

Trends in Hospitalizations and Resource Utilization for Pediatric Pertussis

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KEY WORDS

health services, pertussis, vaccination, hospitalizations

ABBREVIATIONS

CCC: complex chronic condition
 CDC: Centers for Disease Control and Prevention
 CI: confidence interval
 CPI: Consumer Price Index
 HCUP: Healthcare Resource Utilization Project
 KID: Kids' Inpatient Database
 LOS: length of stay
 OR: odds ratio
 Tdap: tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis, adsorbed

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abstract



BACKGROUND AND OBJECTIVE: Pertussis is a serious and preventable childhood illness often necessitating hospitalization. The objective was to describe national trends in pediatric pertussis hospitalizations and resource utilization and factors associated with increased length of stay (LOS).

METHODS: This was a cross-sectional analysis of the 1997 to 2009 Healthcare Cost and Utilization Project Kids' Inpatient Databases. We examined pediatric hospitalizations of children (0–18 years) with a diagnosis of pertussis. Primary outcomes were hospitalizations, LOS, and charges. Weighted linear regression was used to evaluate trends in resource utilization. Multivariate logistic regression was used to determine factors associated with prolonged LOS.

RESULTS: Infants 0 to 6 months old accounted for nearly 90% of pediatric pertussis hospitalizations. Hospitalizations in public payers increased from 50% in 1997 to 67.4% in 2009 ($P < .01$). Among children with complex chronic conditions (CCCs), pertussis hospitalizations increased from 9.4% in 1997 to 16.8% in 2009 ($P < .01$). Mean LOS for pediatric pertussis hospitalizations decreased from 5.40 days in 1997 to 5.28 days in 2009 ($P < .01$), whereas those for children with CCCs increased from 8.86 days in 1997 to 9.25 days in 2009 ($P < .01$). Mean adjusted charges for pediatric pertussis hospitalizations rose from \$14 520 in 1997 to \$22 278 in 2009 ($P < .01$). For all study years, neonates and children with CCCs had greater odds of prolonged LOS.

CONCLUSIONS: Young infants and publicly insured patients account for a disproportionate number of pertussis-related hospitalizations. Patients with CCCs are increasingly contributing to hospitalizations and resource utilization attributable to pertussis. As new vaccine recommendations are implemented, targeted interventions are warranted to increase preventive efforts in these vulnerable populations.

Pertussis is a highly contagious, vaccine-preventable infection with ongoing major public health impact in the pediatric community. Centers for Disease Control and Prevention (CDC) statistics indicate increased reporting of pertussis since 1980 with more than 41 000 cases reported to the CDC in 2012.¹ Factors such as increased awareness, decreased potency of acellular pertussis currently used in routine childhood vaccines compared with whole cell pertussis, and possibly genetic changes in *Bordetella pertussis* have been implicated in the epidemic.² Even with the introduction of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis, adsorbed (Tdap) in 2006, CDC surveillance data report a rise in the incidence of pediatric pertussis in recent years. Children <1 year of age have the highest reported rates of pertussis¹; this group also accounted for >90% of

all reported pertussis-related deaths in 2012.³

Although these surveillance reports have contributed key insights into the epidemiology of pertussis among children, they have been lacking in key areas. First, there is still a paucity of national data on trends in pediatric pertussis hospitalizations and corresponding resource utilization. Second, few studies have assessed characteristics associated with increased resource utilization during hospitalizations. The objective of this study was to describe national trends in pediatric pertussis hospitalizations and resource utilization and factors associated with increased length of stay (LOS).

METHODS

Study Design and Data Source

This was a cross-sectional analysis of pediatric hospitalizations in the United States using the 1997 to 2009 Kids' Inpatient Database (KID) maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Resource Utilization Project (HCUP).⁴ This database is the only pediatric inpatient database that includes data from all payers and multiple hospital types, and it contains information on patient demographics, hospital characteristics, diagnoses, procedures, and resource utilization including LOS and total charges. Data sets have been released every 3 years, beginning in 1997. All currently released data sets (1997, 2000, 2003, 2006, and 2009) were analyzed. The institutional review board at Baylor College of Medicine approved the study.

Study Participants

Patients ≤18 years of age with a primary diagnosis of pertussis were identified by using International Classification

of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) discharge codes (*B pertussis*, 033.0; whooping cough, unspecified organism, 033.9). Patients with a secondary diagnosis of pertussis and a primary diagnosis of a pertussis-related primary diagnosis were also included. Pertussis-related diagnoses were adapted from Cortese et al (Supplemental Tables).⁵

Dependent Variables

Primary outcomes were hospitalizations, LOS, and mean charges among all pediatric pertussis hospitalizations in HCUP KID from 1997 to 2009. LOS was determined by subtracting the admission date from the discharge date. Hospital charge information was collected as the total amount charged by the hospital.

Independent Variables

Patient characteristics consisted of age, race or ethnicity, gender, payer type, household income, and presence of a complex chronic condition (CCC). Age was determined at time of admission. Given epidemiologic distribution of pertussis hospitalizations,³ age was divided into categories of <1 month (neonates), 1 to 2 months, 3 to 4 months, 5 to 6 months, 7 to 11 months, and ≥12 months, similar to those in a previously published pertussis study.⁵ Racial and ethnic data collected by hospitals were categorized as white, black, Hispanic, or other. For institutions that did not systematically collect race or ethnicity information, hospitalizations were classified as missing race, and this group was controlled for in the analysis. Payer types were classified as private, public (including Medicaid and other government programs), and other (including uninsured). Household income was based

on the median household incomes for the patients' zip codes divided into quartiles, with the highest income in the first quartile.⁶ CCC was based on a previous HCUP KID study⁷ and examined as a dichotomous variable (present/absent).

Analysis

Analyses were performed by using SAS 9.2 (SAS Institute, Inc, Cary, NC). Data were weighted to estimate national numbers by using the appropriately scaled weights provided by HCUP.⁶ Weighting within each study year accounted for hospital strata, clustering, and the number of hospitals in each data set. Summary statistics were performed to determine means and proportions. Rao-Scott χ^2 , Kruskal-Wallis, and Brown-Mood median test were used to determine differences in proportions across time between independent variables. Trends in LOS and charges were assessed using weighted linear regression in a merged data set with survey year as the principal predictor variable. Charges from 1997, 2000, 2003, and 2006 were converted into 2009 dollars by using the Consumer Price Index (CPI) for comparison with 2009 charges.

Additionally, we conducted multivariate logistic regression on the data from all study years to examine the factors associated with prolonged LOS. Prolonged LOS was defined as the highest quartile based on previous studies' examination of resource utilization according to quartiles.^{8,9}

We examined relationships between each independent variable and prolonged LOS while controlling for the other independent variables: age, race or ethnicity, gender, payer type,

household income, and presence of CCCs. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs).

RESULTS

Demographics of patients hospitalized with pertussis are shown in Table 1. Infants 0 to 6 months of age accounted for nearly 90% of all pertussis hospitalizations. Increasing proportions of hospitalizations were attributable to public payers over the study years ($P < .01$) reaching two-thirds of all pertussis hospitalizations in 2009. Pertussis

hospitalizations for children with CCCs nearly doubled from 1997 to 2009 ($P < .01$).

Trends in hospitalizations and resource utilization are shown in Table 2. The weighted number of pediatric pertussis hospitalizations fluctuated across the study period. Mean LOS for all pediatric pertussis hospitalizations decreased from 5.40 days in 1997 to 5.28 days in 2009 ($P < .01$). LOS for children with CCCs hospitalized with pertussis increased from 8.86 days in 1997 to 9.25 days in 2009, although

the difference was not statistically significant ($P = .20$). Mean CPI-adjusted hospital charges per pertussis hospitalization increased from \$14 520 in 1997 to \$22 278 in 2009 ($P < .01$). In 1997, mean CPI adjusted charges for pediatric pertussis hospitalizations in infants with CCCs were \$27 044 compared with \$42 477 in 2009 ($P = .03$).

Results of multivariate logistic regression are shown in Table 3. The independent variables age, race or ethnicity, gender, payer type, household income, and presence of CCCs were controlled

TABLE 1 Patient Characteristics of Pertussis Hospitalizations, 1997, 2000, 2003, 2006, and 2009

Variable	1997 N (weighted %)	2000 N (weighted %)	2003 N (weighted %)	2006 N (weighted %)	2009 N (weighted %)	<i>P</i> ^a
Age, mo						<.0001
<1	59 (6.2)	66 (6.2)	97 (8.7)	60 (6.4)	79 (6.9)	
1–2	496 (50.0)	610 (59.7)	647 (57.6)	551 (58.6)	698 (59.8)	
3–4	231 (22.1)	197 (18.2)	216 (19.3)	174 (18.1)	202 (17.5)	
5–6	79 (7.1)	35 (3.1)	43 (3.8)	42 (4.3)	42 (3.6)	
7–11	53 (5.5)	30 (3.4)	33 (3.0)	29 (3.1)	43 (3.6)	
≥12	94 (9.1)	102 (9.4)	84 (7.6)	89 (9.4)	99 (8.6)	
Race or ethnicity						.01
White	339 (35.2)	369 (36.1)	331 (29.6)	303 (32.7)	477 (40.9)	
Black	134 (13.5)	119 (11.6)	93 (8.8)	81 (8.9)	97 (8.5)	
Hispanic	233 (19.4)	261 (23.9)	271 (23.5)	208 (22.0)	285 (24.1)	
Other	74 (5.9)	101 (9.0)	94 (8.5)	84 (9.2)	109 (9.1)	
Missing	231 (26.0)	189 (19.5)	331 (29.6)	269 (27.2)	195 (17.4)	
Gender						.62
Male	478 (47.8)	504 (48.3)	560 (50.2)	476 (50.9)	586 (50.5)	
Female	534 (52.2)	536 (51.7)	557 (49.8)	466 (49.2)	577 (49.5)	
Payer type						<.0001
Private	429 (42.9)	474 (46.5)	410 (36.3)	307 (33.1)	348 (29.4)	
Public	518 (51.0)	516 (50.0)	686 (61.7)	597 (62.7)	777 (67.5)	
Other	62 (6.1)	44 (3.5)	23 (2.0)	41 (4.2)	37 (3.1)	
Household income						<.0001
1st quartile	372 (39.3)	138 (12.9)	324 (29.9)	283 (30.7)	394 (34.8)	
2nd quartile	185 (19.4)	308 (30.5)	300 (26.9)	264 (28.7)	338 (29.4)	
3rd quartile	140 (14.3)	258 (25.7)	269 (23.6)	208 (23.1)	280 (24.1)	
4th quartile	279 (27.0)	328 (30.9)	217 (19.6)	157 (17.5)	137 (11.7)	
CCCs						<.0001
Present	91 (9.4)	93 (8.8)	110 (9.9)	125 (13.2)	195 (16.8)	

^a *P* values represent differences across study years.

TABLE 2 Trends in Resource Utilization for Pertussis Hospitalization, Stratified by Presence of CCC, 1997, 2000, 2003, 2006, and 2009

	1997	2000	2003	2006	2009	P ^b
Pertussis hospitalizations	1012	1041	1130	945	1164	
Mean LOS in days (95% CI)						
Pertussis	5.40 (4.99–5.82)	5.22 (4.76–5.67)	5.60 (5.17–6.03)	5.05 (4.57–5.53)	5.28 (4.89–5.66)	<.01
Pertussis, no CCC	5.02 (4.67–5.36)	4.98 (4.52–5.44)	5.01 (4.67–5.35)	4.31 (3.90–4.72)	4.47 (4.12–4.83)	<.01
Pertussis, CCC	8.86 (7.02–10.71)	7.67 (6.10–9.24)	10.73 (8.37–13.09)	9.94 (8.23–11.65)	9.25 (8.03–10.47)	.20
Total charges in dollars ^a (95% CI)						
Pertussis	14 520 (11 794–17 246)	16 471 (13 234–19 708)	21 796 (18 498–25 094)	20 334 (16 884–23 783)	22 278 (19 258–25 299)	<.01
Pertussis, no CCC	13 058 (10 259–15 857)	15 328 (12 084–18 571)	17 966 (15 438–20 494)	17 425 (13 699–21 152)	18 212 (15 045–21 379)	<.01
Pertussis, CCC	27 044 (20 359–33 729)	28 515 (18 907–38 122)	50 855 (31 131–70 578)	39 651 (29 957–49 344)	42 477 (34 273–50 680)	.03

^a Charges for 1997, 2000, 2003, and 2006 were converted to 2009 estimated value by using CPI.

^b P value represents differences across study years.

for in the analysis. Significant factors independently associated with prolonged LOS are indicated. Across all study years, infants <1 month of age had greater odds of prolonged LOS than infants 1 to 2 months of age. Children with CCCs had greater odds of prolonged LOS than patients without CCCs in 1997 to 2009.

DISCUSSION

Although several large surveillance reports have outlined general trends in the epidemiology of pertussis among children, this analysis of a large, nationally representative database builds on previous work by assessing specific trends in pertussis hospitalizations and resource utilization. Overall, this study demonstrates that the burden of pediatric pertussis hospitalizations is greatest in vulnerable populations. The results of this study have important implications for the development of targeted interventions toward reducing resource utilization attributable to pertussis hospitalizations.

Although this analysis showed no overall trend in the number of pediatric pertussis hospitalizations between 1997 and 2009, the study did find several notable trends in hospitalization according to patient demographics. The youngest infants were responsible for the majority of admissions over all study years. Current pertussis immunization recommendations start at 2 months of age. Several studies have investigated neonatal vaccination strategies with mixed results.^{10–13} Birth priming with acellular pertussis was found to be safe, was variably effective, but demonstrated dampened immune response to other vaccines including *Haemophilus influenzae* type B, hepatitis B, and diphtheria.^{11–13} Until recently,

prevention focused on immunizing all adults in contact with infants <12 months old as a method of cocooning.¹⁴ New recommendations advise women to receive the pertussis vaccine during every pregnancy.¹⁵ This is supported by evidence of higher pertussis antibody titers in the infants of mothers who receive Tdap during pregnancy.¹⁶ Our results support the widespread implementation of the 2012 Advisory Committee on Immunization Practices recommendation for Tdap administration during pregnancy, given the high rates of hospitalization in infants <2 months of age.

Over the study period, the percentage of hospitalization for publicly insured patients increased. Publicly insured children accounted for half of pertussis hospitalizations in 1997 and two-thirds of hospitalizations in 2009. The cause of this trend is unclear but possibly linked to social determinants of health with widening economic differentials over recent years. Environmental factors such as clustering of cases in low-income housing¹⁷ have been implicated in pertussis outbreaks.¹⁸ Data from the study period also identified immunization delays¹⁹ in children with public insurance.^{20,21}

Our study also demonstrated a rise in pertussis hospitalizations in patients with CCCs. Recent studies have shown greater pediatric hospitalization rates and resource utilization in children with CCCs for all pediatric hospitalizations.⁸ Because pertussis is a vaccine-preventable illness, many of the hospitalizations for children with CCCs are potentially avoidable. Future research is needed to determine whether children with CCCs and their families are being adequately targeted in vaccination efforts.

TABLE 3 Factors Associated With Prolonged LOS, 1997, 2000, 2003, 2006, and 2009

Variable	1997 OR (95% CI)	2000 OR (95% CI)	2003 OR (95% CI)	2006 OR (95% CI)	2009 OR (95% CI)
Age, mo (versus 1–2 mo)					
<1	2.62 (1.32–5.19) ^a	6.29 (3.33–11.90) ^a	1.62 (0.96–2.72)	2.63 (1.48–4.67) ^a	2.06 (1.21–3.50) ^a
3–4	0.76 (0.51–1.15)	0.48 (0.29–0.77) ^a	0.67 (0.45–0.99) ^a	0.48 (0.29–0.81) ^a	0.54 (0.34–0.85) ^a
5–6	0.62 (0.34–1.13)	0.32 (0.10–1.03)	0.40 (0.17–0.97) ^a	0.22 (0.06–0.78) ^a	0.72 (0.25–2.04)
7–11	0.53 (0.26–1.09)	0.14 (0.30–0.67) ^a	0.25 (0.09–0.74) ^a	0.49 (0.18–1.34)	0.06 (0.01–0.55) ^a
≥12	0.36 (0.18–0.71) ^a	0.37 (0.19–0.73) ^a	0.12 (0.04–0.31) ^a	0.13 (0.05–0.35) ^a	0.06 (0.01–0.23) ^a
Race or ethnicity (versus white)					
Black	0.51 (0.30–0.86) ^a	0.66 (0.37–1.18)	0.87 (0.47–1.63)	0.74 (0.33–1.66)	0.72 (0.30–1.72)
Hispanic	1.09 (0.65–1.84)	0.83 (0.52–1.33)	0.68 (0.41–1.13)	0.54 (0.28–1.06)	1.11 (0.68–1.82)
Other	1.34 (0.75–2.39)	0.46 (0.22–0.97) ^a	1.11 (0.57–2.16)	1.27 (0.71–2.30)	0.86 (0.47–1.59)
Missing	0.86 (0.52–1.43)	0.84 (0.50–1.41)	0.72 (0.47–1.09)	1.24 (0.71–2.14)	1.06 (0.59–1.90)
Gender (versus female)					
Male	0.97 (0.71–1.31)	1.00 (0.68–1.46)	1.06 (0.79–1.40)	0.67 (0.48–0.95) ^a	0.86 (0.62–1.20)
Payer type (versus private)					
Public	1.47 (1.07–2.02) ^a	1.37 (0.92–2.06)	1.18 (0.82–1.70)	1.18 (0.80–1.76)	0.67 (0.42–1.07)
Other	1.21 (0.55–2.70)	1.41 (0.61–3.26)	1.40 (0.47–4.21)	0.73 (0.24–2.24)	0.67 (0.23–1.97)
Household income (versus first quartile)					
2nd quartile	1.58 (1.04–2.41) ^a	1.62 (0.94–2.77)	1.09 (0.71–1.68)	0.95 (0.63–1.45)	0.88 (0.56–1.39)
3rd quartile	0.87 (0.48–1.58)	1.56 (0.81–3.01)	1.19 (0.74–1.92)	1.27 (0.72–2.25)	0.67 (0.40–1.10)
4th quartile	1.09 (0.73–1.62)	1.84 (1.03–3.30) ^a	0.86 (0.49–1.54)	1.01 (0.56–1.80)	0.94(0.51–1.72)
CCC present (versus not present)	2.67 (1.62–4.39) ^a	2.68 (1.65–4.36) ^a	6.05 (3.95–9.26) ^a	5.19 (3.21–8.39) ^a	5.06 (3.37–7.59) ^a

^a Statistically significant ($P < .05$) result.

Findings on trends in resource utilization were less clear. Although this study did demonstrate a statistically significant difference in LOS between 1997 and 2009, the difference was small and of uncertain clinical significance. Furthermore, LOS demonstrated no clear trend over the study period. Decreased LOS has previously been reported using HCUP KID data for common pediatric diagnoses including skin and soft tissue infections, asthma, and pneumonia.²² This finding may indicate a global trend of decreasing LOS in the inpatient management of pediatric diagnoses. However, unlike these common pediatric conditions, pertussis does not have well defined discharge criteria, possibly contributing to the less pronounced decrease in LOS.

Total charges increased for all pertussis hospitalizations across the study

period. When hospitalizations were stratified according to CCC, charges were found to increase for those having a CCC and those without a CCC. However, the total mean charge for a pertussis hospitalization in a child with a CCC was nearly twice that of a pertussis hospitalization in a child without a CCC for all study years. Given the variation in how hospitals generate charges and modify charges, such data should be used with caution. Although cost-to-charge ratios may provide more valuable data with respect to the financial burden of pertussis hospitalizations, they were not available for all years in the HCUP database.

Our study demonstrated 2 major factors associated with prolonged LOS. In all study years, being a neonate was associated with prolonged LOS during hospitalizations, with ORs ranging

from 1.62 to 6.29 compared with infants 1 to 2 months of age. In a retrospective cohort study, the youngest infants hospitalized with pertussis were at greater risk of complications including apnea, pneumonia, and seizures.²³ Given the higher rates of complications in young infants and unclear discharge criteria, this group is probably observed and treated in the hospital longer, contributing to increases in LOS. Patients with CCCs also had greater odds of prolonged LOS (2.67–6.05) during the study period. Underlying chronic conditions may result in greater intensity of services, such as admission to a higher level of care, additional respiratory support, and subspecialist consultations.

There were methodological limitations to our study. Although HCUP KID is considered to provide a representative sample of pediatric hospitalizations,

discharge information is released only every 3 years and originated from a limited number of states in the early years. The use of weighted numbers in analysis, as done in our study, accounts for most selection bias, and several studies have used HCUP KID data for trend observations.^{22,24–26} HCUP KID does not contain unique patient identifiers or record linkages, thereby preventing analysis of utilization according to detailed patient characteristics. It is also possible that 1 patient contributed to multiple discharges. HCUP KID does not provide laboratory data. Therefore, we could not confirm the diagnosis of *B pertussis*. Our study was subject to database limitations such as coding errors, and a portion of the discharges were missing variables such as race and classification of age by month.

CONCLUSIONS

Pediatric pertussis is a public health concern. Although there were no notable trends in the overall number of hospitalizations across study years, the proportion of hospitalizations attributable to publicly insured infants and patients with CCCs increased during the study period. Specific groups at greater odds for prolonged LOS were neonates and infants with CCCs. As new vaccine recommendations are implemented to reduce the pertussis burden, targeted interventions are warranted to increase preventive efforts in these vulnerable populations.

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