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The high burden of pneumonia on US emergency departments during the 2009 influenza pandemic

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Summary Objectives: During the 2009 influenza A (H1N1) pandemic, unusual influenza activity outside the typical winter season provided a unique opportunity to evaluate the association between influenza and pneumonia incidence. We sought to quantify the impact of the 2009 pandemic on the incidence of emergency department (ED) visits for pneumonia in the United States (US).

Methods: Using the Nationwide Emergency Department Survey, we estimated monthly counts and rates of excess all-cause pneumonia ED visits in the US attributable to the pandemic by comparing observed pneumonia ED visits during the pandemic (April 2009–March 2010) to expected values modeled from the three prior years.

Results: The pandemic was associated with an excess of 180,560 pneumonia ED visits or 0.59 excess pneumonia visits per 1000 US population (95% confidence interval: 0.55, 0.62). These excess visits accounted for 7.0% of all pneumonia ED visits during the pandemic year. The greatest excess occurred during months with highest influenza activity (September–November 2009). Persons aged <65 years accounted for 94% of the excess pneumonia visits.

Conclusions: ED visits for pneumonia increased substantially during the 2009 pandemic, especially during peak influenza activity, suggesting a strong association between influenza activity and pneumonia incidence during the pandemic period.

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Introduction

Influenza infection is considered as an important contributor to pneumonia pathogenesis and burden.¹ Influenza can cause primary viral pneumonia and also predispose to secondary bacterial pneumonia with pathogens such as *Streptococcus pneumoniae* and *Staphylococcus aureus*.^{2–5} However, quantifying the burden of pneumonia attributable to influenza on a population level is challenging.⁶ Both influenza and pneumonia incidences peak in winter months,^{7–10} but several other factors may contribute to this temporal association between influenza and pneumonia, including activity of other respiratory viruses during the winter,^{11,12} environmental factors such as cold temperatures and decreased daylight in the winter,¹³ and increased person-to-person contact during the winter holidays.¹⁴

In 2009, the influenza A (H1N1) pandemic resulted in unusually high influenza activity in the United States (US) during the autumn, and to a lesser extent, during the preceding spring and summer.^{15,16} Influenza A (H1N1)pdm09 disproportionately affected children and young adults compared to the typical seasonal influenza pattern in which serious complications of influenza were more concentrated among older adults.^{15,16} These distinctive features of influenza activity during the 2009 pandemic provided a unique opportunity to evaluate the impact of influenza on pneumonia burden in the absence of winter-specific factors and in children and younger adult populations who do not typically contribute a high burden of influenza-associated pneumonia.

Weinberger et al.¹⁶ demonstrated that the 2009 influenza A (H1N1) pandemic was associated with increases in hospitalizations coded as pneumococcal pneumonia in the age groups most severely affected by the pandemic. Similar increases were recently reported for invasive pneumococcal pneumonia.¹⁷ Nevertheless, emergency department (ED) visits and hospitalizations are rarely coded specifically as pneumococcal pneumonia because most pneumonia episodes never have an etiology identified, partly due to the limitations of routine diagnostic tests.¹⁸ Furthermore, influenza infections can facilitate the development of non-pneumococcal pneumonia,⁴ but only pneumococcal disease was considered in previous studies. A comprehensive evaluation and quantification of the impact of the 2009 influenza pandemic on all-cause pneumonia burden is currently lacking.

With over 136 million US ED visits annually, the ED is an important venue for healthcare utilization, both as an entry point for hospitalizations and for outpatient treatment of serious illness.¹⁹ To quantify the impact of the 2009 influenza A (H1N1) pandemic on pneumonia burden in US EDs, we estimated excess all-cause pneumonia ED visits attributable to the pandemic by comparing rates of pneumonia ED visits observed during the pandemic year with expected rates estimated from modeling data from the three pre-pandemic years.

Methods

Data source

We obtained ED visit data from the Nationwide Emergency Department Sample (NEDS), a component of the Healthcare

Cost and Utilization Project (HCUP) maintained by the Agency for Healthcare Research and Quality (AHRQ).²⁰ NEDS is the largest source of US ED data, and contains information from 25 to 30 million ED visits annually beginning in 2006. The sample, which includes data from 29 participating states and represents approximately 20% of all US ED visits, is stratified by hospital geographic region, trauma center designation, urban–rural status, teaching hospital status, and ownership. EDs represent the primary sampling units and all visits from sampled EDs are included. The NEDS sampling framework is updated annually and includes statistical weights and clustering elements to allow calculation of national estimates.²⁰

For each ED visit, NEDS contains up to 15 diagnoses coded using the International Classification of Diseases, Ninth Revision Clinical Modification (ICD-9-CM). Additionally, NEDS contains data on month and year of visit, disposition from the ED, and patient demographics.

Pneumonia case definition

A pneumonia ED visit was defined as an ED visit with a primary (first-listed) pneumonia diagnosis, or with a secondary pneumonia diagnosis (listed in diagnosis fields 2–15) with an accompanying primary diagnosis of respiratory failure, shock, septicemia, a sign or symptom consistent with pneumonia, another acute respiratory infection, or an acute exacerbation of a chronic pulmonary disease (Table 1).²¹ This case definition for all-cause pneumonia was not restricted to a specific pathogen.

Statistical analyses

NEDS data were used to calculate monthly counts of pneumonia ED visits nationwide from April 2006 through March 2010. Calculations were stratified by eight age groups: <2 years; 2–4 years; 5–17 years; 18–39 years; 40–64 years; 65–74 years; 75–84 years; and ≥85 years. For each age group we used Poisson regression models for survey data to calculate annualized incidence rates for each study month using monthly counts of pneumonia ED visits as the outcome and the respective July US population estimate²² as the model offset term. Indicators for calendar months and year were included as covariates. To account for the variability in duration of calendar months, the monthly denominators were adjusted by multiplying the annual US population estimate by the fraction of days in each month within a year.

The study period was divided into two time segments: the 36-month pre-pandemic period (April 2006–March 2009) and the 12-month pandemic period (April 2009–March 2010). We first used pre-pandemic data and our Poisson regression model to estimate the monthly pneumonia ED visit rates for each age group expected during each month of the pandemic period in the absence of any perturbation (e.g. influenza A (H1N1) pandemic). We then estimated rates of excess pneumonia ED visits attributable to the pandemic in each age group by subtracting the expected monthly rates calculated with the pre-pandemic Poisson model from the observed monthly rates during the pandemic period. Thus, our analytic approach

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