Epidemiol. Infect. (1994), **112**, 329–345

Nosocomial Legionnaires' disease in England and Wales, 1980–92

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(*Accepted 12 November 1993*)

SUMMARY

Two hundred and eighteen nosocomial cases of Legionnaires' disease with 68 deaths were reported to the National Surveillance Scheme for Legionnaires Disease between 1980 and 1992, representing 15% of the reported infections acquired in England and Wales. Twenty-two nosocomial outbreaks accounted for 135 (62%) of these cases, the remainder occurring as single cases either in hospitals where other single cases or outbreaks had been reported in different years or as 'sporadic' cases in hospitals from which no other cases were reported. A clinical history prior to onset of Legionnaires' disease was available for 124 patients, 61 of whom had undergone recent transplant therapy or were immunosuppressed for other reasons.

Sixty cases (27%) were diagnosed by culture of the organism and isolates from 56 patients were typed: 25 (42%) were non *L. pneumophila* serogroup 1 infections.

Methods for prevention and control of nosocomial outbreaks are discussed, in particular the susceptibility to Legionnaires' disease of certain groups of hospital patients.

INTRODUCTION

Legionella infection has been widely reported since its recognition in 1977 as a cause of both epidemic and sporadically acquired pneumonia. The earliest recognized community outbreak, diagnosed retrospectively, occurred in 1957 [1] and the earliest hospital acquired (nosocomial) outbreak in 1965 [2]. Legionella infection has been reported to cause between 0 and 47% of hospital acquired pneumonia, the proportion varying by type of hospital unit [3]. In the light of significant morbidity and mortality due to this infection, particularly in immunosuppressed patients, a review of hospital acquired cases in England and Wales was undertaken to determine the size of the problem, types of patients and hospitals involved and the lessons for prevention and control.

METHODS

The National Surveillance Scheme for Legionnaires Disease at the Communicable Disease Surveillance Centre (CDSC) of the Public Health Laboratory Service (PHLS) was established in 1977. Fifty-three Public Health Laboratories

and approximately 350 other hospital microbiological laboratories voluntarily report, on a weekly basis to CDSC, any case of legionella infection they have identified. CDSC also receives telephone and written reports of suspected cases from physicians, public health doctors, occupational health physicians and others. Laboratories are also requested to send strains to the PHLS Legionella Reference Unit, at the Central Public Health Laboratory, Colindale, London for further identification. For surveillance purposes CDSC set the following criteria for accepting a report as either a confirmed or presumptive case of Legionnaires' disease: a diagnosis of pneumonia *and* microbiological demonstration of recent legionella infection fulfilling one or more of the following criteria: (i) isolation of *Legionella* species from a clinical specimen; (ii) serological testing by indirect immunofluorescent antibody test (IFAT) with a formalized yolk sac antigen giving a fourfold rise in antibody titre to 64 or more, or a single high titre of 128 or more, (or > 64 if part of an outbreak), or by rapid microagglutination test (RMAT) giving a fourfold rise to 16 or more, or a single titre of 32 or more; (iii) positive direct fluorescence (DFA) on a clinical specimen using validated monoclonal antibodies [4]; (iv) urine ELISA using validated reagents [5].

Since 1979, on receipt of each report at CDSC, a questionnaire has been sent to the reporting doctor, requesting clinical and epidemiological data including occupation, details of any travel in the United Kingdom (UK) or abroad, and hospital visits or admissions before onset of infection. Information about each case meeting the surveillance definition is entered onto a microcomputer database. The database is examined for the occurrence of clusters of cases in time and place, and premises with which cases have been associated in previous years. Further information is requested on clusters or outbreaks, although this information is often limited as a result of the small number of cases involved, particularly in the early years of the review.

Case definitions and case groupings for nosocomial Legionnaires' disease

Cases were defined according to the degree of epidemiological and microbiological information which linked them to a source of infection in a hospital.

Case definitions

Definitely nosocomial

Patients who spent all of the 10 days in hospital before onset of symptoms of legionellosis.

Probably nosocomial

Patients who spent between 1 and 9 of the 10 days in hospital prior to onset of symptoms and: either (*a*) became ill in a hospital associated with one or more cases of Legionnaires' disease; or (*b*) yielded an isolate that was indistinguishable by monoclonal antibody (mAb) subgrouping, using the international mAb panel [6] or restriction fragment length polymorphism (RFLP) subtyping [7], from isolates obtained from the hospital water system at about the same time.

Possibly nosocomial

Patients who spent between 1 and 9 of the 10 days in hospital prior to onset of symptoms, in a hospital not known to be associated with any other cases of Legionnaires' disease.

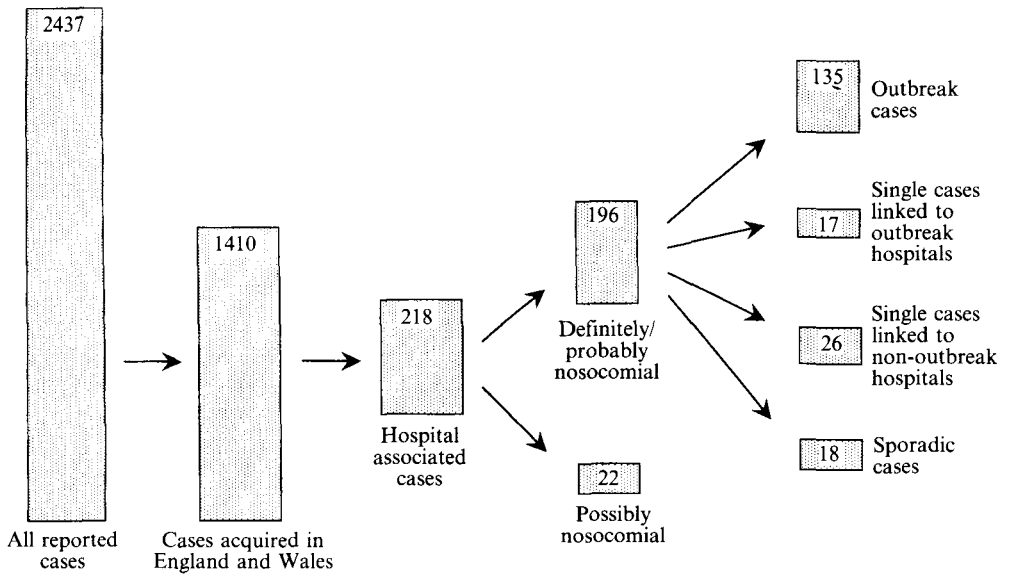

Fig. 1. Legionnaires' disease, England and Wales, 1980–92.

Case groupings

Outbreaks

Two or more cases occurring within 6 months of each other.

Linked cases

Single cases occurring in a hospital associated with one or more other cases more than 6 months before or after the single case.

Sporadic cases

Single cases occurring at hospitals where no other cases have been reported. (This group includes sporadic cases reported in hospital employees.)

RESULTS

Between 1980 and 1992, 2347 cases of Legionnaires' disease in English and Welsh residents were reported, of whom 1410 (60%) acquired their infection in the UK; 218 of these (15%) were associated with hospitals, with 196 classified as definitely or probably nosocomial and 22 as possibly nosocomial (Fig. 1). Altogether, 68 hospitals in England and Wales were associated with cases of nosocomial legionella infection; 135 cases were associated with outbreaks at 17 different hospitals, with a further 17 single cases linked to 10 of these outbreak hospitals. Twenty-six cases were linked to 12 other hospitals not associated with outbreaks, and 18 cases occurred sporadically. A further 22 sporadic cases were possibly nosocomial, 10 of the patients were known to be working in a hospital before the onset of their illness.

Cases were reported from most regions within England and Wales. One hundred and thirty-two cases (60%) were male and 86 (40%) female. Their ages ranged from 1 to 92 years (Fig. 2). Sixty-eight (31%) of the patients died.

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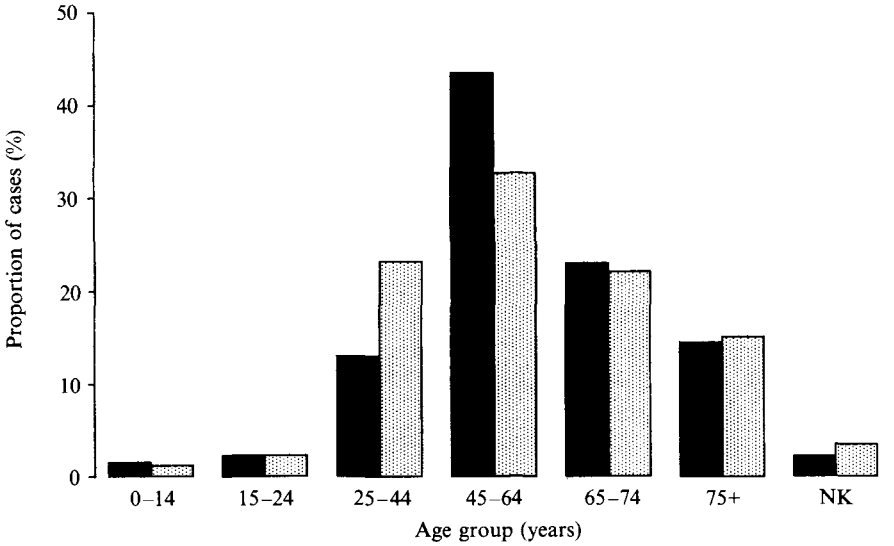

Fig. 2. Nosocomial Legionnaires' disease, England and Wales, 1980–92. ■, Males ($N = 132$); ▨, females ($N = 86$).

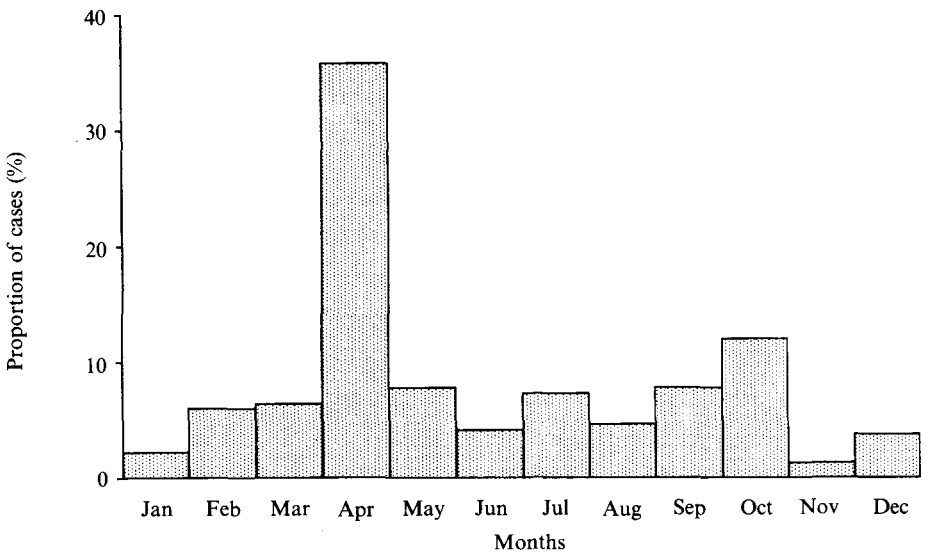

Fig. 3. Nosocomial Legionnaires' disease. Seasonal distribution, England and Wales, 1980–92. $N = 218$.

There was no clear seasonal peak of infection although the majority of cases occurred between March and October. An outbreak at Stafford District General Hospital in 1985 was responsible for 68 of the cases with an onset in April (Fig. 3).

Methods of diagnosis

Two hundred and eight of the nosocomial cases were due to infection with *Legionella pneumophila*, and 10 with *L. bozemanii*. In 60 cases the diagnosis was

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Table 1. *Nosocomial Legionnaires' disease, England and Wales 1980–92. Species, serogroups and subgroups of nosocomial cases diagnosed by culture of the organism (N = 60)*

Species	Serogroup	Number	Subgroup*
L. pneumophila	1	34	Knoxville (9), Philadelphia (9), Olda (1), Bellingham (1), Benidorm (5), Oxford (3), Heysham (1), Pontiac 2a† (2)
	3	1	
	4	2	
	5	3	
	6	3	
	8	2	
	10	3	
	12	1	
	Unkn	1	
L. bozemanii	1	10	

† Rebeiro and colleagues, 1987 [35].
* Joly and colleagues, 1986 [6].
† Rebeiro and colleagues, 1987 [35].

Table 2a. *Nosocomial Legionnaires' disease, England and Wales 1980–92. Cases and deaths by reported underlying conditions*

Clinical conditions	Cases	Deaths
Transplant patients	30	13
Other immunosuppressed	31	12
Other medical/surgical	63	18
Out-patients (Stafford Hospital)	68	22
None (hospital employees)	10	1
Not known	16	2
Total	218	68

Table 2b. *Nosocomial Legionnaires' disease, England and Wales 1980–92. Cases and deaths amongst immunosuppressed group*

Immunosuppressed group	Cases	Deaths
Organ transplants		
Renal	18	5
Cardiac	10	7
Liver	2	1
Other immunosuppression		
Leukaemia	7	4
Lymphoma	5	3
Carcinoma	3	—
Renal disease	4	2
Diabetes	3	—
Other	9	3
Total	61	25

confirmed by culture of the organism, and in 107 by seroconversion. The diagnosis was made presumptively in 48 cases by single high antibody titre, in 2 cases by monoclonal DFA from post mortem lung specimens, and in 1 by urine ELISA.

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Table 3a. *Nosocomial outbreaks and cases linked to outbreak hospitals 1980–92*

RHA of hospital outbreak	Year	No. of cases	No. of deaths	No. of cases immunosuppressed	Suspected source of infection
1 SW Thames	1980	8	3	—	HWS
	1981	1	—	—	
2 W Midlands	1980	4	1	—	HWS
3 Wales	1980	2	2	—	HWS
4 Wessex	1981	2	1	2	Not known
5 Wales	1983	4	1	4	HWS
	1989	1	—	—	
6 S Western	1985	2	1	2	HWS
	1988	1	—	—	
7 NW Thames	1985	2	—	—	HWS
8 W Midlands	1985	2	—	—	Not known
9 W Midlands	1985	68	22	—	Cooling tower
10 Mersey	1986/7	3	1	3	HWS
	1991	1	—	1	
	1991	1	—	1	
11 N Western	1987	2	1	2	HWS
12 Northern	1987	1	—	1	
	1987	3	1	2	HWS
	1989	1	1	1	
13 NW Thames	1987	2	—	2	HWS
	1987	1	—	—	
14 W Midlands	1988	2	—	—	HWS
15 Trent	1983	1	—	—	
	1988/9	13	2	—	HWS
	1990	1	—	—	
16 Yorkshire	1985	1	—	—	
	1988	3	—	—	HWS
	1989	1	—	1	
17 W Midlands	1982	1	1	1	
	1989	2	1	2	CWS
18 W Midlands	1990	2	1	2	CWS
19 Mersey	1985	1	—	1	
	1987	1	—	—	
	1991	1	—	—	
	1991	2	1	1	HWS
20 Northern	1991	1	1	1	
	1991	3	3	2	HWS
21 Northern	1992	2	1	2	HWS
22 W Midlands	1992	2	2	1	HWS
Total		152	48	35	

Among the cases from which an isolate was obtained, 10 were due to *L. bozemanii* serogroup 1 (Sg1) infection. The remainder were due to *L.pneumophila*, 34 cases of which were reported as serogroup 1, while 7 other serogroups accounted for 15 cases and in 1 case the serogroup was not reported. Monoclonal antibody subgrouping results were available for 31 of the *L. pneumophila* serogroup 1 infections (Table 1) and RFLP subtyping results were available from isolates of 27 of the cases.

Clinical histories

Information on past medical history or current underlying conditions was

https://doi.org/10.1017/S0950268800057745 Published online by Cambridge University Press

available for 124 (57%) of the nosocomial cases: 30 patients had undergone recent transplant therapy and 31 had a range of other immunosuppressive conditions; 63 patients were in hospital for other medical or surgical treatment. Ten of the remaining 94 cases were working in hospitals at the time of their illness and had no reported medical histories; 68 patients, associated with the Stafford Hospital outbreak, were mostly outpatients who acquired their infection while visiting the hospital, and no information was available for 16 cases (Tables 2a, 2b).

The outbreaks and cases linked to outbreak hospitals

Twenty-two outbreaks were identified, ranging in size from 2 to 68 cases (Table 3a). They involved 135 cases, with a further 17 cases linked to 10 of the hospitals at which outbreaks had occurred. Deaths were reported for 45 (33%) of the outbreak cases and 3 cases linked to outbreak hospitals. Three hospitals reported more than one outbreak. One in South Wales reported outbreaks in 1980 and 1983, a hospital in the West Midlands had outbreaks in 1980, 1988 and 1990, and another in the North East of England in 1987, 1991 and 1992.

Suspected sources of infection

Hospital water systems were believed to be the source of infection in 19 outbreaks and cooling towers (wet cooling systems) alone were believed to be responsible in 1 hospital and may have contributed to 2 other outbreaks in which the water system was believed to be the main source.

Outbreaks involving immunosuppressed patients

Thirteen of the outbreaks included transplant or other immunosuppressed patients. Three outbreaks plus 3 linked cases were associated with 1 hospital in the Northern Region where a total of 11 patients from the Cardiothoracic Centre (CTC) developed Legionnaires' disease, 7 of whom died. Nine of the 11 cases were due to *L. bozemanii* infection, all culture proven, and 2 were due to *L. pneumophila* Sg 1 (mAb subgroup 'Oxford', RFLP type 27). In the first *L. bozemanii* outbreak, 3 cases in 1987 were associated with the CTC, 2 of whom had undergone cardiac transplantation. One of the patients died [8]. A single case occurred in 1989 in a transplant patient who died and in 1991 there was a second outbreak in which all three patients died. One of the patients had had a cardiac transplant, the second was receiving treatment for a thoracic tumour and the third for thoracic lymphoma. The latter two patients were nursed on a high dependency unit separate from the transplant ward and had been on ventilators with humidifiers. A review of procedures found that bottles used to supply water to the humidifiers had been rinsed with tap water after sterilization. The third outbreak occurred in 1992 with two cases in cardiac transplant patients, one of whom died. *Legionella bozemanii* Sg1 was isolated from the nine patients, and also from samples of water taken periodically from outlets within the hospital building. The remaining two cases, one of whom died, occurred in transplant patients in 1987 and 1991, and were due to *L. pneumophila* Sg1 infection. Indistinguishable isolates were obtained from both patients and the hospital water system.

At a hospital in Wales, four patients, one of whom died, were affected in the second outbreak associated with the hospital which occurred in September and

October 1983. The patients were in different wards and all immunosuppressed, and their illnesses included Graves disease, systemic lupus erythematosus, diabetes and rheumatoid arthritis. Eight weeks before the outbreak the temperature of the hot water throughout the hospital had been reduced by about 10 °C to between 45 °C and 53 °C in order to lower the working temperature in the operating theatres during hot weather. A water sample from a shower unit yielded *L. pneumophila* Sg1 of a strain reported to be indistinguishable by mAb subgrouping from isolates from two cases in the outbreak, but different from those associated with the earlier outbreak at the hospital in 1980 [9].

In 1985, two female patients contracted Legionnaires' disease whilst undergoing treatment in a South Western Region hospital renal transplant unit. One patient died. The source of infection was identified as the shower used by the patients in the unit. *Legionella pneumophila* Sg1 was isolated from water samples from the shower fitting and was indistinguishable by mAb subgrouping from strains isolated from one of the patients. Three years later a doctor working in the unit was also diagnosed as having Legionnaires' disease, but no clinical isolate was obtained to compare with those in the earlier outbreak.

An outbreak involving three cases and one death in 1986/87 plus two linked cases in 1991, was associated with a hospital renal unit in the Mersey Region. Three of the patients had had renal transplants and the other two were undergoing treatment for leukaemia and lymphoid granuloma. Isolates from three of the patients were identified as *L. pneumophila* Sg6, RFLP type 26 and from one other as *L. pneumophila* Sg12, RFLP type 26, the first reported clinical case of this serogroup in the UK [10]. Isolates obtained from samples of the unit's water supply, which is regularly tested, were also identified in 1987 as *L. pneumophila* Sgs 6 and 12, RFLP type 26. Extensive studies suggest that all these isolates are genotypically homogeneous and represent a single strain despite the phenotypic differences indicated by the serogrouping results [11].

Seven small outbreaks were associated with 14 cases of Legionnaires' disease and 5 further cases were linked to 3 of the outbreak hospitals. A total of eight patients died in these outbreaks. Epidemiological and microbiological investigations confirmed the water supply as the source of infection in four of the outbreaks, two of which were due to cold water systems. Three of these four outbreaks were in the West Midlands Region, one in 1989 in a transplant unit, one in a renal unit in 1990 at a hospital that also had outbreaks in 1980 and 1988, and the other in 1992 involving one immunosuppressed patient who had renal disease and one surgical patient. The fourth outbreak was in the renal unit of a hospital in North West Thames Region. In two other outbreaks, isolates were obtained from water samples but not from the patients at the time of infection, and in the remaining outbreak, no information as to the source of infection was available.

The remaining outbreaks

Nine outbreaks involved 109 cases. Three large outbreaks, one in 1980, 1985 and 1989 accounted for 79% of these cases.

In the first large outbreak which occurred at Kingston Hospital in South West Thames Region, 11 cases were recognized (6 retrospectively) between December 1979 and July 1980. Two of the cases were hospital employees and one a visitor

to the hospital. Eight of the cases were formally reported to CDSC and are included in this review. There were three deaths. The in-patients had all been resident in a new building in the hospital complex during the incubation period. The source of infection was initially thought to be the air conditioning cooling tower exhaust which was cleansed and chlorinated, but cases only ceased to occur after the water supply to the building was chlorinated and the hot water temperature raised to between 55 and 60 °C. *Legionella pneumophila* Sg1 was isolated from one patient, from cooling tower water samples and also from the water system in the hospital [12]. The initial control measures appeared to be successful but a linked case was diagnosed in a patient 1 year later, following the 24 h use of a reserve calorifier in the block where the patient took a bath and shower. Subsequent cleaning of the calorifier and heating to 70 °C for 1 h prevented further cases occurring [13].

In 1985, 68 cases of Legionnaires' disease, with 22 deaths, were associated with Stafford District General Hospital in the West Midlands Region [14]. Onset of infection was between 7 and 27 April for all the cases. Two had been admitted to the hospital before the outbreak and the rest had visited the hospital site within 10 days of the onset of symptoms. A single visit was made by 58 of the cases, 57 of whom visited the out-patient department. Eleven had accompanied relatives or friends to the out-patient department and four had been visitors to wards. Thirty-two of the people who contracted Legionnaires' disease had underlying chronic disease. The source of the outbreak was identified as the wet cooling system which was producing a contaminated aerosol in the air conditioning system, *L.pneumophila* Sg1, subgroup Pontiac 1a was isolated from 11 post-mortem lung specimens [14]. Subsequently, the clinical isolates and isolates from the insulation material of the chiller battery in the ventilation unit serving the out-patient department were shown to be indistinguishable by mAb subgrouping and RFLP subtyping ('Knoxville', RFLP type 25) (T. G. Harrison, unpublished).

In the third large outbreak, which occurred at the University Hospital in Nottingham in Trent Region, 12 cases of Legionnaires' disease were identified over a 9-month period in 1988/9 and were associated with ten different wards in the south block of the hospital [15]. Three patients were long stay in-patients and another was a frequent visitor to one of these patients. The others included patients with cardiac disease, 2 of whom died, and 2 admitted for eye surgery. A thirteenth case, 4 months after the outbreak was believed to have ceased, involved a member of staff, and 1 year later a linked case was diagnosed in a patient on a ward which had been affected in the outbreak. Epidemiological and microbiological investigations confirmed that the source of infection was the hospital water supply. *Legionella pneumophila* Sg1, subgroup 'Benidorm' RFLP type 14 was isolated from one patient and from numerous water outlets in the south block of the hospital [15].

Six of the nine 'remaining' outbreaks were small. Two occurred in 1980, 2 in 1985 and 2 in 1988; a total of 15 cases, 2 further cases linked to one of the outbreaks and 3 deaths. The hospital water system was identified as the source of infection in one outbreak in 1980, in the West Midlands Region, where 4 cases and 1 death occurred in a mixed group of hospital patients. In the other 1980 outbreak, in Wales, two surgical patients on different wards who both died, were either

Table 3b. *Nosocomial Legionnaires' disease, England and Wales 1980–92. Other linked cases not associated with recognized outbreaks*

RHA of hospital	Year	No. of cases	No. of deaths	No. of cases immunosuppressed
1 NW Thames	1980	1	—	1
	1986	1	—	—
	1987	1	—	—
2 W Midlands	1980	1	1	—
	1981	1	1	—
3 NW Thames	1980	1	—	1
	1992	1	1	1
4 Mersey	1981	1	1	1
	1983	1	1	—
	1991	1	1	—
5 SW Thames	1981	1	1	—
	1985	1	—	—
6 Yorkshire	1982	1	1	1
	1983	1	—	1
7 Yorkshire	1983	1	—	—
	1990	1	1	1
8 SW Thames	1985	1	—	1
	1990	1	—	—
9 Yorkshire	1986	1	—	—
	1988	1	—	—
10 Trent	1987	1	1	1
	1991	1	1	1
11 NE Thames	1988	1	—	1
	1989	1	—	1
12 Trent	1990	1	1	1
	1991	1	—	1
Total		26	12	14

infected from a contaminated aerosol spray from a cooling tower or from the hospital water system.

The source of infection was believed to have been the hot water system in an outbreak in 1985 in a hospital in North West Thames Region, when the temperature of the hospital water was reduced during maintenance work. Two elderly patients developed nosocomial Legionnaires' disease. In the other outbreak in 1985, at a hospital in the West Midlands, no source of infection was identified.

A hospital in the Yorkshire Region reported a single case of Legionnaires' disease in 1985 in a member of staff. Three years later, in 1988, an outbreak was reported from the same hospital in a mixed group of patients and in 1989 a case in a transplant patient was also reported. Isolates were obtained from the two linked cases and from one of the outbreak cases and showed infection to be due to *L. pneumophila* Sg1 subgroup 'Philadelphia' RFLP type 1. Samples of water from the hospital also contained this strain of legionella.

The other outbreak in 1988, affecting two female medical patients, was reported from the same West Midlands Region hospital which had experienced an outbreak in 1980 affecting four patients (see above). The hospital water system was again believed to be the source of infection.

Table 3c. *Nosocomial Legionnaires' disease, England and Wales 1980–92. Sporadic nosocomial cases*

Sporadic cases	No. of cases	No. of deaths	No. of cases immunosuppressed
Definitely nosocomial	18	5	6
Possibly nosocomial	12	2	6
Possibly nosocomial (hospital employees)	10	1	—
Total	40	8	12

The linked cases not associated with recognized outbreaks

Twelve hospitals were associated with more than one single case each of Legionnaires' disease where the intervals between onsets of infection at the same hospital exceeded 6 months, and ranged from 1 to 12 years (Table 3b). Twenty-six cases with 12 deaths were included in this linked group. Fourteen of the cases and five of the deaths were among immunosuppressed patients.

In five hospitals, all ten of the reported linked cases of Legionnaires' disease occurred in immunosuppressed patients. Two cases, due to infection with *L. pneumophila* Sg8, were reported from a hospital in the North East Thames Region, one in 1988 and one in 1989 [16]. Isolates from both patients and from water samples taken from the showerhead in the unit and hot water supplied to other wards, all shared the same serogroup and were RFLP type 25.

A hospital from the Yorkshire Region reported two cases of nosocomial Legionnaires' disease a year apart. *Legionella pneumophila* Sg5 was identified by culture of the organism in an immunosuppressed patient in 1982 and serologically in a renal patient in 1983. An isolate obtained from water samples taken from the patient's ward in 1992 was of the same serogroup and shared the same RFLP type as the patient isolate.

Six other single cases of Legionnaires' disease were reported in immunosuppressed patients from three hospitals. In one hospital, two patients, both of whom died, were infected in a renal unit 4 years apart. In the second hospital, cases occurred in a cardiac transplant patient and a leukaemic patient in 1990 and 1991 respectively. In the third hospital, the first case occurred in 1980 in an immunosuppressed patient with sphenoidal carcinoma and the second in a patient with leukaemia, 12 years later in 1992; *L. pneumophila* Sg10 was isolated from the patient in 1992 and from water samples from the hospital water supply at that time.

In 1983 a case of Legionnaires' disease occurred in a patient admitted to hospital for emergency abdominal surgery. *Legionella pneumophila* Sg4 infection was diagnosed by culture. Seven years later, a cardiac transplant patient at the same hospital developed Legionnaires' disease and a strain of the same serogroup was again isolated, not only from the patient but also from samples of water taken from the hospital's water supply.

The remaining 14 linked cases, 6 of whom died, were associated with 6 different hospitals. They included 2 hospital staff members who became ill 2 years apart while employed at the same hospital; 2 cardiac patients who contracted

Legionnaires' disease 4 years apart; and 1 renal transplant patient who developed Legionnaires' disease in 1985 followed by a case of Legionnaires' disease in 1990 in a doctor working at the same hospital. In none of the cases was a source of infection identified.

The sporadic cases

Cases of sporadic Legionnaires' disease were reported in 18 patients who spent all 10 days in hospital before onset of symptoms for legionellosis and in 12 patients who spent between 1–9 days in hospital before onset of symptoms (Table 3c). Seven of these 30 patients died. Twelve were immunosuppressed, including 7 who had had renal transplants, 2 of whom died. One of the transplant patients had pneumonia with infection due to both *L. bozemanii* and *Chlamydia* sp. [17]. In two immunosuppressed patients, the respective hospital water supplies were implicated as the source of infection: in one *L. pneumophila* Sg5 was found and in the other *L. pneumophila* Sg1 subgroup 'Oxford' RFLP type 27.

A further ten sporadic cases of legionellosis were reported in adults working in hospitals during their incubation period. They comprised 2 nurses, 1 of whom died, 2 plumbers, 3 porters, an engineer, a microbiologist and a gas pipe fitter. In none was a source of infection within the hospital clearly implicated.

DISCUSSION

Reports of nosocomially acquired legionella infection are uncommon in England and Wales, although there are likely to be many cases which remain unrecognized and some which are diagnosed but not reported to CDSC. Of all the cases of Legionnaires' disease reported to CDSC, an average of 17 patients each year are believed to have acquired their infection in hospital compared with an average of 84 cases which are reported as community acquired and 80 cases which are associated with travel. Although the nosocomial cases comprise the smallest group within the National Surveillance Scheme, the case fatality rate is almost three times higher (31%) than in the community acquired cases (11%) or cases associated with travel (11%) (CDSC, unpublished).

Legionnaires' disease has been described as a disease associated with building services [18]. Outbreaks have been linked to aerosols from cooling towers [14], hot water systems [19, 20], humidifiers [21, 22], respiratory therapy equipment [23, 24] and whirlpools [25]. The isolation of *L. pneumophila* from an Oxford hospital shower unit in 1979 [26] led to the investigation of hospital plumbing systems as possible sources of legionella infection and to the introduction of a range of control measures. Contaminated hospital water or air conditioning systems have the potential to expose already susceptible people to the risk of legionella infection.

The first opportunity in the UK to investigate and document the attempted control of an outbreak of nosocomial infection occurred following the outbreak of Legionnaires' disease at Kingston Hospital in 1980 [12]. The investigation highlighted the need for multidisciplinary action in long-term control and prevention of further outbreaks. During the early 1980s codes of practice were revised and reissued as new epidemiological, microbiological, chemical and engineering information became available [18]. Addressing the issues of ignorance, neglect and the dissemination of new knowledge were the overriding objectives of

this multidisciplinary approach to the prevention of Legionnaires' disease. Nevertheless, the largest hospital associated outbreak in the UK occurred at Stafford District Hospital in 1985 [14]. Errors in the design and management of the air conditioning system, together with a breakdown in hospital staff communication, were all identified by the subsequent Public Enquiry which made several recommendations, particularly on the hospital engineering practices [27, 28].

Most of the outbreaks in this survey were considered to be due to contaminated hospital domestic water systems rather than to air conditioning systems. Although legionellae are frequently found in hospital water systems [29], additional factors need to be present to create a risk of human infection. These include changes in water temperature, inadequate maintenance of the plumbing systems, and irregular use of various parts of the plumbing systems. Most of these causes of water contamination may also be relevant to the sporadic cases of legionella infection reported, the majority of which have no identifiable source. Establishing the cause of infection in a single case is less likely to occur, since clinical isolates, which are required for comparison with environmental isolates, are frequently not available.

The association between nosocomial legionellosis and immunosuppression, whether by treatment or disease, and chronic underlying diseases such as renal, heart or lung disease, is well documented [30–32]. The high fatality rate in these patients, once they become infected with legionellae, highlights their special vulnerability. In this review 61 cases (28%) were known to be receiving transplant therapy or other immunosuppressive treatment, 25 of these patients died, including 7 of 10 cardiac transplant patients and 7 of 12 patients with leukaemia or lymphoma. The proportion of nosocomial legionellosis cases with immunosuppression increases if the 68 cases in the Stafford Hospital outbreak are excluded (because the source of that outbreak was considered to be a cooling tower producing an aerosol to which a large number of visitors, patients, and staff were exposed in the out-patient department). Transplant or immunosuppressed patients accounted for 27 (40%) of the outbreak cases, and 34 (41%) of the linked or sporadic cases of the remaining 150 nosocomial cases in this review.

Where contamination has been identified, eradication of legionellae has not proved possible from many hospital water systems [8, 33] and three hospitals in this review were associated with more than one outbreak each. Cold water systems were the suspected source of infection in two outbreaks, and may represent a risk to vulnerable patients if the systems are not maintained below a temperature at which legionellae will multiply actively. A study in 1983 aimed to identify the determinants of *L. pneumophila* contamination of water systems in 15 hospitals. The results showed that hospitals with preventive maintenance programmes recovered *L. pneumophila* from their water systems as frequently as did those without maintenance programmes. None of the participating hospitals reported clinical infection from legionella during the study [34]. Thus the goal of eradication of legionellae in hospital water supplies may be unnecessary providing other measures are taken, such as regular maintenance of the water systems and prospective active surveillance of nosocomial respiratory infections [9, 35]. Targeted surveillance has been introduced in some hospitals to monitor all cases

of pneumonia in high risk patient groups [36, 37] and transplant patients at one hospital have been offered antibiotic prophylaxis to prevent legionella infection [38]. In the absence of recognized cases of legionellosis, it is considered unnecessary to routinely examine hospital water systems for legionellae [39, 40]. However, regular surveillance of hospital water systems has been proposed as a feature of the audit of maintenance programmes [3].

The three nosocomial outbreaks due to *L. bozemanii* are the first from this species to be reported from the UK. Regular monitoring of the water system within the hospital unit concerned, and active case searching, has been extensively carried out since *L. bozemanii* was suspected and identified. The investigators at this hospital stress that other cases elsewhere may be missed unless specimens are obtained for culture when patients are undergoing investigation for suspected opportunist infection [8].

Between 1980 and 1992, 27% of the nosocomial cases of Legionnaires' disease were identified by culture of the organism. This compares with 13% for legionellosis cases associated with travel and 10% of cases acquired in the community over the same time period (CDSC, unpublished). It is widely recognized that the majority of culture proven cases of Legionnaires' disease are due to *L. pneumophila* Sg1, which carry the mAb 2 epitope (sometimes referred to in the UK as 'Pontiac' strains) [41]. However, only 25 (45%) of the 56 nosocomial strains typed, were from this group, compared with 81 and 83% for the travel and community cases respectively (CDSC, unpublished). In contrast, 25 (42%) nosocomial isolates were from strains other than *L. pneumophila* Sg1 compared with only 11 and 9% for the other two groups of cases (CDSC, unpublished). These results support the view that hospitalized patients are more susceptible to the non *L. pneumophila* Sg1 infections than other groups of patients.

It is widely recognized that hospital acquired legionellosis is under-diagnosed in many centres but the relatively low number of nosocomial cases in this review may be due to several reasons. Firstly, CDSC's case definitions for nosocomial legionella infection may be more rigorous than those used elsewhere. Our definitions include those patients who were hospitalized for at least 10 days before onset of infection or were part of an outbreak, or were linked to another case at the same hospital in a different time period. Patients who were in hospital for less than the full incubation period for Legionnaires' disease and who were not linked to other cases from the same hospital have been described as possibly nosocomial cases and analysed separately. Other studies have been less specific and defined cases as nosocomial if they had been in hospital or visited the hospital a minimum of 2 days prior to the onset of first symptoms [42–48]. Secondly, CDSC's reports of sporadic infection almost certainly reflect low ascertainment. A proportion of nosocomial legionellosis cases may not be detected using standard serological methods for diagnosis. Greater use of isolation methods or the application of the direct fluorescent antibody test to specimens, using species specific monoclonals should be encouraged when patients are being investigated for opportunist pneumonia infections.

A greater use of rapid diagnostic methods together with the implementation of a statutory reporting scheme for Legionnaires' disease, and prompt reporting by hospitals to the local Consultant in Communicable Disease Control (CCDC) and

then to CDSC, should lead to earlier recognition of cases and hence the application of appropriate control measures. The occurrence of a single nosocomial case of legionella infection should evoke immediate investigation, as should the presence of *any* legionellae organisms in hospital water systems, not just those identified as *L. pneumophila* Sg1. A combination of these measures would provide not only a more accurate estimate of the incidence of legionellosis in hospitals but also an appraisal of the degree to which the implementation of official guidelines and advice [39, 49, 50] are contributing to the control of nosocomial legionellosis.

ACKNOWLEDGEMENTS

We wish to thank Mr Daniel Dedman, Ms Kate Fern and Ms Maureen Bezzant for their assistance in preparing and maintaining the legionellosis database at CDSC and Mr Richard Birtles for his microbiological support. We are also indebted to all the PHLS and hospital microbiologists, Consultants in Communicable Disease Control and others who have contributed information to the National Surveillance Scheme for Legionnaires' Disease.

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