



High costs of influenza: Direct medical costs of influenza disease in young children[☆]

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ABSTRACT

This study determined direct medical costs for influenza-associated hospitalizations and emergency department (ED) visits. For 3 influenza seasons, children <5 years of age with laboratory-confirmed influenza were identified through population-based surveillance. The mean direct cost per hospitalized child was \$5402, with annual cost burden estimated at \$44 to \$163 million. Factors associated with high-cost hospitalizations included intensive care unit (ICU) admission and having an underlying high-risk condition. The mean medical cost per ED visit was \$512, with annual ED cost burden estimated at \$62 to \$279 million. Implementation of the current vaccination policies will likely reduce the cost burden.

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1. Introduction

Disease burden attributed to the influenza virus is substantial and results in excess hospitalizations and emergency department (ED) visits for children [1–4]. Although robust estimates of the total hospitalization burden exist [5], reported mean influenza-related hospitalization costs vary widely for both children alone [6–8] and children and adults [9]. The mean costs for influenza hospitalizations ranged from \$3521 [9], to \$13,446 [7]. The methods, populations studied, and the results differ greatly, with the lowest estimates using ICD-9-CM codes [9] for the diagnosis of influenza rather than laboratory-confirmed influenza, and the highest esti-

mates using laboratory-confirmed influenza cases from tertiary care centers that included greater proportions of children with complex medical conditions [7,8].

The cost of influenza-related ED visits has received less attention than the cost of hospitalized cases, and has not been assessed in population-based settings. One study reported an estimated mean cost of \$142 for ED visits, however data were collected over a decade ago [9]. While the overall costs for ED visits are reported to be small compared to inpatient services, far more ED influenza visits occur, thus adding substantially to the total cost burden of influenza [4,9].

Moreover, major gaps in our knowledge about the factors associated with high costs remain. Studies have shown that a small number of children often account for a disproportionate share of medical care expenditures [10–12]. Mean influenza cost estimates may be influenced by children with complex conditions requiring high levels of care. Indeed, studies have noted higher costs in older children and in children with high risk conditions [6,8,9]. However, the specific factors associated with high influenza-related costs need additional study. A better understanding of the factors associated with the direct medical costs of influenza can support

Abbreviations: ED, emergency department; ACIP, Advisory Committee on Immunization Practices; NVSN, New Vaccine Surveillance Network; ICU, intensive care unit; IQR, interquartile range; ARI, acute respiratory infection.

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the current efforts toward more effective control of influenza and thereby reduce costs associated with influenza illness.

We assessed influenza costs using a multi-site, population-based New Vaccine Surveillance Network (NVSN). Active inpatient and ED surveillance for acute respiratory infections (ARI) identified children with laboratory-confirmed influenza at the 3 NVSN sites. We examined the direct medical costs in children less than 5 years of age hospitalized or evaluated in the ED during 3 consecutive influenza seasons. We also evaluated factors associated with high-cost hospitalizations.

2. Methods

2.1. Study design and population

The design and methods of the NVSN active population-based surveillance project have been previously described [4,13–17]. For this study, 3 seasons of data from the inpatient and ED surveillance were analyzed (2003–2004, 2004–2005, and 2005–2006) from three counties in the US which contain the cities of Nashville, Rochester, and Cincinnati. The surveillance hospitals at each county cared for >95% of hospitalized children in their respective counties, while the surveillance EDs at each county cared for a variable proportion of the county's pediatric ED visits: 30% in Nashville, 60% in Rochester, and 95% in Cincinnati. For hospital surveillance, children were enrolled within 48 h of admission, Sunday through Thursday. In the ED, children were systematically enrolled at each site: 3–4 days per week in Nashville and Rochester (rotating days) and every fourth day in Cincinnati. Children admitted to the hospital through the ED were categorized as hospitalized and all costs from both sources were combined.

Children eligible for enrollment were <5 years of age, had symptoms of an acute respiratory infection or fever, and were residents of the active surveillance counties. Children were excluded if they had fever and neutropenia associated with chemotherapy, were hospitalized in the prior 4 days, were transferred from another surveillance hospital, or had symptoms for greater than 14 days.

Demographic, medical, and social histories were obtained by standardized interviews of the parents or guardians. Clinical laboratory evaluations, hospital course, and discharge diagnoses were obtained from hospital and ED records. High-risk medical conditions for influenza complications were recorded and included asthma and reactive airways disease, chronic lung conditions, cardiac disease, long-term salicylate therapy, sickle cell disease, immunologic disorders, kidney disease and chronic renal dysfunction, genetic metabolic syndromes, diabetes, neurological disorders, and other chronic diseases [18]. Children were considered premature if their parents reported that the child had been born more than 4 weeks early.

Nasal and throat swabs were collected from each enrolled child for influenza culture and reverse transcriptase polymerase chain reaction (RT-PCR) testing. A child was considered influenza positive if either the viral culture or two independent RT-PCR tests on the same specimen were positive [4]. During 2003–2005, respiratory syncytial virus (RSV) cultures and RT-PCR testing were also performed.

Cost and physician fee charge data were gathered from the accounting databases at each participating hospital. Although the billing source for each site varied, each contained similar data elements. Detailed data on services, procedures and costs were collected for each child; a physician from each of the 3 sites (MAS, PS, KE) sorted costs into the following 5 general summary categories following the typology of an earlier study: diagnostics, therapeutics, room costs, medical supplies and physician services

[8]. Department-specific cost-to-charge ratios that were available from hospitals were used to adjust these medical costs. Cost-to-charge ratios were not available for physician fees. To avoid issues inherent to traditional hospital accounting data systems, total costs for physician services were estimated using gross physician fees [19,20]. For a sensitivity analysis and projections, physician fees were later adjusted using a generic cost-to-charge ratio [21]. The Medical component of the Consumer Price Index was used to adjust costs for inflation converted to constant 2006 dollars.

Data obtained from the hospital accounting databases were merged with the NVSN database to develop a comprehensive dataset which included demographic, medical, and cost data. Data from all 3 years and all 3 sites were combined. To examine high cost hospitalizations, children were grouped into 2 categories. If direct medical costs were in the top 10th percentile, the hospitalization was considered to be *high cost* [11], while those hospitalizations with costs in the lower 90th percentile were considered *non-high cost*. Pediatricians who categorized expenditures for all hospitalizations (MAS, PS, KE) also reviewed the medical records of the high cost children to determine to what extent their costs could be attributed to influenza.

2.2. Institutional Review Board Approval

Informed written consent was obtained from the parent/guardian of each child enrolled. The Institutional Review Boards at the Centers for Disease Control and Prevention (CDC) and at each site approved the study. Neither the treating clinicians nor parents/guardians were informed of the research virology results during the hospitalization or ED visit.

2.3. Statistical analyses

We summarized direct medical costs using univariate analysis and calculated means, standard deviations, medians, and interquartile distributions. We used the Kruskal–Wallis test to determine group differences in the median total costs and length of hospital stays, and the Chi-square and Fisher's Exact tests to analyze the relationships and characteristics associated with high cost and non-high cost children. A two-sided *P*-value of <0.05 indicated statistical significance. We conducted all statistical analyses in SAS 9.1 (SAS Institute Inc. Cary, NC).

We estimated the total cost burden of medically attended influenza (hospitalizations and ED visits) using mean costs from this study, and rates of hospitalizations and ED visits from an earlier study reporting on rates from the same NVSN sites as in the present study [4]. This prior study reported rates of hospitalizations attributable to influenza for years 2000–2004 varying between 0.4 per 1000 children (95% confidence interval 0.2–0.6 per 1000) and 1.5 per 1000 children (95% confidence interval 1.2–1.9 per 1000) [4]. ED visit rates, which were available for 2 of the 4 years, were 6 per 1000 children (95% confidence interval 4–9 per 1000) for 2002–2003 and 27 per 1000 (95% confidence interval 22–33 per 1000) for 2003–2004. In calculations, in order to account for variations in burden across seasons, we used a range for hospitalization rate of 0.4–1.5 per 1000 children, with 95% confidence interval of 0.2–1.9 per 1000 children. We used a range for ED visit rates of 6–27 per 1000 children with 95% confidence interval from 4 to 33 per 1000 children [4]. These rates are consistent with those reported in other studies, and most published rates fall within these confidence bands [3,14,22–24]. To estimate the total national influenza burden, we multiplied the influenza attributed ED visit and hospitalization rates from the prior study [4] by the average number of children <5 years of age residing in the US according to the U.S. Census Bureau estimates for 2003 through 2006 [25]. To estimate cost burden for these children, we multiplied the influenza attributed

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