. Four were amongst staff who worked in or visited the communications wing of the headquarters and two cases occurred in the local community. A case-control study implicated the operations room of the communications wing as the main area associated with infection. This wing was air-conditioned and smoke tracer studies showed that drift from the exhaust as well as from the base of the cooling tower entered the main air-intake which serviced the air-conditioning system. *Legionella pneumophila* serogroup 1 subgroup pontiac was isolated from water and sludge in the cooling tower pond. Contaminated drift from the top of the cooling tower was probably responsible for the two community cases. An additional discovery was that symptoms suggestive of the sick-building syndrome were associated with working in this wing.

INTRODUCTION

Air-conditioned buildings have been associated with outbreaks of legionnaires' disease and the sick-building syndrome. Twenty-two outbreaks of legionnaires' disease were reported in the United Kingdom between 1979 and 1985 of which five were associated with cooling towers of air-conditioning systems in hotels, hospitals and office buildings. During the same period, interest increased in the sick-building syndrome and humidifier fever, both of which have also been linked on occasions to air-conditioned buildings. The former is generally considered to describe staff working in the same building whose complaints of ill health are more common than might reasonably be expected (1). The complaints include nasal and eye symptoms, drying of the mucous membranes and symptoms of work-related asthma. In contrast, humidifier fever is suggested by fever, joint and muscle pains, dry skin and headache. In both conditions, symptoms improve over weekends and holidays. We report an outbreak of legionnaires' disease associated with a building in which symptoms of the sick-building syndrome were present in the workforce.

BACKGROUND

In October 1985, a case of legionnaires' disease was reported in a 41-year-old man who was employed by a county police force. He became ill on 13 September and had been admitted to hospital where the diagnosis was established when an immunofluorescent antibody blood test (IFAT) revealed a titre of 256 against *Legionella pneumophila* serogroup 1. The patient worked in the operations room of the communications wing of the police headquarters where 40 staff were employed. This department was situated in the only air-conditioned wing of the headquarters building. A second case of legionnaires' disease was discovered by the occupational health physician during a preliminary survey of 10 staff who worked in this wing and who were unwell in September. The occurrence of two cases of legionellosis in one building made it imperative to discover the cause of the outbreak. Control measures were instituted on 19 October.

METHODS

Pilot interviews of staff suggested that a history of influenza-like illnesses were more common in those who worked in the communications wing than in other areas of the building. Moreover, there was a history of minor complaints, mainly of eye strain and headaches associated with the staff who worked in this wing.

A case search was carried out to identify cases of legionnaires' disease amongst the 273 permanent staff who worked in the building. The occupational health department reviewed employees who had been unwell and those who had been admitted to hospital since June 1985. Additional cases were sought in the local community with the help of general practitioners and among patients admitted with pneumonia to local hospitals. The case definition was based on a history of chest infection or pneumonia supported by a fourfold rise in immunofluorescent antibody test (IFAT) titre to 64 or more, against *L. pneumophila* serogroup 1 or a single reproducible titre of 64(2).

A case-control study was conducted to test the hypotheses that the communications wing was associated with legionella infection and symptoms suggestive of the sick building syndrome or humidifier fever. All staff who worked in the communications wing were requested to complete a questionnaire. A total of 79 controls were randomly selected amongst staff who worked in each room throughout the rest of the building. Information was sought on respiratory or influenza-like illnesses and on 12 different symptoms since 1 May 1985, on visiting or working in different areas of the building as well as the use of drinking water facilities, showers and toilet areas. In addition, information was also sought on symptoms suggestive of the sick-building syndrome or humidifier fever from October 1984. All members of staff were invited to partake in a serological survey and serum samples were tested for legionella antibodies against antigens prepared from *L. pneumophila* serogroup 1 using the immunofluorescent antibody test polyvalent immunoglobulin conjugate (2).

Microbiological investigations were initiated when the air-conditioning system came under suspicion following detection of the second case. Water and sludge samples were collected from the cooling tower pond and water samples from each

of two calorifiers and also from taps and showers throughout the building. Samples were cultured for legionellae at Public Health Laboratory Service (PHLS) Lincoln and Birmingham laboratories on legionella blood agar (3) or on a modification of Edelstein's medium (4). Isolates were identified and any *L. pneumophila* serogroup 1 were typed with monoclonal antisera (5) at the PHLS Centre for Applied Microbiology and Research, Porton Down. Washers and shower heads were removed, and examined by Thames Water.

An engineering survey of the air-conditioning system was undertaken a few days later, following which smoke tests were carried out to determine if drift from the base of the cooling tower and exhaust from the top of the tower could enter the air-intake.

RESULTS

The outbreak

Six cases of legionnaires' disease, five men and one woman, were identified. Four patients were admitted to hospital. The age range was between 36 and 75 years, mean 53 years. Four cases were amongst staff who worked in the police headquarters and two were local residents. One patient, who worked at the headquarters suffered from chronic lymphatic leukaemia. All became ill between 13 and 26 September 1985. Of the four cases who worked in the building, three were based in the operations room of the communications wing and one visited the communications area several times during a training course in September. The attack rate for permanent and training staff working in the whole building in September was 4 of 274 and for the communications wing was 3 of 40. Of the two community cases, one lady regularly walked her dog in the grounds of the headquarters and the second patient lived approximately one quarter of a mile from the building.

Serological results were available for 25 other members of the communications wing staff. Two had high IFAT titres, of 128 and 256 respectively: one of these reported only minor illness in September, not resulting in absence from work, while the other could recall only a heavy cold in July. Two others had titres of 16: each had been absent for 3 days in late September with upper respiratory tract symptoms. Of 96 staff who worked elsewhere in the building and who were tested serologically four had titres of 16 and 32: they were not known to have been ill.

Case-control study

Completed questionnaires were returned by 30 of the 40 permanent staff who worked in the communications wing and by 68 of the 79 controls. Three staff who worked in the communications wing and who returned questionnaires had an IFAT of 128 or greater and had a history of pneumonia.

Influenza-like illnesses and/or chest infections were more common in staff who worked in the communications wing compared with those who worked in the remainder of the building (Table 1). Staff were also more likely to have taken time off work (Table 2). Within the wing, no association was seen between illness or seropositivity and the use of toilet or drinking water facilities. There was no association in the remaining staff who had worked outside the communications

Table 1. *Reported illnesses in staff who worked in the communications wing and in other areas of the police headquarters*

	Communications wing	Other areas	Total
Ill	20	26	46
Not ill	10	42	52
Total	30	68	98

Yate's continuity corrected χ^2, $P = 0{\cdot}017$.

Table 2. *Absence from work through illness and place of work*

	Communications wing	Other areas	Total
No time off work	8	19	27
Time off work	11	5	16
Total	19	24	43

Yate's continuity corrected χ^2, $P = 0{\cdot}029\,31$.
Those who did not answer a specific question were excluded from analyses.

Table 3. *Reported symptoms in staff who worked in the communications wing and in other areas of the building*

	Communications wing		Other areas		
Symptom	Yes	No	Yes	No	χ^2 test P value
Dizziness	4	26	6	62	NS
Headache	17	13	31	37	NS
Eye strain	13	17	5	63	0·000 08
Eye itchiness	8	22	11	57	NS
Tiredness	13	17	16	52	NS
Skin rash	1	29	2	66	NS
Stomach upset	4	26	6	62	NS
Diarrhoea	6	24	11	57	NS
Muscle ache	12	18	13	55	NS
Joint pain	4	26	8	60	NS
Weight loss	2	28	2	66	NS
Nasal symptoms	13	17	20	48	NS
'Flu-like symptoms	16	14	21	47	NS
Fever	5	25	8	60	NS
Sore throat	14	16	16	52	0·040 10
Chest pain	7	23	5	63	NS
Wheezing	3	27	3	65	NS
Shortness of breath	4	26	4	64	NS
Dry cough	14	16	7	61	0·000 16
Phlegm	9	21	9	59	NS

NS, not significant.
Those who did not answer a specific question were excluded from analyses.

https://doi.org/10.1017/S0950268800030648 Published online by Cambridge University Press

Table 4. *Timing of symptoms associated with working in the communications wing*

Symptom	Yes	No
Dry cough		
Worse weekdays	10	4
Worse days off	3	11
Worse holidays	1	13
Eye strain		
Worse weekdays	12	1
Worse days off	0	13
Worse holidays	0	13
Sore throat		
Worse weekdays	13	1
Worse days off	3	11
Worse holidays	0	14

wing and who had an IFAT titre of 16 or greater with reported illnesses, individual symptoms, smoking or different areas in the building. In addition, no association was seen between illness or seropositivity and the use of toilet or drinking water facilities. Of the four seropositive staff who worked in the naturally ventilated departments, three had not visited the communications wing.

Dry cough and eye strain were strongly associated with working in the communications wing (Table 3). Although eye strain was more common several hours into a shift, of the 14 who reported dry cough, five reported it worse immediately on starting work. Sore throat was associated with working in the same wing and in over a third it was noted immediately on commencing work. Within the communications wing, eye strain was reported throughout October 1984 to September 1985. In contrast, sore throat was most apparent from January to March only. All symptoms improved significantly during weekends and during the holiday periods (Table 4). There was no association between seropositivity and any of the symptoms of the sick-building syndrome or humidifier fever.

Environmental results

The building

The police headquarters was built in 1980. It is a three-storey building constructed around a central courtyard. There are five separate wings leading from the main administrative building and these house the following departments: communications, recreation, residential, gymnasium and training school. Each wing is insulated with rockwool.

The communications wing is on three floors. The basement houses the computing department, the telephone room and plant room. On the ground floor, staff worked in the operations room, teleprinter room, criminal records office and the criminal investigations department. Overlooking the operations room is a galleried area which has a mess, toilet facilities, major-incident room and locker room.

Ventilation and water distribution systems

The communications wing was artificially ventilated. Although plans had been drawn to have a combination of natural and artificial ventilation for the remainder of the building, air-conditioning had not been installed due to high costs and most of the building was ventilated through small top windows.

The cooling tower for the recirculating air-conditioning system was housed underneath the radiomast and its pond had been chemically treated with alkyl dimethyl benzyl ammonium chloride and a mixture of isothiazolones, since 1981. In June 1984, the water-treatment company added a specific chemical, a chlorinated phenolic thio-ether to control the growth of legionella. There was no specific cleaning programme for the cooling tower and the pond had been last drained, cleaned and refilled in 1983. The air-intake was beside the base of the cooling tower and was several feet away from the louvered doors through which air entered the building. Air was then humidified by steam and 2·5% was recirculated. It was observed that drift from the cooling tower exhaust could enter the air-intake through the louvered doors. It was also noted and later confirmed by a smoke test that condensate escaped through the base of the tower and entered the air-intake when the fan extract of the tower was not in operation.

Cold water was distributed throughout the building from two large water-storage tanks in the roof. The hot water from two calorifiers was distributed at 45 °C.

Microbiological results

Microbiological growth was monitored by the water-treatment company, which tested the total bacterial counts each month. An annual programme to detect legionella had been agreed in 1984 and the first test, in May 1985, revealed no growth. During the outbreak however, *L. pneumophila* serogroup 1 subgroup pontiac was isolated from water taken on 18 October from the cooling tower and also from sludge taken on 19 October from the pond. Legionellae were not isolated from any other samples.

Control measures

As an emergency measure the cooling tower was drained and disinfected on 19 October. Following the identification of *L. pneumophila* in water samples collected from the cooling tower pond on the same day, further measures were carried out. The cooling tower pond was drained, cleaned and superchlorinated to a minimum of 50 ppm for 4 h. It was then drained again, refilled and continuously chlorinated to 5 ppm free residual chlorine. The water-storage tanks were chlorinated, cleaned and water chlorinated to 2 ppm free residual chlorine at the taps. The hot water for distribution was heated to 65 °C in the calorifiers. The air-inlet to the building was resited outside the building and some distance away from the cooling tower exhaust. Subsequently, the cooling tower for the air-conditioning system was replaced with an air-cooled system.

DISCUSSION

This outbreak of legionnaires' disease was associated with working in the communications wing of the police headquarters. Within this wing, the attack rate was higher than in most recorded outbreaks in the United Kingdom (6–8). Moreover, the age of those affected was relatively young and only one patient was immunocompromised.

The ventilation system in the communications wing was implicated as the route of infection since there was no association between illness and the water distribution system. The system was implicated further when *L. pneumophila* serogroup 1 subgroup pontiac was cultured from the water and sludge of the cooling tower pond. Smoke tracer studies demonstrated that condensate from the base of the tower as well as exhaust could enter the air-intake and circulate throughout the communications wing. Thus the engineering investigation highlighted faults in the design of the ventilation system. Maintenance of the cooling tower was probably inadequate since it had not been drained for 2 years.

Although three of the four cases of legionnaires' disease within the building occurred in those who worked regularly in the air conditioned communications wing, it is likely that the two community cases were infected by exhaust drift from the cooling tower. No further cases of legionnaires' disease were reported amongst staff at the police heaquarters following the implementation of control measures.

An unusual feature of the outbreak was the associated finding of a number of symptoms attributed to the sick-building syndrome (1). The principal features were eye strain as well as dryness and irritation of mucous membranes including a dry cough. There were no major symptoms of humidifier fever associated with the communications wing. All symptoms were much reduced during days off or during holiday time. Although seropositivity to *L. pneumophila* may be associated with a dry cough there was no evidence that these two symptoms were linked to this outbreak of legionnaires' disease.

The cause of the sick-building syndrome has not been established but cavity wall insulation, office furniture, cigarette smoke, bacteria from humidifiers and lack of fresh air have all been considered (1). The syndrome is more common in air-conditioned buildings than in those that are naturally ventilated. In the police headquarters, the symptoms of the sick-building syndrome could not be attributed to either urea formaldehyde, or office furniture as this was standard throughout the building. Moreover, the building had been opened for 5 years and complaints could not be attributed to recent change in working conditions. It is therefore possible that microorganisms could be one of the causes of the symptoms of the sick-building syndrome because, as in this building, an inadequately maintained cooling tower and air-conditioning system would encourage their growth.

This is the second outbreak of legionnaires' disease in the UK which has been associated with symptoms suggestive of the sick-building syndrome. In the previous outbreak, a cooling tower was the source of the infective aerosol of legionella and although a positive association was observed between sore eyes and sitting near an air vent (Dr R. Stanwell-Smith, personal communication), it was not possible to carry out a study as described above.

This outbreak of legionnaires' disease has emphasized not only the continuing

dangers of uniquely designed and inadequately maintained cooling towers in the transmission of legionella but also the added risk of the sick-building syndrome.

ACKNOWLEDGEMENTS

We wish to thank Dr J. Colbourne, Dr P. J. L. Dennis, Dr I. D. Farrell, Dr J. G. P. Hutchison and Dr T. J. Rowbotham, for their microbiological help and advice; Dr N. D. Parkin for informing us of the index case; Dr T. M. Pole for the preliminary case-finding survey; the Chief Constable and staff of the Police Headquarters building, and the Director of Property Services, Lincolnshire County Council, and his staff for their help and co-operation; others who assisted during the investigation, including the staff of Lincoln Public Health Laboratory and Miss D. Lynch, Communicable Disease Surveillance Centre, Colindale.

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