Secondhand Smoke Exposure and Illness Severity among Children Hospitalized with Pneumonia

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Objective To assess the relationship between secondhand smoke (SHS) exposure and disease severity among children hospitalized with community-acquired pneumonia (CAP).

Study design Children hospitalized with clinical and radiographic CAP were enrolled between January 1, 2010, and June 30, 2012 at 3 hospitals in Tennessee and Utah as part of the Centers for Disease Control and Prevention's Etiology of Pneumonia in the Community study. Household SHS exposure was defined based on the number of smokers in the child's home. Outcomes included hospital length of stay, intensive care unit admission, and mechanical ventilation. Proportional hazards and logistic regression models were used to assess associations between SHS exposure and outcomes. All models were adjusted for age, sex, race/ethnicity, household education level, government insurance, comorbidities, enrollment site, year, and season.

Results Of the 2219 children included in the study, SHS exposure was reported in 785 (35.4%), including 325 (14.8%) with ≥2 smokers in the home. Compared with nonexposed children, the children exposed to ≥2 smokers had longer length of stay (median, 70.4 hours vs 64.4 hours; adjusted hazard ratio, 0.85; 95% CI, 0.75-0.97) and were more likely to receive intensive care (25.2% vs 20.9%; aOR, 1.44; 95% CI, 1.05-1.96), but not mechanical ventilation. Outcomes in children exposed to only 1 household smoker were similar to those in nonexposed children.

Conclusion Children hospitalized with CAP from households with ≥2 smokers had a longer length of stay and were more likely to require intensive care compared with children from households with no smokers, suggesting that they experienced greater pneumonia severity. *(J Pediatr 2015;167:869-74).*

There is no safe level of exposure to secondhand smoke (SHS).[1] Although smoking rates and involuntary exposure to SHS are declining in the US, the burden and negative health effects of SHS exposure remain substantial.[2] The pediatric population is particularly vulnerable, and with approximately 40% of US children aged 3-11 years regularly exposed to cigarette smoke,[3] much work remains.

SHS exposure is an established risk factor for both upper and lower respiratory tract illness in children.[4-10] Chronic SHS exposure induces inflammatory and functional changes in the airway that increase the risk of acute and chronic respiratory illnesses.[6,11-13] Exposure to SHS also is associated with increased illness severity in children with asthma, including a higher frequency of acute exacerbations and poorer long-term lung function.[14-16] Similarly, SHS-exposed children who are hospitalized with bronchiolitis or influenza experience more severe illness compared with nonexposed children.[17-19] Nonetheless, to date few studies have assessed the effects of SHS exposure on the severity of all-cause childhood pneumonia.

Pneumonia is a leading cause of pediatric hospitalization in the US,[20] and identifying modifiable risk factors to reduce pneumonia severity is a priority.[21] The objective of the present study was to examine the relationship between household SHS exposure and disease severity in children aged <18 years hospitalized with community-acquired pneumonia (CAP) at 3 US children's hospitals, as measured by hospital length of stay, intensive care unit admission, and the use of invasive mechanical ventilation.

aHR	Adjusted hazard ratio
CAP	Community-acquired pneumonia
EPIC	Etiology of Pneumonia in the Community
SHS	Secondhand smoke

Methods

This study used data from children aged <18 years enrolled in the Centers for Disease Control and Prevention's Etiology of Pneumonia in the Community (EPIC) study.[22] The EPIC study is a prospective, population-based surveillance study of childhood CAP hospitalizations at 3 US children's hospitals: Le Bonheur Children's Hospital in Memphis, Primary Children's Medical Center in Salt Lake City, and Monroe Carell Jr Children's Hospital at Vanderbilt in Nashville. Children were enrolled in the EPIC study between January 2010 and June 2012. Eligible children were hospitalized at a study hospital and resided within a defined study catchment area. Inclusion criteria were evidence of acute infection (eg, fever), signs or symptoms of acute respiratory illness (eg, new cough), and radiographic evidence of pneumonia. Exclusion criteria were any of the following: recent hospitalization (30 days for immunocompetent or 90 days for immunocompromised), cystic fibrosis, significant immunosuppression, tracheostomy, or a clear alternative diagnosis (eg, pulmonary embolism).

Data collection for the EPIC study was done through standardized interviews (collecting sociodemographic characteristics, medical history, and history of present illness) and medical record reviews (capturing hospitalization course and outcomes). Informed consent was obtained before enrollment. The study protocol was approved by the Institutional Review Board of each study institution and the Centers for Disease Control and Prevention.

Household SHS Exposure

SHS exposure was determined by caregiver response to the question, "How many household members smoke (either indoors or outdoors)?" Children whose caregiver responded "none" were considered nonexposed (referent group). Those indicating the presence of 1 or more household smokers (hereinafter referred to as "any household smoker") were further categorized as 1 household smoker or ≥2 household smokers. Children missing household SHS exposure data were excluded. Children aged >9 years who identified themselves as current smokers and those missing personal smoking history data were excluded as well.

Outcomes

The primary outcome was hospital length of stay, measured in hours. Secondary outcomes included intensive care unit admission and receipt of invasive mechanical ventilation. Although a single, validated measure for assessing childhood pneumonia outcomes is not available, our selected measures are often used to assess disease outcomes in children hospitalized with acute respiratory illness, including pneumonia.[18,23] Children missing outcome data were excluded from our analysis.

Statistical Analyses

Descriptive statistics included frequency and percentage for categorical variables and median and IQR for continuous variables. Baseline characteristics according to reported home SHS exposure were compared using the Kruskall-Wallis and χ^2 tests for continuous and categorical variables, respectively. Multivariable Cox proportional hazard regression was used to model the association between SHS exposure and hospital length of stay (ie, time to discharge). In Cox regression, a hazard ratio <1 indicates a lower probability of experiencing the outcome for the comparator group at any given point in time. Thus, in our study, a hazard ratio <1 indicates a lower probability of discharge for children exposed to SHS compared with nonexposed children. Visual inspection of log-log plots was used to confirm the proportional hazards assumption (data not shown). For categorical outcomes (intensive care unit admission and invasive mechanical ventilation), multivariable logistic regression was used. For each outcome, 2 separate models were constructed. The first model compared no reported home SHS exposure with any household smoker. The second model compared no reported home SHS exposure with 1 household smoker and also with ≥2 household smokers. All models were adjusted for the following factors, selected a priori based on hypothesized associations with SHS exposure and/or outcomes: age, sex, race/ethnicity, household education level, government insurance, individual high-risk comorbidities (ie, persistent asthma [requiring inhaled corticosteroids], prematurity [if age <24 months], neurologic disorder, cardiopulmonary disorder, and other [including endocrine, renal, hepatic, hematologic, immunologic, chromosomal, and genetic/metabolic disorders]), enrollment site, season (winter, spring, summer, fall), and year. Adjusted hazard ratio (aHR) or aOR and 95% CI were reported.

For the primary outcome, 2 alternative models were examined as well. First, the main analysis was repeated after including terms for microbiologic etiology (bacterial and viral detection from blood and/or respiratory specimens, as described previously[22]). Then the main analysis was repeated after stratifying by asthma history. The results of both analyses were similar to those of the main analysis (data not shown). All analyses were conducted using Stata 13.1 (StataCorp, College Station, Texas).

Results

A total of 2358 children with CAP were enrolled in the EPIC study. Of these, 2219 children (94.1%) with complete data constituted the final study population (Figure 1; available at www.jpeds.com). Among these children, 1434 (64.6%) were not exposed to SHS, 460 (20.7%) were exposed to 1 household smoker, and 325 (14.7%) were exposed to ≥2 household smokers (Table I). The median age of the children was 26 months (IQR, 12-63); 55.0% were male; and 39.2%, 33.1%, and 19.5% were non-Hispanic white, non-Hispanic black, and Hispanic, respectively. Overall, 36.7% of the children had 1 or more high-risk comorbidities, including 11.8% with persistent asthma. Asthma occurred with similar frequency in SHS-exposed