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MAJOR ARTICLE

Pneumococcal Pneumonia Requiring Hospitalization in US Children in the 13-Valent Pneumococcal Conjugate Vaccine Era

Liset Olarte,[1] William J. Barson,[2] Ryan M. Barson,[2] José R. Romero,[3] John S. Bradley,[4] Tina Q. Tan,[5] Laurence B. Givner,[6] Jill A. Hoffman,[7] Philana Ling Lin,[8] Kristina G. Hultén,[1] Edward O. Mason,[1] and Sheldon L. Kaplan[1]

Departments of Pediatrics of [1]Baylor College of Medicine, Houston, Texas; [2]Ohio State University College of Medicine, Columbus; [3]University of Arkansas for Medical Sciences, Little Rock; [4]Rady Children's Hospital San Diego, California; [5]Northwestern University Feinberg School of Medicine, Chicago, Illinois; [6]Wake Forest School of Medicine, Winston-Salem, North Carolina; [7]University of Southern California School of Medicine, Los Angeles; and [8]Children's Hospital of Pittsburgh of the University of Pittsburgh Medical Center, Pennsylvania

Background. The impact of PCV13 on a number of clinical aspects of pneumococcal pneumonia (PP) in children has not been reported. We compared the serotype distribution, antibiotic susceptibility, and outcomes of children with PP 4 years before and 4 years after the introduction of PCV13.

Methods. We identified patients ≤18 years with PP at 8 children's hospitals in the United States (2006–2014). Pneumococcal isolates were collected prospectively. Serotyping and antibiotic susceptibility were performed in a central laboratory. Clinical and laboratory data were collected retrospectively. Annual pneumococcal pneumonia hospitalization rates per 100 000 admissions with 95% confidence intervals were calculated. Dichotomous variables were analyzed by χ^2 test and continuous variables with Mann-Whitney *U* test.

Results. A total of 377 patients with PP requiring hospitalization were identified. Hospitalization rates of PP decreased from 53.6 to 23.3 per 100 000 admissions post PCV13 ($P < .0001$). Complicated PP rates also decreased ($P < .0001$). Need for intensive care, mechanical ventilation, and invasive procedure remained unchanged after the introduction of PCV13. Comorbidities were more common among children with uncomplicated than complicated pneumonia (52.2% vs. 22.5%, $P < .001$). Overall, PCV13 serotypes 19A, 3, 7F, and 1 caused 80% of PP. Hospitalization rates of PCV13 serotype pneumonia decreased from 47.2 to 15.7 per 100 000 admissions post PCV13. In 2014, the most common serotypes were 3, 19A and 35B.

Conclusions. PP requiring hospitalization significantly decreased in children after PCV13 introduction. Complicated PP rates decreased steadily in 2011–2014. PCV13 serotypes 19A and 3 were still responsible for half of the cases of PP in 2011–2014.

Keywords. pneumonia; empyema; *Streptococcus pneumoniae*; PCV13; pneumococcal disease.

Streptococcus pneumoniae is the most common cause of community-acquired bacterial pneumonia in children and often is associated with complications such as parapneumonic empyema [1, 2]. Following the introduction of the 7-valent pneumococcal conjugate vaccine (PCV7) in the United States in 2000, the frequency of culture-positive pneumococcal pneumonia as well as all cause pneumonia in hospitalized children was substantially reduced [3–5]. However, a resurgence in the frequency of invasive pneumococcal disease (IPD) including pneumonia subsequently occurred, primarily due to serotype 19A which was not included in PCV7 [6–8]. In the United States, several investigators also reported an increasing frequency of parapneumonic empyema in children, especially due to serotypes 1, 3, and 19A [9, 10]. Similar observations were made in Canada following PCV7 introduction [11].

The 13-valent pneumococcal conjugate vaccine (PCV13) which added 6 additional serotypes (1, 3, 5, 7F, 6A, 19A) to PCV7 (4, 6B, 9V, 14, 18C, 19F, and 23F) was introduced for routine administration to young children in the United States in 2010. Subsequently, IPD including pneumonia in children was further reduced, particularly cases caused by serotypes 19A and 7F [12–14]. In other countries where PCV13 was introduced, the frequency of all cause pneumonia and pneumococcal pneumonia as well as pleural effusion/empyema has diminished [15–20]. The objective of the current study was to assess the impact of PCV13 on the clinical and microbiologic characteristics of invasive pneumococcal pneumonia in children at 8 children's hospitals in the United States.

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Correspondence: L. Olarte, Texas Children's Hospital, Feigin Center, Ste 1150, 1102 Bates Ave, Houston, TX 77030 (liset.olarte@alumni.bcm.edu).

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METHODS

Setting, Population, and Design

The US Pediatric Multicenter Pneumococcal Surveillance Study Group consists of investigators from 8 children's hospitals (Houston, TX; Pittsburgh, PA; Little Rock, AR; San Diego, CA; Los Angeles, CA; Chicago, IL; Columbus, OH; and Winston-Salem, NC) who have been prospectively identifying children with IPD since September 1993. We identified patients ≤ 18 years of age with pneumococcal pneumonia from our database between January 1, 2006, and December 31, 2014. The study was divided into 3 periods: pre-PCV13 (January 2006–December 2009), PCV13-transition year (2010), and post-PCV13 (January 2011–December 2014). The study was approved by the Institutional Review Boards of each of the participating hospitals.

Data Collection and Definitions

Pneumococcal pneumonia was defined as the isolation of *S. pneumoniae* from blood, pleural fluid, lung abscess, or lung tissue with clinical presentation and radiographic changes consistent with pneumonia. Patients with pneumococcal pneumonia who were managed in the outpatient setting were excluded from this study. Clinical information was abstracted from medical records and recorded on a standardized case report form which included demographics, comorbidities, pneumococcal immunization status, clinical presentation, laboratory results, imaging studies (chest radiographs, ultrasound, computerized tomography scan, and/or magnetic resonance imaging), invasive procedures (thoracentesis, chest tube placement with/without fibrinolysis, video-assisted thoracoscopic surgery [VATS], interventional radiology drainage of lung abscess and/or open thoracotomy), hospitalization course, and outcome. Uncomplicated and complicated pneumonia definitions were based on the radiologist's assessment of the imaging studies, characteristics of pleural fluid obtained during invasive interventions and/or description of the findings from VATS or open thoracotomy. Uncomplicated pneumonia was defined as a pulmonary consolidation ± nonloculated small pleural effusion (≤10 mm rim or < 25% of hemithorax opacified). Complicated pneumonia was defined as a pulmonary consolidation plus one of the following: presence of a large size pleural effusion, loculated pleural fluid, parapneumonic empyema, necrotizing pneumonia or lung abscess. Fever was considered present if the temperature was ≥100.4°F anytime during a hospital day. Laboratory studies that were collected from patient charts included white blood cell (WBC) count, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR), and/or viral studies obtained at the time of admission; if not available, we included the first results obtained within the initial 48 hours after admission. The imaging and laboratory studies were ordered by the treating physician as part of routine medical care and were not systematically obtained in all patients. The dates of administration of PCV7 and/or PCV13 were documented through the medical records or by contacting the patient's healthcare provider.

Microbiologic Methods

Pneumococcal isolates were identified using standard methods in the microbiology laboratories of each hospital. All isolates were sent to a central laboratory (Infectious Disease Research Laboratory, Texas Children's Hospital, Houston, TX) for serotyping by the Quellung reaction using commercially available antisera (Statens Serum Institut, Copenhagen, Denmark; Daco, Inc, Carpinteria, CA). Determination of minimum inhibitory concentration (MIC) for penicillin and ceftriaxone was performed by microbroth dilution with Mueller-Hinton media supplemented with 3% lysed horse blood. Susceptibility to erythromycin, clindamycin and trimethoprim-sulfamethoxazole (TMP-SMX) was determined by Kirby Bauer disk diffusion testing. Susceptibility categories were determined using the 2014 Clinical and Laboratory Standards Institute guidelines (nonmeningeal breakpoints for pneumococci: penicillin: ≤2.0 μg/mL = susceptible, 4.0 μg/mL = intermediate and ≥8.0 μg/mL = resistant; ceftriaxone: ≤1.0 μg/mL = susceptible, 2.0 μg/mL = intermediate and ≥4.0 μg/mL = resistant) [21].

Data Analysis

Annual hospitalization rates per 100 000 admissions with 95% confidence intervals (CI) based on a Poisson distribution were calculated for all pneumococcal pneumonia, complicated pneumococcal pneumonia, and serotype-specific pneumonia cases. Descriptive statistics were used to characterize the study population. The $\chi 2$ test and Fisher exact test were used to compare categorical variables. Continuous variables were analyzed by the Mann-Whitney *U* test. A two-tailed *P* value ≤.05 was considered statistically significant. IBM SPSS statistics v22.0.0 was the statistical program used.

RESULTS

Demographics, Clinical Presentation, and Hospital Course

We identified 422 patients with pneumococcal pneumonia from our database. Forty-five patients were excluded from this study (outpatient management 19, medical data not available 3, diagnosis based on polymerase chain reaction only 2, no radiographic evidence of consolidation (only nonspecific infiltrates) 10, misclassification 4, sample from foreign body aspiration 4, sputum sample 1, polymicrobial tracheal aspirate sample 2). A total of 377 patients with pneumococcal pneumonia requiring hospitalization from 2006 to 2014 were included. The hospitalization rate of all pneumococcal pneumonia cases decreased from 53.6 (95% CI: 46.8–61.0) per 100 000 admissions in 2006–2009 to 23.3 (95% CI: 19.0–28.2) per 100 000 admissions in 2011–2014 (-56%, $P < .0001$) (Figure 1). Complicated pneumococcal pneumonia hospitalization rates decreased from 38.6 (95% CI: 32.9–45.0) per 100 000 admissions in 2006–2009 to

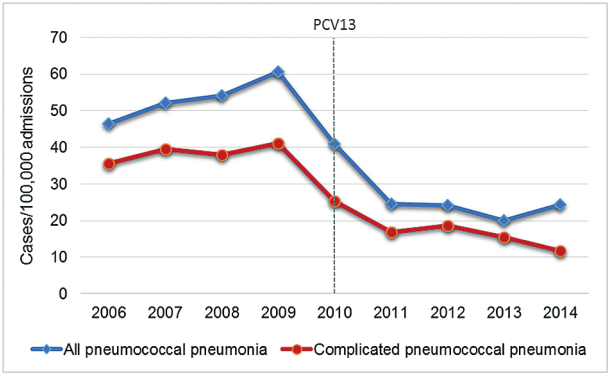

Figure 1. Annual hospitalization rates of all pneumococcal pneumonia and complicated pneumococcal pneumonia per 100 000 admissions from 2006 to 2014. The annual admissions among the 8 children's hospitals were 2006 = 101 116; 2007 = 103 524; 2008 = 105 367; 2009 = 111 969; 2010 = 114 615; 2011 = 118 077; 2012 = 107 737; 2013 = 110 241; and 2014 = 111 089.

15.6 (95% CI: 12.2–19.8) per 100 000 admissions in 2011–2014 (−60%, $P < .0001$).

No differences in age, sex, race/ethnicity, comorbidity, clinical presentation, or hospital course were identified between 2006–2009 and 2011–2014 (Tables 1 and 2). In 2011–2014, of the 79 immunized patients, 38 (48.1%) received at least 1 dose of PCV13 and 22 (27.8%) ≥3 doses of PCV13. Tables 1 and 2 do not include the 47 pneumococcal pneumonia cases identified in PCV13-transition year 2010.

Table 1. Demographic Characteristics and Clinical Presentation of Children With Pneumococcal Pneumonia Before and After the Introduction of 13-valent pneumococcal conjugate vaccine

	2006–2009 n = 226	2011–2014 n = 104	*P*
Sex, male, n (%)	119 (52.7)	54 (51.9)	.9
Race/ethnicity, n (%)			
White	100 (44.2)	41 (39.4)	.4
Black	49 (21.7)	20 (19.2)	.6
Hispanic	47 (20.8)	32 (30.8)	.05
Other	30 (13.3)	11 (10.6)	.4
Age, months, median (IQR)	103 (60.6–170.2)	119 (56.2–197.3)	.4
Age groups, n (%)			
<2 years	14 (6.2)	9 (8.7)	.4
≥2 < 5 years	41 (18.1)	18 (17.3)	.8
≥5 years	171 (75.7)	77 (74)	.7
Comorbidity, n (%)	65 (28.8)	34 (32.7)	.5
Received ≥ 1 PCV dose, n (%)[a]	165/214 (77.1)	79/92 (85.9)	.08
Bacteremic pneumonia, n (%)[b]	140/213 (65.7)	60/97 (61.9)	.6
Complicated pneumonia, n (%)	163 (72.1)	70 (67.3)	.4
Empyema	115 (50.9)	47 (45.2)	.3
Necrotizing pneumonia	77 (34.1)	26 (25)	.09
Lung abscess	14 (6.2)	2 (1.9)	.09
Hemolytic-uremic syndrome, n (%)	12 (5.3)	2 (1.9)	.2

Abbreviations: IQR, interquartile range; PCV, pneumococcal conjugate vaccine.

[a]Immunization status was not available in 12 patients in each study period.

[b]Blood cultures were not obtained in 13 and 7 patients in 2006–2009 and 2011–2014, respectively.

Table 2. Hospital Course of Children With Pneumococcal Pneumonia Before and After the Introduction of 13-valent pneumococcal conjugate vaccine

	2006–2009 n = 226	2011–2014 n = 104	*P*
Intensive care, n (%)	95 (42)	49 (47.1)	.4
Mechanical ventilation, n (%)	53 (23.5)	24 (23.1)	.9
Invasive procedure, n (%)	154 (68.1)	70 (67.3)	.9
VATS (initial intervention)	70 (31)	32 (31)	1
Chest tube without fibrinolysis	59 (26.1)	24 (23.1)	.6
Failure, required VATS	9/59 (15.3)	3/24 (12.5)	1
Chest tube with fibrinolysis	17 (7.5)	11 (10.6)	.4
Failure, required VATS	4/17 (23.5)	1/11 (9.1)	.6
Others[a]	8 (3.5)	3 (2.9)	1
Hospitalization, days, median (IQR)	11(7–15)	9 (7–16)	.4
Fever after admission, days, median (IQR)	6 (2.2–9)	4 (1–10)	.1
Antibiotic therapy, days, median (IQR)	20 (14–24)	21 (14–27)	.7
Case fatality rate, n (%)	1(0.4)	0	1

Abbreviations: IQR, interquartile range; VATS, video-assisted thoracoscopic surgery.

[a]Other invasive procedures performed in 2006–2009 were lung abscess drainage by interventional radiology (n = 6) and thoracentesis (n = 2); and in 2011–2014 were lobectomy (n = 1), thoracentesis (n = 1), and bronchoscopy plus open lung biopsy (n = 1).

Viral coinfections were detected more frequently in those tested in the 2011–2014 time period (22/65, 34%) compared to the 2006–2009 period (19/97, 20%), but this was likely related to more molecular tests being available during that time frame. Viral coinfections in the combined years included influenza virus (n = 24), respiratory syncytial virus (n = 10), human metapneumovirus (n = 3), rhinovirus (n = 3), parainfluenza virus (n = 2), adenovirus (n = 1), and Epstein-Barr virus (n = 1). Two other patients had two respiratory viruses detected (rhinovirus + respiratory syncytial virus; rhinovirus + influenza virus). WBC count (median 14.8 × 10^3/μL [interquartile range 8.3–23.3], CRP (median 23.6 mg/L [IQR 15.3–32.7]), and ESR (median 61 mm/hr [IQR 47–91.2]) were no different between 2006–2009 and 2011–2014.

From 2006 to 2014 (including 2010), 4.2% of patients (16/377) developed hemolytic-uremic syndrome in association with pneumococcal pneumonia. One patient died due to pneumococcal pneumonia in this study. Comorbidities were actually more common among children with uncomplicated pneumonia (60/115, 52.2%) than for children with complicated pneumonia (59/262, 22.5%); $P < .001$. Additional comparisons of interest between uncomplicated and complicated pneumococcal pneumonia cases are shown in Supplementary Table 1.

Pneumococcal Serotypes

A total of 364 (96.6%) of 377 isolates were available for serotyping and antibiotic susceptibility testing (not available for testing: 2006–2009 = 9 and 2011–2014 = 4). The hospitalization rate of pneumonia cases caused by PCV13 serotypes decreased from 47.2 (95% CI: 40.8–54.2) per 100 000 admissions in 2006–2009 to 15.7 (95% CI: 12.2–19.8) per 100 000 admissions in 2011–2014 (−67%, $P < .0001$). Four PCV13 serotypes (19A, 3, 7F, and 1) caused 80% (291/364) of the pneumococcal pneumonia cases from 2006

to 2014. The annual hospitalization rates of serotype-specific pneumonia cases are shown in Figure 2. Statistically significant declines in the hospitalization rate of serotypes causing pneumococcal pneumonia were found only for serotype 19A (26.1 [95% CI: 21.4–31.4] vs. 7.4 [95% CI: 5.1–10.4] per 100 000 admissions; −72%, $P < .0001$) and serotype 1 (5.0 [95% CI: 3.1–7.6] vs. 0.4 [95% CI: 0.5–1.6] per 100 000 admissions; −92%, $P < .0001$). No significant changes were observed for serotype 7F (5.5 [95% CI: 3.5–8.2] vs. 2.9 [95% CI: 1.5–5.0] per 100 000 admissions; −47%, $P = .07$) and serotype 3 (7.3 [95% CI: 5.0–10.4] vs. 4.5 [95% CI: 2.7–6.9] per 100 000 admissions; −38%, $P = .08$). The most common non-PCV13 serotypes during 2011–2014 were 33F (n = 5), 35B, 15A and 22F (n = 3 each). The hospitalization rate of pneumonia cases caused by non-PCV13 serotypes did not substantially increase between 2006–2009 and 2011–2014 (4.3 [95% CI: 2.5–6.7] vs. 6.7 [95% CI: 4.5–9.6] per 100 000 admissions; +56%, $P = .1$). However, a peak in the hospitalization rate of non-PCV13 serotypes was observed in 2014 (Figure 2). The actual number of isolates per year for the most common serotypes are shown in Supplementary Figure 1. A listing of all serotypes for the years 2006 through 2014 is shown in Table 3.

Eleven patients with PCV13 serotype pneumonia (6 with serotype 3 and 5 with serotype 19A) had received ≥3 doses of PCV13. Two of these patients had a comorbidity (sickle cell disease, and liver transplantation), and 2 previously-healthy patients had coinfection with influenza virus.

PCV13 serotypes were more common among complicated cases (233/253, 92.1%) than uncomplicated cases (75/111, 67.6%); $P < .001$. Serotype 19A was significantly more common among the complicated cases (126/253, 49.8%) than the uncomplicated cases (39/111, 35.1%); $P = .01$. Similarly, serotype 3 was significantly associated with complicated cases (50/253, 19.8%) vs. uncomplicated cases (6/111, 5.4%); $P < .001$. Although serotype 1 isolates were more common among the complicated cases than the uncomplicated cases (21/253, 8.3% vs. 4/111, 3.6%), the difference was not significant ($P = .1$). Of interest, hemolytic-uremic syndrome was observed in patients with pneumonia caused by serotypes 19A (n = 9), 3 (n = 5), 7F (n = 1), and no isolate to serotype (n = 1).

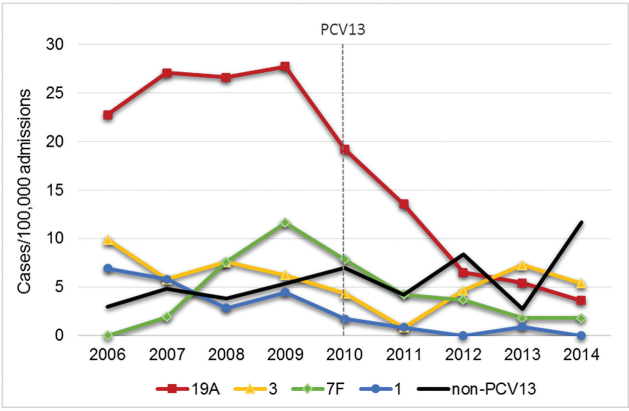

Figure 2. Annual hospitalization rates of serotype-specific pneumonia cases per 100 000 admissions from 2006 to 2014.

Table 3. Serotypes of Pneumococcal Isolates From Children With Pneumococcal Pneumonia From 2006 to 2014

	2006–2009 n = 217	2010 n = 47	2011–2014 n = 100	Total[a] n = 364
PCV13 serotypes				
19A	110	22	33	165
3	31	5	20	56
7F	23	9	13	45
1	21	2	2	25
5	3	0	0	3
PCV7 serotypes				
19F	4	1	1	6
9V	3	0	0	3
14	2	0	0	2
4	1	0	0	1
6B	1	0	0	1
23F	0	0	1	1
Non-PCV13 serotypes				
33F	0	3	5	8
22F	3	0	3	6
35B	0	0	3	3
15A	0	0	3	3
23B	2	0	2	4
6C	1	2	2	5
12F	1	0	2	3
10	0	0	2	2
11	2	0	1	3
15B	1	0	1	2
17	1	1	1	3
15C	0	0	1	1
16	0	0	1	1
38	1	0	1	2
23A	1	0	1	2
24	0	0	1	1
33	2	0	0	2
33A	1	1	0	2
35F	1	1	0	2
9N	1	0	0	1

Abbreviations: PCV13, 13-valent pneumococcal conjugate vaccine; PCV7, 7-valent pneumococcal conjugate vaccine.

[a]Thirteen isolates were not available for serotyping (nonviable).

Antibiotic Susceptibility Testing

Susceptibility to the antibiotics tested increased generally post PCV13. The proportion of isolates susceptible to penicillin increased from 90.8% (197/217) in 2006–2009 to 97% (97/100) in 2011–2014; $P = .05$. Increases were also seen for ceftriaxone, clindamycin and TMP-SMX but these changes were not significant. A higher proportion of isolates associated with uncomplicated (109/111; 98.2%) vs. complicated (231/253; 91.3%) pneumonia were susceptible to penicillin ($P = .015$); a similar difference was noted for clindamycin susceptibility.

DISCUSSION

Among our 8 children's hospitals, the hospitalization rate of culture-proven pneumococcal pneumonia per 100 000 admissions decreased by 56% when comparing the 4 years (2006–2009) prior to the 4 years (2011–2014) after the introduction of PCV13 in the United States. The demographic characteristics of patients including the proportion with comorbidities, the hospital course, the need for surgical drainage and complications were no different between these 2 time periods. Over the entire study period, serotypes 19A, 3, 7F and 1 accounted for 80% of cases. We noted a substantial decline in the hospitalization rate of pneumonia caused by serotypes contained in PCV13, primarily due to decreases in serotypes 19A and 1. Of interest, we did not note a significant change in the annual hospitalization rates of pneumonia caused by serotype 3 throughout the study. Overall, hospitalization rates of non-PCV13 serotype pneumonia did not increase significantly over the post-PCV13 years; but in the last year of the study, the highest rate of non-PCV13 serotype hospitalizations was noted. Only 11 patients developed pneumococcal pneumonia due to a PCV13 serotype isolate despite having received ≥3 doses of PCV13.

Other reports from the United States have addressed the impact of PCV13 introduction on IPD. The Centers for Disease Control and Prevention (CDC) observed among the Active Bacterial Core surveillance sites that the average annual number of culture-proven pneumococcal pneumonia in patients <18 years decreased by 53% after the introduction of PCV13, which is very similar to the 56% decrease we observed [13]. Declines in specific serotypes for pneumococcal pneumonia were not reported in the CDC study. In a study from Children's Medical Center Dallas, cases of pneumonia decreased from 31.7% of IPD cases in the PCV7 era to 17% of cases in the PCV13 era through June of 2014 [14]. In a study from Massachusetts, there was no significant change in the frequency of various pneumococcal clinical syndromes including pneumonia when the years 2007–2009 were compared to the years 2010–2012 for children ≤5 years of age [22].

Investigators from around the world also have reported declines in pneumococcal pneumonia following the use of PCV13. A 62.5% reduction for culture-proven pneumococcal pneumonia was found among pediatric patients in France after the introduction of PCV13 [15]. Although, PCV13 (non-PCV7) serotypes causing pneumococcal pneumonia decreased by 74% post-PCV13, an increase in non-PCV13 serotypes was also not noted [15]. Investigators from Israel [18] and Uruguay [23] also reported substantial reductions in bacteremic pneumococcal pneumonia and hospitalization rates of culture-proven pneumococcal pneumonia, respectively, among pediatric patients after introduction of PCV13. In both studies, serotypes 1, 5, and 19A were among the most common serotypes associated with pneumococcal pneumonia.

A recent study on parapneumonic empyema hospitalizations in US children <18 years of age reported that both probable pneumococcal and unspecified parapneumonic empyema declined after the introduction of PCV13 [24]. Interestingly, rates of probable staphylococcal empyema were higher than rates of pneumococcal empyema among children <2 years, particularly in 2011–2013. This is consistent with our results where <10% of children with culture-proven pneumococcal pneumonia were <2 years of age. Also, in that study asthma was the most common underlying condition in patients with all parapneumonic empyemas, which is similar to the distribution of underlying conditions in our study (data not shown).

Our group had previously compared the demographic and clinical characteristics and hospital course of children with uncomplicated versus complicated pneumococcal pneumonia in the pre-PCV era from 1993 through 2000 [2]. Unlike our initial study, we found in the current study that children with uncomplicated or complicated pneumonia were no different in age, and that children in either group were substantially older than the ages of children in our first study. In both studies, children with complicated pneumonia had fever for a longer duration prior to admission than children with uncomplicated pneumococcal pneumonia. An underlying condition was more common in children in the uncomplicated group in both studies. Interestingly, we have reported that in children with pneumococcal meningitis seen from 2007 through 2013, neurologic sequelae were more common among children without an underlying condition compared to those with one [25]. Why children without underlying conditions appear to have more complicated pneumococcal meningitis or pneumonia than those with underlying conditions is unclear.

Serotypes 1 and 3 and serogroup 19 were responsible for 24.4%, 8.4%, and 9%, respectively, of complicated pneumococcal pneumonia cases in our earlier study in the pre-PCV era. In this current study, serotypes 1, 3, and 19A caused 8.3%, 19.8%, and 49.8%, respectively, of the complicated cases. Finally, unlike our pre-PCV era study where penicillin susceptibility did not differ between uncomplicated and complicated pneumonia, in this study penicillin susceptible isolates were more common among children with uncomplicated pneumococcal pneumonia.

We have a number of limitations to our study. First, our study was not population-based and only captured culture-proven pneumococcal pneumonia cases. We know molecular testing of pleural fluids, in particular, might identify additional pneumococcal pneumonia cases but this was not available routinely in most of our centers. Second, laboratory and imaging studies were not obtained consistently among all study centers. Third, we did not have information on the immunization status of about 8% of the patients. Lastly, we did not assess changes in blood culture ordering or pleural fluid drainage practices that might have influenced the number of culture-proven pneumococcal pneumonia cases identified. Also, we did not have the

number of all-cause pneumonia identified at our study sites during the study period to compare whether trends are similar to culture-proven pneumococcal pneumonia cases. The strengths of our study include the multicenter design, and 4-year time frame before and after PCV13 was introduced.

In conclusion, we have found that after the introduction of PCV13 in the United States, the hospitalization rate of proven pneumococcal pneumonia decreased more than 50% at 8 children's hospitals. The clinical presentation and management did not change. The hospitalization rates of pneumonia cases caused by serotypes 19A and 1 declined substantially whereas decreases in cases due to serotype 3 was not noted. After 2010, antibiotic resistance also decreased and was seen in only 3% and 1% of isolates for penicillin and ceftriaxone, respectively. Continued surveillance is necessary to determine whether or not non-PCV13 serotype isolates will substantially increase as a cause of pneumococcal pneumonia in the coming years.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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