Two Nursing Home Outbreaks of Respiratory Infection with *Legionella sainthelensi*

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OBJECTIVE: To describe outbreaks of infection caused by *Legionella sainthelensi* occurring in older residents of two nursing homes and to determine risk factors for the development of infection.

DESIGN: Descriptive epidemiology and a case-control study.

SETTING: Two nursing homes (140 beds and 254 beds in nursing homes A and B, respectively) located in southern Ontario, Canada, experiencing outbreaks of respiratory tract infection in July and August 1994.

SUBJECTS: Case-residents of the two nursing homes who met clinical and laboratory criteria for *Legionella* infection. Control-residents were defined as those who were in the homes during the outbreaks and were asymptomatic.

MEASUREMENTS: Active surveillance was conducted in both nursing homes to identify symptomatic residents. Residents with fever or respiratory tract symptoms had nasopharyngeal swabs taken for viral antigen detection and culture, urine for *Legionella* antigen detection, and acute and convalescent serology for viruses, *Mycoplasma pneumoniae, Chlamydia pneumoniae,* and *Legionella.* Chest X-rays were performed, and an attempt was made to obtain blood and sputum cultures. Water samples from shower heads, faucets, and air conditioning units were collected for *Legionella* culture and polymerase chain reaction (PCR) assay. A case-control study was done to assess possible risk factors for legionellosis.

RESULTS: Twenty-nine cases — 17 in nursing home A; 12 in nursing home B — were identified. Four (14%) case-residents had documented pneumonia and four case-residents died. Univariate analysis revealed that a history of stroke (odds ratio (OR) 2.3 (95% CI, 1.0–5.3)), eating pureed food (OR 4.6 (95% CI, 1.6–12.7)), and having fluids administered with medication (OR 2.5 (95% CI, 1.0–5.9)) were significant risk factors. Cases were less likely to wear dentures (OR .4 (95% CI, .2–.9)) or to eat solid food (OR .3, (95% CI, .1–.6)). Only eating pureed food remained significant in a multivariable analysis (OR 4.6 (95% CI, 1.6–13.0, $P = .01$)).

CONCLUSION: This report describes outbreaks of legionellosis in two nursing homes, representing the first reported outbreaks of infection caused by *Legionella sainthelensi.* The association with illness of dietary characteristics indicative of swallowing disorders suggests that aspiration was the most likely mode of infection. The diagnosis of legionellosis should be considered during outbreaks of respiratory infection in nursing homes. J Am Geriatr Soc 47:547–552, 1999.

Key words: legionellosis; pneumonia; nursing home infections

Outbreaks of respiratory infections are common in long-term care facilities for older people.[1] However, microbiologic investigations are performed infrequently, and the etiologic agent often remains unrecognized. *Legionella* species are widely distributed in the environment and cause infections with nonspecific features, especially in immunocompromised or older hosts.[2] Despite numerous community and hospital outbreaks of legionellosis reported since the first identified cases of Legionnaires' disease in 1976,[3–8] only two reports describe cases in long-term care facilities.[9,10] The organism in these cases was *Legionella pneumophila. Legionella sainthelensi* is a bacterium that was first isolated in freshwater areas affected by the volcanic eruptions of Mount St. Helens in Washington state.[11] Although there have been few reports of human infection with this organism, illness that has been reported thus far varies in severity from mild respiratory tract infection to pneumonia.[12,13] We describe outbreaks of infection with *L. sainthelensi* that occurred in two Canadian nursing homes in 1994.

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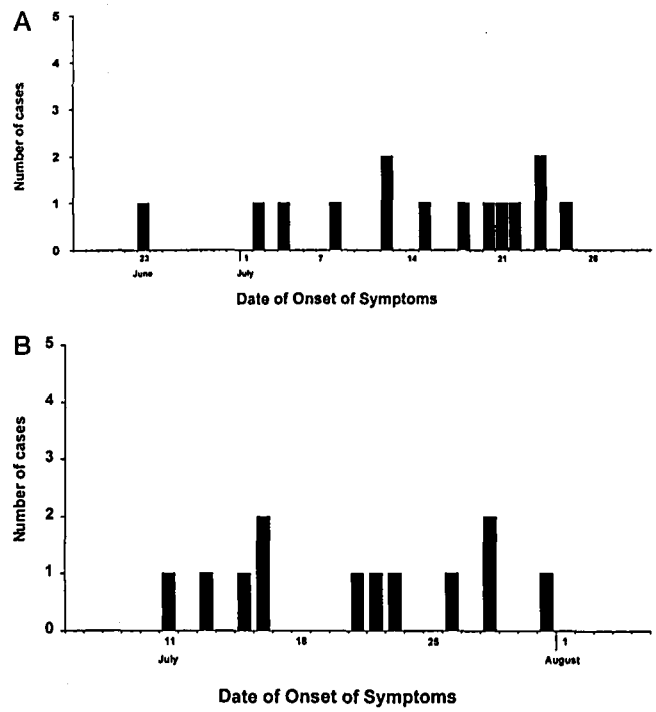

Figure 1. A Dates of onset of symptoms for cases of legionellosis in nursing home A, 1994. Three cases were asymptomatic and do not appear on the epidemic curve. B Dates of onset of symptoms for cases of legionellosis in nursing home B, 1994.

On July 11, 1994, five residents with respiratory symptoms were identified on one unit of a 140-bed nursing home (nursing home A). On July 20, 1994, excessive respiratory infections were also noted in a 254-bed nursing home (nursing home B). These nursing homes were located in the province of Ontario in two different metropolitan areas approximately 45 kilometers apart.

METHODS

Outbreak Investigation and Control

At both homes, active surveillance was initiated to identify symptomatic residents. In nursing home A, nursing and public health staff monitored residents for fever or respiratory symptoms, whereas in nursing home B surveillance for infection was performed by an infection control nurse. Residents with fever or respiratory symptoms had nasopharyngeal swabs taken for viral antigen detection and culture, urine for *Legionella* antigen detection, and acute and convalescent serology for viruses, mycoplasma, and legionella. An attempt was made to obtain sputum and blood cultures. Chest X-rays were performed, when clinically indicated, at the discretion of the attending physician. Environmental investigations included obtaining water samples from shower heads, faucets, and air conditioning units for detection of *Legionella*.[14] Distances from residents' beds to the room air conditioning unit and bathroom, as well as from the residents' rooms to the tub room and showers on the floor, were measured. The surrounding area was surveyed for the presence of cooling towers and other potential aerosol producing sources. To control the outbreak in nursing home A, the water was hyperchlorinated and superheated to 65°C at the farthest tap. Shower heads and faucets were disinfected with bleach.[14] In nursing home B, the water system was hyperchlorinated and the hot water tank and air conditioners descaled[15] after cultures were obtained. Water cultures were repeated after the institution of control measures in both homes. Once the diagnosis of legionellosis was made in each facility, all symptomatic residents were treated with oral erythromycin.

Case-Control Study

Clinical and demographic data were obtained from all residents in each nursing home present from 1 week before the first identified case to 1 week after the last. Although legionellosis is traditionally associated with two distinct illnesses (Legionnaires' disease and Pontiac fever), a wide spectrum of illness ranging from mild cough to pneumonia was observed at both nursing homes. Therefore, for the case-control study, a case definition was developed that could account for the spectrum of illness observed. Cases of *Legionella* infection were defined as residents present in the nursing home at the time of the outbreak who met any one of the following criteria: (1) a fourfold rise in *Legionella* serum antibodies to a titer ≥1:128; (2) a positive urine *Legionella* antigen test; (3) at least one respiratory symptom or sign and a single serologic convalescent titre ≥1:256; (4) three or more symptoms or signs of lower respiratory tract infection; or (5) two or more symptoms or signs and an infiltrate on chest X-ray. Respiratory symptoms and signs included in the definition were new or increased cough, new or increased sputum production, fever ≥38°C, pleuritic chest pain, new chest findings on examination, new or increased shortness of breath, or respiratory rate >25 per minute. Controls were defined as residents who were asymptomatic during the outbreak and included those who had negative urine tests for *Legionella* antigen. A case-control study was performed by comparing cases to controls in both nursing homes. In nursing home A, all residents in the facility were assessed for symptoms and had urine samples tested for *Legionella* antigen. All asymptomatic residents with negative urinary antigen were included as controls. In nursing home B, two controls were selected randomly for each case and matched for both age and sex. Potential exposures were identified through chart review, interviews with nursing staff, and environmental measurements. Data collected included possible risk factors for legionellosis, dietary factors, swallowing ability, and resident location.

Laboratory Methods

Nasopharyngeal swabs were examined by direct immunofluorescence assay for the detection of influenza, parainfluenza, and respiratory syncytial virus antigens. Specimens were also processed by standard methods for viral isolation (capable of detecting influenza virus, parainfluenza virus, respiratory syncytial virus, adenovirus, herpesvirus, and coronavirus). Acute and convalescent sera were obtained to detect antibodies to respiratory viruses and *Mycoplasma pneumoniae* by complement fixation. Serologic testing for detection of *Chlamydia pneumoniae* antibodies was done by microimmunofluorescence.[16] Sera were also tested by immunofluorescence to detect antibodies to 25 *Legionella* species.[17] Detection of *Legionella* antigen from urine was performed using a broad spectrum ELISA (enzyme-linked immunofluorescent assay).[18] When possible, serologic testing for *L. sainthelensi*-specific antibody was done when the urinary antigen was positive. Water samples were tested using standard methods for the culture of *Legionella* species.[14]

Table 1. Results of Laboratory Testing of Residents Present During the Outbreak Period in Nursing Homes A and B

Laboratory Test	No. Specimens Collected	No. (%) Positive Specimens	No. (%) Cases
Urine antigen	137	13/137 (9)	13/21 (62)
Paired Legionella sera*	47	9/47 (19)	9/23 (39)
Paired viral sera*	24	0/24 (0)	0/10 (0)
Paired *Chlamydia pneumoniae* sera*	24	2/24 (8)	0/10 (0)
Paired *Mycoplasma* sera*	24	0/24 (0)	0/10 (0)
Viral DFA and culture†	14	1/14 (7)	0/5 (0)

*Acute and convalescent sera obtained at least 14 days apart (seroconversion is defined by a fourfold rise in serum antibodies to ≥1:128).
†Direct immunofluorescence assay and viral isolation for the detection of influenza, parainfluenza, and respiratory syncytial viruses; one resident (a non-case) had parainfluenza 2 virus antigen detected by direct immunofluorescence assay.

Environmental samples from nursing home B were also sent for detection of *Legionella* DNA by polymerase chain reaction (PCR).[19]

Statistical Analysis

Data entry and analysis were performed using Epi-Info 6.01 software (CDC, Stone Mountain, GA) and SPSS 4.0 (SPSS Inc, Chicago, IL). Univariate analysis stratified for site was performed. All odds ratios were estimated by the Mantel-Haenszel method with 95% confidence limits. A multivariable analysis was done that included exposures having a level of significance of $P < .1$. To assess the possible effects of bias introduced by missing data, the multivariable analysis was repeated after recoding the missing values into categories that were judged to be the most likely or appropriate given other information available.

RESULTS

Descriptive Epidemiology

Twenty-nine cases of legionellosis were identified in the two nursing homes, 17 in nursing home A and 12 in nursing home B (Figures 1a and 1b). Mean age of case-residents was 84 years (range 69 to 102 years). Case residents developed symptoms of infection between June 23 and July 26, 1994, in nursing home A and between July 11 and July 31 in nursing home B. The most common symptoms were cough in 21 (72%) case-residents, fever in 16 (55%), and tachypnea, crackles, or fever in seven (24%). Twenty-one (72%) of 29 case-residents had laboratory evidence of *Legionella* infection (Table 1). Of 23 case-residents who had acute and convalescent *Legionella* serology available, nine had a fourfold rise in antibody titres to *L. sainthelensi* serogroup 1; serologic testing was negative for all other *Legionella* antigens tested.

In nursing home A, nine residents were defined as cases on the basis of a positive urine antigen test, six on the basis of fourfold rise in *L. sainthelensi* serogroup 1 serum antibodies to a titer ≥1:128, and two on the basis of clinical criteria alone. Of the nine residents with a positive urine test, six were symptomatic (three had a productive cough, two had fever, and one had wheezes and tachypnea). Of the six residents who seroconverted, five had a productive cough and one had fever. In nursing home B, four residents were defined as cases on the basis of a positive urine antigen test (three had cough and fever; one had cough alone), three seroconverted (two had cough alone and one had cough and fever), and five met clinical criteria (two had cough, fever, crackles, and a radiological infiltrate; two had cough, fever, and an infiltrate; one had cough, fever, and crackles). All four of the case-residents who had chest X-rays had clinical and radiographic evidence of pneumonia (Table 2). Six residents died (four case-residents and two residents with cough who did not meet the case definition). All deaths occurred within 1 week of the onset of symptoms and were thought to have been related to respiratory tract infection.

Forty-one other residents were symptomatic at the time of the outbreaks but did not meet the case definition. Thirty-three (80%) of these residents had cough, 12 (29%) had fever, and 13 (32%) had tachypnea, cough, or wheezes. Nineteen of these 41 symptomatic residents had serological testing done, and all of these results were negative.

Of the 137 residents who had urine sent for *Legionella* antigen detection, 10 (17%) of 58 symptomatic residents and three (4%) of 79 asymptomatic residents had a positive test ($P < .01$). Direct immunofluorescence assay of nasopharyngeal secretions for viral antigens was done in 14 residents and was positive in only one (a resident with cough alone) for parainfluenza virus serotype 2. Viral cultures were negative in all 14 residents tested (Table 1). Viral and mycoplasma serologic testing of 24 residents was negative. Two residents in nursing home B had a fourfold increase in antibody titers to *C. pneumoniae*; neither of these individuals was included as either cases or control. Sputum and blood cultures obtained from only two residents (both cases) were negative.

Legionella sainthelensi serogroup 1 was isolated from samples obtained from four of 11 water faucets in residents' bathrooms in nursing home A. There was no growth from samples obtained from four shower heads or four air conditioning units in the facility. There was also no growth of *Legionella* isolated from seven water faucets, five air conditioning unit specimens, or from two cooling towers located near nursing home B. Testing of water samples by PCR failed

Table 2. Clinical Syndromes Associated with *Legionella sainthelensi* in Older Nursing Home Residents

No. Residents	Nursing Home A	Nursing Home B
Pneumonia*	2	2
Respiratory infection without pneumonia	12	10
Asymptomatic	3	0

*The diagnosis of pneumonia required the presence of respiratory tract symptoms or signs and radiographic evidence of a pulmonary infiltrate.

Table 3. Results of Combined Univariate Analysis from Nursing Homes A and B

	No. (%) Exposed		Mantel-Haenszel	
	Cases (n = 29)*	Controls (n = 145)*	OR (95% CI)	*P* Value
Past medical history				
Male sex	14/29 (48)	44/145 (30)	2.4 (1.0–5.5)	.03
Stroke	12/29 (41)	34/145 (23)	2.3 (1.0–5.3)	.04
CHF	2/28 (7)	14/140 (10)	0.7 (0.1–3.2)	.47
Diabetes	7/29 (24)	19/145 (13)	2.0 (0.8–5.6)	.12
Cancer	1/29 (3)	16/145 (11)	0.3 (0.03–2.2)	.19
COPD	4/29 (14)	13/144 (9)	1.7 (0.5–5.8)	.28
Seizure	0/29 (0)	10/142 (7)	0 (0–2.1)	.29
Dietary factors				
Dysphagia	1/27 (4)	8/133 (6)	0.7 (0.08–5.8)	.59
Aspiration	3/25 (12)	9/129 (7)	1.8 (0.4–7.3)	.32
Dentures	13/28 (46)	95/138 (69)	0.4 (0.2–0.9)	.02
Good swallowing	17/24 (70)	77/112 (69)	0.6 (0.3–1.5)	.29
Fair swallowing	5/25 (20)	23/115 (20)	1.0 (0.3–3.0)	.59
Poor swallowing	5/25 (20)	11/110 (10)	2.4 (0.8–7.6)	.12
Solid diet	10/29 (34)	93/143 (65)	0.3 (0.1–0.6)	.01
Minced diet	11/29 (38)	40/143 (28)	1.7 (0.7–4.2)	.16
Pureed diet†	8/29 (28)	11/138 (8)	4.6 (1.6–12.7)	.01
Fluids/semifluids with medication	16/25 (64)	56/133 (42)	2.5 (1.02–5.9)	.03
Mobility				
Independent mobility	3/29 (10)	32/139 (23)	0.4 (0.1–1.3)	.09
Assisted mobility	3/27 (11)	24/141 (17)	0.6 (0.2–2.1)	.29
Immobile	21/27 (78)	82/134 (61)	2.2 (0.9–5.9)	.07
Continuous variables (Mean age in years, or distance in feet (SD))				
Age	84.8 (7.4)	84.1 (9.3)		.67
Bed to AC Unit‡	10.8 (3.8)	10.9 (3.8)		.85
Bed to tub room	36.0 (18.8)	43.9 (20.1)		.05
Room to bathroom	14.4 (4.0)	13.9 (3.6)		.54

*Denominator may vary because of missing values.
†A pureed diet remained significant (OR 4.60, 95% CI, 1.63–13.00, $P = .01$) in the multivariable model.
‡AC = air conditioner

to detect *Legionella* species DNA. Repeat water cultures from nursing home A were positive 3 months after the outbreak. The potable water was superheated again. Water cultures from nursing home B continued to remain negative over a 12-month period.

Case-Control Study

In nursing home A, data for the case-control study were obtained from 96 of the 138 residents present during the time of the outbreak. Seventeen cases were found. Control data were obtained from 79 asymptomatic individuals who had negative urine *Legionella* antigen tests. In nursing home B, 12 cases were identified from among the 252 residents present during the outbreak. Control data were obtained from the 66 asymptomatic residents who had negative urine antigen tests. The combined univariate analysis (see Table 3) revealed that case-residents were more likely to have been male (OR 2.4 (95% CI, 1.0–5.5, $P = .03$)), to have had a stroke (OR 2.3 (95% CI, 1.0–5.3, $P = .04$)), to have been on a pureed diet (OR 4.6 (95% CI 1.6–12.7, $P = .01$)), or to have had fluids or semifluids mixed with their medication (OR 2.5 (95% CI, 1.02–5.9, $P = .03$)) (Table 2). Both wearing dentures (OR .4 (95% CI, .2–.9, $P = .02$) and eating solid food (OR .3 (95% CI, .1–.6, $P = .01$)) had protective effects.

Variables with a *P* value less than .1 were retained for the multivariable analysis. These included gender, history of stroke, wearing dentures, a pureed diet, immobility, taking medications with fluids or semifluids, and distance (in feet) from the bed to tubroom. Stepwise logistic regression was performed. To minimize the risk of confounding attributable to location, the site (nursing home A or B) was kept in the final model. Neither confounding by, nor interaction with nursing home site was detected by stratified analysis for any of the variables. The only exposure that remained significant in the multivariable analysis was a pureed diet (OR 4.6, 95% CI 1.6–13.0, $P = .01$).

DISCUSSION

In this report, we have described two nursing home clusters of respiratory infection associated with laboratory evidence of *L. sainthelensi* serogroup 1 infection (fourfold rise in specific antibody titres, detection of urinary *Legionella* antigen, and isolation of the organism from potable water sources in one of the facilities). Although *Legionella* species are widely distributed in the environment, and outbreaks of legionellosis have been well described,[3–8,20] only one previous outbreak in a nursing home has been reported.[9] Although it is possible that the outbreaks in these two nursing homes

represent very unusual events, we believe that it is more likely that *Legionella* infection in nursing homes is frequently unrecognized: the discovery of a *Legionella* outbreak in nursing home A led investigators at nursing home B to consider the diagnosis of legionellosis. One of the reasons why legionellosis in nursing homes may be unrecognized is that its clinical features are nonspecific. Respiratory tract illness indistinguishable from that caused by a virus was the most common clinical presentation of *L. sainthelensi* infection in these two outbreaks. The clinical features of our cases resembled those reported previously for patients with infection caused by *L. sainthelensi,*[12,13] with illnesses ranging from persistent cough, to acute bronchitis, to pneumonia. The incidence of documented pneumonia (14%) in these two outbreaks was less than that in the single previously reported nursing home outbreak of legionellosis, in which nearly a third of symptomatic individuals had pneumonia.[9] However, neither the respiratory illness that predominated in our outbreaks nor *Legionella* pneumonia have clinical features that permit the distinction of etiology. This investigation shows that legionellosis should be considered in outbreaks of undiagnosed respiratory infection in nursing homes.

Standard definitions of either community-acquired or nosocomial infections are often not applicable to most long-term care facilities.[21] These standard definitions often make use of laboratory tests and radiology facilities that are usually not readily available in nursing homes. An important feature of this investigation was the development of a case definition that could be applied to residents of nursing homes. Because of the difficulty in obtaining adequate respiratory or serological specimens from nursing home residents,[22,23] a broad spectrum urinary ELISA[18] was used, allowing for a prompt, convenient, and accurate method of detecting legionellosis.[18,24]

The exact mode of transmission of infection with *Legionella* has long been debated.[25] There is evidence to support both aspiration and inhalation of contaminated water as modes of transmission of infection.[7,26] Potable water, water from cooling towers, and aerosols from other devices have been identified as sources of infection.[7,20,27,28] In our investigation we were unable to identify sources of contaminated aerosols such as cooling towers. Measurements of distances to potential sources of aerosolization were not significant in the multivariable analysis. Residents of long-term care facilities commonly have underlying conditions (such as stroke) that predispose to aspiration.[29] In these two facilities, as in many nursing homes, very few residents had formal evaluations for swallowing difficulties. However, the most common reason for placement on a pureed diet in the two nursing homes was the perception by nursing and medical staff of swallowing difficulties. That surrogate markers for aspiration were significant in both the univariate analysis (stroke, having fluids or semifluids mixed with medication, a pureed diet) and the multivariable analysis (pureed diet) provides supporting evidence for aspiration as the mode of transmission of infection in these outbreaks. Furthermore, the use of unboiled tap water in the preparation of the pureed food in both homes strengthens this hypothesis.

There are several limitations to this investigation. The lack of clinical isolates of *Legionella* is not unexpected since sputum can rarely be obtained from nursing home residents,[22,23] and the inability to detect *Legionella* in the water supply of nursing home B may have been attributable to limited sampling before hyperchlorination. It is possible that a few of the cases with symptoms of lower respiratory tract infection, but without laboratory evidence of legionellosis, may have been infected with other unidentified pathogens. However virologic and serologic investigations did not detect other infectious agents in these residents. Combining data from both nursing homes in the analysis may have led to bias as a result of confounding by nursing home location. However, the risk of confounding was minimized by stratifying the univariate analysis by nursing home site and by keeping site in the final multivariable model.

In conclusion, we describe the two largest outbreaks of legionellosis reported in nursing homes, both of which were caused by infection with *L. sainthelensi*. Supporting evidence suggests that aspiration was the mode of transmission in the two homes and that the source of infection was the potable water supply. Physicians should maintain an index of suspicion for the possibility of legionellosis in respiratory outbreaks in nursing homes.

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