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Trends in Legionnaires' Disease-Associated Hospitalizations, United States, 2006–2010

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Background. *Legionella pneumophila* is a waterborne cause of both healthcare-associated and community-acquired pneumonia. *Legionella pneumophila* serogroup 1 is responsible for 80% of infections. There is currently limited published disease burden data on Legionnaires' disease-associated hospitalization in the United States.

Methods. In this study, we estimated the annual incidence of Legionnaires' disease-associated hospitalizations in United States and identified demographic, temporal, and regional characteristics of individuals hospitalized for Legionnaires' disease. A retrospective study was conducted using the National Hospital Discharge Survey (NHDS) data from 2006 to 2010. The NHDS is a nationally representative US survey, which includes estimates of inpatient stays in short-stay hospitals in the United States, excluding federal, military, and Veterans Administration hospitals. All discharges assigned with the Legionnaires' disease *International Classification of Diseases 9th Clinical Modification* discharge diagnostic code (482.84) were included in this study.

Results. We observed the annual incidence and number of Legionnaires' disease-associated hospitalizations (per 100 000 population) in the United States by year, age, sex, race, and region. Over a 5-year period, 14 574 individuals experienced Legionnaires' disease-associated hospitalizations in the United States. The annual population-adjusted incidence (per 100 000 population) of Legionnaires' disease-associated hospitalizations was 5.37 (95% confidence interval [CI], 5.12–5.64) in 2006, 7.06 (95% CI, 6.80–7.40) in 2007, 8.77 (95% CI, 8.44–9.11) in 2008, 17.07 (95% CI, 16.62–17.54) in 2009, and 9.66 (95% CI, 9.32–10.01) in 2010. A summer peak of Legionnaires'

disease-associated hospitalizations occurred from June through September in 2006, 2007, 2008, and 2010.

Conclusions. Legionnaires' disease-associated hospitalizations significantly increased over the 5-year study period. The increasing disease burden of Legionnaires' disease suggests that large segments of the US population are at risk for exposure to this waterborne pathogen.

Keywords. bacteria; hospitalizations; Legionnaires; pneumonia; United States.

Legionnaires' disease (LD) is caused by the Gram-negative bacteria *Legionella*, which is responsible for a severe pneumonia called Legionnaires' disease and a flu-like syndrome called Pontiac fever [1]. Legionnaires' disease is one of the most common causes of atypical pneumonia [1]. The most common causative agent of LD is serogroup 1 of *Legionella pneumophila* [1].

In the environment, *L pneumophila* thrives in conditions with increased temperatures, humidity, and rainfall [2]. Increased growth of *Legionella* can be found in aging water infrastructure where sludge, eroded pipes, and air conditioning vents are present [2–4]. Detection of *L pneumophila* has been reported in larger buildings, especially those found in urban areas of the Northeast, Midwest, and Southern United States [2, 5]. Under appropriate conditions, acquisition of *L pneumophila* may occur via inhalation of contaminated aerosolized water [1]. Individuals who are older than 50 years of age, immunosuppressed, experience comorbid conditions, or those with history of smoking are at an increased risk for LD [1].

Common clinical features of LD include shortness of breath, fever, gastrointestinal distress, and arthralgia [1]. The most commonly used laboratory assay to diagnose LD is the urinary antigen test, which detects *L pneumophila* serogroup 1 antigen in urine within 1 to 3 days after infection and yields results within 15 minutes [6]. Approximately 40% of LD cases require intensive care unit admissions, and an estimated 5% to 10% of LD patients will die, in part, due to delayed or inappropriate treatment that highlights its potential severity [3, 7]. Trends in reported LD cases observed in US Centers for Disease Control and Prevention National Notifiable Disease Surveillance System data suggest that LD is gaining new prominence as a health threat among adults [8]. To further ascertain the burden and patterns of LD in the United States, we conducted an analysis of national hospital discharge data for the period 2006–2010.

METHODS

Data Source

We analyzed US National Hospital Discharge Survey (NHDS) data to estimate the annual incidence of LD-associated

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hospitalizations from 2006 through 2010. The US NHDS captures demographic characteristics from sample of discharge records from short-stay, nonfederal, general, and children's hospitals [9]. In the NHDS, *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* diagnostic codes are used to classify patients' medical diagnoses. Hospital discharge records containing the ICD-9-CM code for LD (482.84) were selected. Using these data, we examined changes in LD-associated hospitalizations by age, sex, region, month of discharge, and time to identify potential high-risk population groups that may be at increased risk for severe LD. The NHDS uses the US Bureau of the Census classification to categorize the hospitals by location into 1 of 4 US geographic regions (Northeast, Midwest, South, and West). The NHDS estimates are adjusted by using population weighting ratio, inflation by reciprocals of probabilities of selection, and accounting for nonresponses [9].

Data Analysis

For the years 2006 through 2010, the incidence of LD-associated hospitalizations was calculated using SPSS software, version 25 ([IBM Corp. Released 2017] IBM SPSS Statistics for Windows, version 25.0; IBM Corp., Armonk, NY). United States census data were used to obtain national population estimates for each year studied. The monthly distribution of LD-associated hospitalizations was calculated using the month of discharge data element. Rates of LD-associated hospitalizations were calculated as the number of hospital discharges with the diagnostic code for LD listed (ICD-9-CM, 482.84) divided by the sum of the annual population census estimates for each demographic group (eg, males, females, specified age groups, race). Incidence rates were calculated for the following age groups: ≤ 39 , 40–49, 50–59, 60–69, 70–79, and ≥ 80 years of age. Rates were reported as the number of LD-associated hospitalizations per 100 000 population with 95% confidence intervals (CIs) [10].

RESULTS

A total of 14 574 LD-associated hospitalizations were identified between 2006 and 2010. The population-adjusted annual

incidence of LD-associated hospitalizations was 5.37 (95% CI, 5.12–5.64) in 2006, 7.06 (95% CI, 6.80–7.40) in 2007, 8.77 (95% CI, 8.44–9.11) in 2008, 17.07 (95% CI, 16.62–17.54) in 2009, and 9.66 (95% CI, 9.32–10.01) in 2010 (Table 1, Figure 1). Individuals aged 39 years or younger had the lowest rate of LD-associated hospitalizations in all 5 years of the study. The incidence rate increased with age and peaked in the group 60–69 years of age. With the exception of 2007 and 2009, males showed a significantly higher incidence rate compared with females. Among racial groups, whites had a comparatively higher incidence rate in 2006 and 2008, whereas rates for blacks were higher in 2007 and 2010. A peak in the monthly weighted hospitalizations is seen for the months of May–September in 4 (2006, 2007, 2008, and 2010) of the 5 study years (Table 2, Figure 2). The LD-associated hospitalization incidence was higher in the Northeast (2 years, 2007 and 2009), Midwest (2007, 2008, 2010), and West (2008, 2009, 2010) compared with incidence rates in the South in all years studied (Table 3). In 2009, notable spikes in the incidence of LD-associated hospitalization were observed in the Northeast and West regions.

DISCUSSION

The NHDS data show a sustained increase in LD-associated hospitalizations in the United States during 2006–2010 with the mean age of patients ranging from 50 to 80 years, both of which are reflected in data nationwide [8, 11, 12]. In our study, the population-adjusted incidence of LD-associated hospitalizations almost doubled between 2006 and 2010 (5.37 to 9.66/100 000 population). The national incidence was highest during 2009 (17.07/100 000 population) and was notably highest in the Northeast (30.59; 95% CI, 29.18–32.06) and West regions (37.30; 95% CI, 36.01–38.71). This 2009 peak is consistent with other studies and national reports that document a steep increase in the number of LD cases in the Northeast [2, 13–15]. Although the underlying reasons for the increase in LD-associated hospitalizations during 2009 remains unclear, several factors may be responsible, including an increase in cases reported from New York City, a higher prevalence of LD risk factors among low-income populations,

Table 1. Incidence of LD-Associated Hospitalizations (per 100 000 Population) With 95% CI From National Hospital Discharge Survey, United States, 2006–2010 by Age Group

Year	Total	Age Group, Years IR (95% CI)					
		≤ 39	40 to 49	50 to 59	60 to 69	70 to 79	≥ 80
2006	5.37 (5.12–5.64)	0.07 (0.04–0.12)	3.70 (3.18–4.30)	12.12 (11.08–13.26)	14.70 (13.30–16.31)	23.80 (21.60–26.30)	20.71 (18.21–23.60)
2007	7.06 (6.80–7.40)	0.22 (0.16–0.30)	4.72 (4.12–5.4)	22.15 (20.74–23.70)	9.55 (8.42–10.83)	8.92 (7.60–10.50)	55.57 (51.48–60.01)
2008	8.77 (8.44–9.11)	1.83 (1.63–2.04)	3.30 (2.81–4.01)	6.42 (5.70–7.24)	59.85 (57.10–62.80)	20.87 (18.80–23.2)	2.96 (2.12–4.14)
2009	17.07 (16.62–17.54)	5.60 (5.30–6.01)	32.47 (31.01–34.20)	7.61 (7.01–8.51)	89.58 (86.30–93.01)	5.51 (4.50–6.80)	0
2010	9.66 (9.32–10.01)	2.18 (1.97–2.41)	15.57 (14.44–16.78)	21.03 (19.68–22.46)	6.90 (6.00–7.92)	28.50 (26.07–31.14)	34.09 (30.96–37.53)

Abbreviations: CI, confidence interval; IR, incidence rate; LD, Legionnaires' disease.

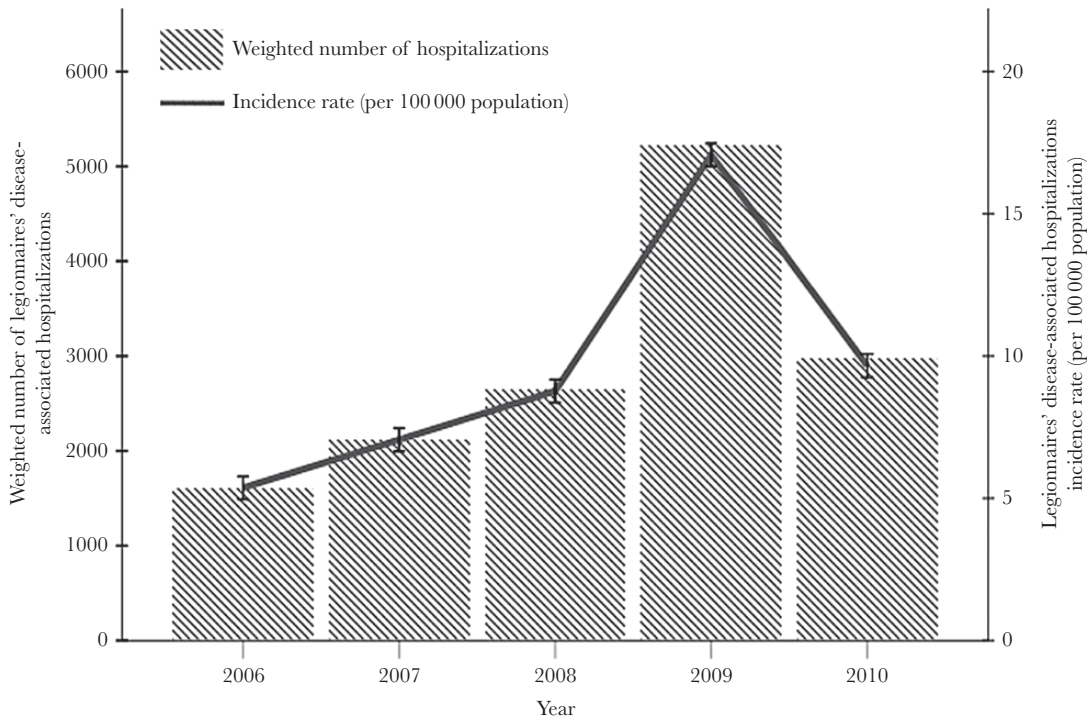


Figure 1. Weighted total number and annual incidence of Legionnaires' disease-associated hospitalizations, 2006–2010.

Table 2. Incidence of LD-Associated Hospitalizations (per 100 000 Population) With 95% CI From National Hospital Discharge Survey, United States, 2006–2010 by Sex and Race

Year	Sex IR (95% CI)		Race IR (95% CI)			
	Female	Male	White	Black	Others	Not Stated
2006	3.64 (3.35–4.0)	7.17 (6.74–7.61)	4.08 (3.83–4.34)	3.02 (2.51–3.62)	1.18 (0.80–1.75)	—
2007	8.41 (8.01–9.01)	5.67 (5.30–6.10)	3.82 (3.60–4.10)	7.11 (6.31–8.01)	—	—
2008	2.59 (2.40–2.90)	15.15 (14.60–15.80)	4.64 (4.41–5.01)	—	—	—
2009	21.24 (20.53–22.01)	12.77 (12.21–13.35)	6.25 (6.01–6.60)	4.39 (3.80–5.10)	54.98 (52.11–58.01)	—
2010	6.79 (6.40–7.21)	12.61 (12.06–13.19)	5.40 (5.11–5.69)	17.62 (16.38–18.96)	—	—

Abbreviations: CI, confidence interval; IR, incidence rate; LD, Legionnaires' disease.

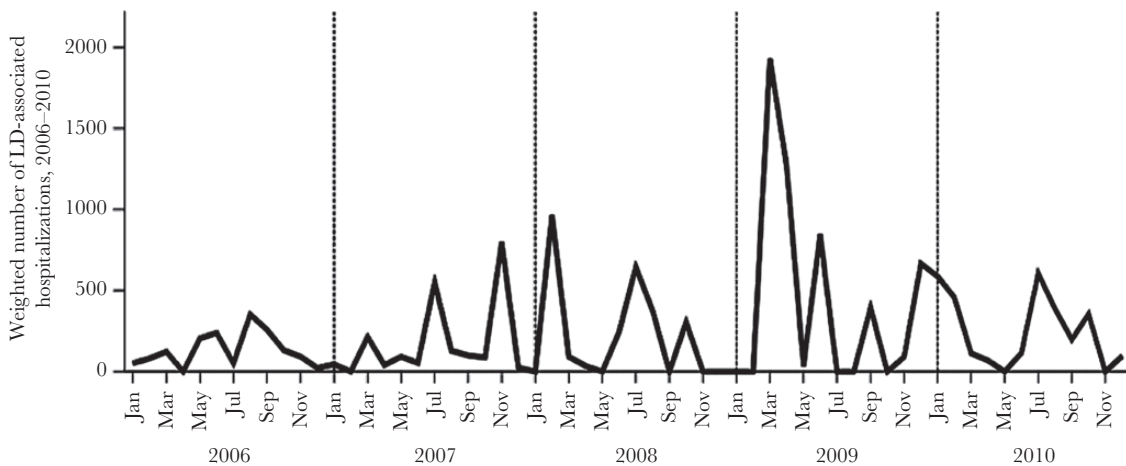


Figure 2. Monthly distribution of weighted Legionnaires' disease-associated hospitalizations over 5 consecutive years, 2006–2010.

Table 3. Incidence of LD-Associated Hospitalizations (per 100 000 Population) With 95% CI From National Hospital Discharge Survey, United States, 2006–2010 by Region^a

Year	Region IR (95% CI)			
	Northeast	South	West	Midwest
2006	2.96 (2.54–3.50)	5.99 (5.54–6.50)	4.59 (4.11–5.12)	7.17 (6.60–7.84)
2007	16.59 (15.60–17.70)	3.41 (3.10–3.80)	—	12.69 (11.90–13.60)
2008	4.48 (4.01–5.10)	3.57 (3.23–4.01)	13.64 (13.01–14.60)	15.83 (15.01–17.01)
2009	30.59 (29.18–32.06)	3.04 (2.73–3.40)	37.30 (36.01–38.71)	7.99 (7.34–8.70)
2010	5.55 (4.96–6.20)	9.49 (8.94–10.07)	10.85 (10.12–11.63)	12.09 (11.29–12.94)

Abbreviations: CI, confidence interval; IR, incidence rate; LD, Legionnaires' disease.

^aList of States by region. Northeast: Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania. Midwest: Michigan, Ohio, Illinois, Indiana, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas. South: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas. West: Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Hawaii, Alaska.

and maintenance of water systems particularly those found in large buildings [13, 15].

This study has some limitations. First, the NHDS database provides inpatient hospitalization data and does not reflect individuals who may have received care for LD in military, Veterans Administration hospitals, or in emergency departments only. Second, racial group information was not reported in 42.2% of hospitalizations analyzed. This observation may lead to unreliable estimates of the LD-associated hospitalization burden in race-specific groups. Third, seasonality studies have shown that LD patterns typically demonstrate a summer spike, with an increased incidence occurring during the warmer, more humid months of June–September [4]. With NHDS data, however, we cannot ascertain the precise time and location of the acquisition of infection. Nevertheless, because the date of illness onset and data of admission are likely to be within 4 weeks of each other, the epidemiologic onset curve is likely to appear similar to the graph of hospitalizations described in this report.

CONCLUSIONS

Legionnaires' disease is an important cause of hospitalization among Americans. Surveillance and research investigations suggest that LD cases have substantial potential to increase in coming years due to aging of the US population, aging infrastructure, and changing climatic factors [2]. This underscores the importance of the understanding of this disease's characteristics and early diagnosis of *Legionella pneumophila* infection among patients to prevent severe clinical sequelae. Improved knowledge and access to *Legionella* diagnostic assays may also help to improve the timeliness of treatment and reduce health-care costs associated with LD.

Acknowledgments

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