Home Smoke Exposure and Health-Related Quality of Life in Children with Acute Respiratory Illness

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OBJECTIVE: This study aims to assess whether secondhand smoke (SHS) exposure has an impact on health-related quality of life (HRQOL) in children with acute respiratory illness (ARI).

METHODS: This study was nested within a multicenter, prospective cohort study of children (two weeks to 16 years) with ARI (emergency department visits for croup and hospitalizations for croup, asthma, bronchiolitis, and pneumonia) between July 1, 2014 and June 30, 2016. Subjects were surveyed upon enrollment for sociodemographics, healthcare utilization, home SHS exposure (0 or ≥1 smoker in the home), and child HRQOL (Pediatric Quality of Life Physical Functioning Scale) for both baseline health (preceding illness) and acute illness (on admission). Data on insurance status and medical complexity were collected from the Pediatric Hospital Information System database. Multivariable linear mixed regression models examined associations between SHS exposure and HRQOL.

RESULTS: Home SHS exposure was reported in 728 (32%) of the 2,309 included children. Compared with nonexposed children, SHS-exposed children had significantly lower HRQOL scores for baseline health (mean difference –3.04 [95% CI –4.34, –1.74]) and acute illness (–2.16 [–4.22, –0.10]). Associations were strongest among children living with two or more smokers. HRQOL scores were lower among SHS-exposed children for all four conditions but only significant at baseline for bronchiolitis (–2.94 [–5.0, –0.89]) and pneumonia (–4.13 [–6.82, –1.44]) and on admission for croup (–5.71 [–10.67, –0.75]).

CONCLUSIONS: Our study demonstrates an association between regular SHS exposure and decreased HRQOL with a dose-dependent response for children with ARI, providing further evidence of the negative impact of SHS. *Journal of Hospital Medicine* 2019;14:212-217. © 2019 Society of Hospital Medicine

Acute respiratory illnesses (ARIs), including acute exacerbations of asthma, croup, pneumonia, and bronchiolitis, are among the most common illnesses in childhood.[1] Although most ARIs can be managed in the outpatient setting, hospitalization is common with respiratory illnesses accounting for >425,000 hospitalizations annually.[1] Pneumonia, asthma, and bronchiolitis each rank among the top five reasons for pediatric hospitalization in the United States.[1] Successful efforts to prevent or mitigate the severity of ARIs could have a major impact on child health.

Exposure to secondhand smoke (SHS) is a preventable risk factor for ARI in children, particularly when there is regular exposure in the home.[2] Chronic exposure to SHS impacts systemic inflammation by suppressing serum interferon-gamma,[3] which can lead to increased susceptibility to viral and bacterial infections,[4] and increasing Th2 (atopic) cytokine expression, which is associated with asthma.[5] SHS exposure in children has also been linked to diminished lung function.[6] As a result, SHS exposure is associated with increased ARI susceptibility and severity in children.[7-10]

Much research has focused on the clinical impact of SHS exposure on respiratory health in children, but little is known about the impact on patient-reported outcomes, such as health-related quality of life (HRQOL). Patient-reported outcomes help provide a comprehensive evaluation of the effectiveness of healthcare delivery systems. These outcomes are increasingly used by health service researchers to better understand patient and caregiver perspectives.[11] Given the known associations between SHS exposure and ARI morbidity, we postulated that regular SHS exposure would also impact HRQOL in children. In this study, we assessed the relationship

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between SHS exposure and HRQOL within a large, multicenter, prospective cohort of children presenting to the emergency department (ED) and/or hospital with ARI.

METHODS

Study Population

This study was nested within the Pediatric Respiratory Illness Measurement System (PRIMES) study, a prospective cohort study of children with ARI in the ED and inpatient settings at five tertiary care children's hospitals within the Pediatric Research in Inpatient Settings Network in Colorado, Pennsylvania, Tennessee, Texas, and Washington. Eligible children were two weeks to 16 years of age hospitalized after presenting to the ED with a primary diagnosis of asthma, croup, bronchiolitis, or pneumonia between July 1, 2014 and June 30, 2016. Because of an anticipated low frequency of croup hospitalizations, we also included children presenting to the ED and then discharged to home with this diagnosis. Children were assigned to a PRIMES diagnosis group based on their final discharge diagnosis. If there was a discrepancy between admission and discharge diagnoses, the discharge diagnosis was used. If a child had more than one discharge diagnosis for a PRIMES condition (eg, acute asthma and pneumonia), we chose the PRIMES condition with the lowest total enrollments overall. If the final discharge diagnosis was not a PRIMES condition, the case was excluded from further analysis. Patients with immunodeficiency, cystic fibrosis, a history of prematurity <32 weeks, chronic neuromuscular disease, cardiovascular disease, pulmonary diseases (other than asthma), and moderate to severe developmental delay were also excluded. Children admitted to intensive care were eligible only if they were transferred to an acute care ward <72 hours following admission. A survey was administered at the time of enrollment that collected information on SHS exposure, HRQOL, healthcare utilization, and demographics. All study procedures were reviewed and approved by the institutional review boards at each of the participating hospitals.

SECONDHAND SMOKE EXPOSURE

To ascertain SHS exposure, we asked caregivers, "How many persons living in the child's home smoke?" Responses were dichotomized into non-SHS exposed (0 smokers) and SHS exposed (≥1 smokers). Children with missing data on home SHS exposure were excluded.

Health-Related Quality of Life Outcomes

We estimated HRQOL using the Pediatric Quality of Life (PedsQL™) 4.0 Generic Core and Infant Scales. The PedsQL instruments are validated, population HRQOL measures that evaluate the physical, mental, emotional, and social functioning of children two to 18 years old based on self- or caregiver-proxy report.[12-15] These instruments have also shown responsiveness as well as construct and predictive validity in hospitalized children.[11] For this study, we focused on the PedsQL physical functioning subscale, which assesses for problems with physical activities (eg, sports activity or exercise, low energy, and hurts or aches) on a five-point Likert scale (never to almost always a problem). Scores range from 0 to 100 with higher scores indicating a better HRQOL. The reported minimal clinically important difference (MCID), defined as the smallest difference in which individuals would perceive a benefit or would necessitate a change in management, for this scale is 4.5 points.[16,17]

Children ≥8 years old were invited to complete the self-report version of the PedsQL. For children <8 years old, and for older children who were unable to complete them, surveys were completed by a parent or legal guardian. Respondents were asked to assess perceptions of their (or their child's) HRQOL during periods of baseline health (the child's usual state of health in the month preceding the current illness) and during the acute illness (the child's state of health at the time of admission) as SHS exposure may influence perceptions of general health and/or contribute to worse outcomes during periods of acute illness.

Covariates collected at the time of enrollment included sociodemographics (child age, gender, race/ethnicity, and caregiver education), and healthcare utilization (caregiver-reported patient visits to a healthcare provider in the preceding six months). Insurance status and level of medical complexity (using the Pediatric Medical Complexity Algorithm)[18] were obtained using the Pediatric Hospital Information System database, an administrative database containing clinical and resource utilization data from >45 children's hospitals in the United States including all of the PRIMES study hospitals.[13]

Analysis

Descriptive statistics included frequency (%) and mean (standard deviation). Bivariate comparisons according to SHS exposure status were analyzed using chi-squared tests for categorical variables and analysis of variance for continuous variables. Multivariable linear mixed regression models were used to examine associations between home SHS exposure and HRQOL for baseline health and during admission, overall and stratified by diagnosis. Covariates in each model included age, sex, race/ethnicity, caregiver education, and healthcare visits in the preceding six months. We also included a hospital random effect to account for clustering of patients within hospitals and used robust standard errors for inference.

In a secondary analysis to explore potential dose-response effects of SHS exposure, we examined associations between an ordinal exposure variable (0 smokers, 1 smoker, ≥2 smokers) and HRQOL for baseline health and during admission for the acute illness. Because of sample size limitations, diagnosis-specific analyses examining dose-response effects were not conducted.

RESULTS

Study Population

Of the 2,334 children enrolled in the PRIMES study, 25 (1%) respondents did not report on home SHS exposure and were excluded, yielding a final study population of 2,309 children, of whom 728 (32%) had reported home SHS exposure. The

TABLE 1. **Characteristics of the Study Population**

Characteristic	Combined N = 2,309	Nonexposed n = 1,581	SHS-Exposed n = 728	*P* Value
Age, mean (SD)	3.6 (3.7)	3.4 (3.7)	3.9 (3.9)	.01
Male	1,326 (59)	917 (60)	409 (58)	.6
Race/Ethnicity				
Non-Hispanic white	912 (40)	663 (42)	249 (34)	
Non-Hispanic black	511 (22)	304 (19)	207 (29)	
Hispanic	559 (24)	402 (26)	157 (22)	
Other	316 (14)	206 (13)	110 (15)	<.001
Comorbidities[a]				
Nonchronic	1,278 (55)	928 (59)	350 (48)	
Noncomplex Chronic	924 (40)	583 (37)	341 (47)	
Complex Chronic	101 (4)	66 (4)	35 (5)	<.001
Caregiver Education				
<High School	233 (10)	146 (9)	87 (12)	
High School	553 (24)	312 (20)	241 (33)	
>High School	1,508 (66)	1,112 (71)	396 (55)	<.001
Public Insurance	1,303 (57)	770 (49)	533 (73)	<.001
Diagnosis				
Asthma	664 (29)	415 (26)	249 (34)	
Bronchiolitis	740 (32)	502 (32)	238 (33)	
Croup	342 (15)	255 (16)	87 (12)	
Pneumonia	563 (24)	409 (26)	154 (21)	<.001
Healthcare Visits in the Last 6 Months				
0	240 (10)	156 (10)	84 (12)	
1-2	932 (40)	645 (41)	287 (39)	
3-4	714 (31)	482 (30)	232 (32)	
5+	423 (18)	298 (19)	125 (17)	.6

[a]Comorbidities were assessed using the Pediatric Medical Complexity Algorithm (see reference 10); Pediatric Respiratory Illness Measurement System eligibility criteria excluded children with immunodeficiency, cystic fibrosis, a history of prematurity <32 weeks, chronic neuromuscular disease, cardiovascular disease, pulmonary diseases (other than asthma), and moderate to severe developmental delay. Data are presented as no. (%) unless otherwise noted. *P* values compared nonexposed to SHS-exposed columns.

Abbreviations: SHS, secondhand smoke; SD, standard deviation.

study population included 664 children with asthma (mean age seven years [3.5]; 38% with home SHS exposure), 740 with bronchiolitis (mean age 0.7 years [0.5]; 32% with home SHS exposure), 342 with croup (mean age 1.7 [1.1]; 25% with home SHS exposure), and 563 with pneumonia (mean age 4.4 [3.8]; 27% with home SHS exposure; Table 1). Compared with non-SHS-exposed children, those with home SHS exposure tend to be slightly older (3.9 vs 3.4 years, $P = .01$), more likely to be non-Hispanic Black (29% vs 19%, $P < .001$), to have a chronic condition (52% vs 41%, $P < .001$), to come from a household where caregiver(s) did not graduate from college (45% vs 29%, $P < .001$), and to have public insurance (73% vs 49%, $P < .001$).

Home SHS Exposure and Health-related Quality of Life

The overall mean HRQOL score for baseline health was 83 (15), with a range across diagnoses of 82 to 87. Compared with non-SHS-exposed children, children with home SHS exposure had a lower mean HRQOL score for baseline health (adjusted mean difference –3.04 [95% CI -4.34, –1.74]). In analyses stratified by diagnosis, baseline health scores were lower for SHS-exposed children for all four conditions, but differences were statistically significant only for bronchiolitis (adjusted mean difference –2.94 [–5.0, –0.89]) and pneumonia (adjusted mean value –4.13 [–6.82, –1.44]; Table 2); none of these differences met the MCID threshold.

The overall mean HRQOL score at the time of admission was 56 (23), with a range across diagnoses of 49 to 61, with lower scores noted among SHS-exposed children compared with non-SHS-exposed children (adjusted mean difference –2.16 [–4.22, –0.10]). Similar to scores representing baseline health, admission scores were lower across all four conditions for SHS-exposed children. Only children with croup, however, had

TABLE 2. **Adjusted Mean Difference in Health-Related Quality of Life (PedsQL Physical Functioning Scale) for SHS-Exposed Children Compared with Nonexposed Children**

	Adjusted Mean Difference (95% CI)	
	Baseline	**Admission**
Combined	–3.04 (–4.34, –1.74)	–2.16 (–4.22, –0.10)
Diagnosis		
Asthma	–2.44 (–5.09, 0.22)	–1.53 (–5.86, 2.81)
Bronchiolitis	–2.94 (–5.00, –0.89)	–2.63 (–5.49, 0.23)
Croup	–0.10 (–2.98, 2.79)	–5.71 (–10.67, –0.75)
Pneumonia	–4.13 (–6.82, –1.44)	–2.04 (–6.57, 2.48)

Covariates included age, gender, race/ethnicity, caregiver education, insurance status, comorbidities, and healthcare visits during the past 6 months.

Abbreviation: PedsQL, Pediatric Quality of Life.

TABLE 3. **Adjusted Mean Difference in Health-Related Quality of Life (PedsQL Physical Functioning Scale) for Children Living with One Smoker or ≥2 Smokers**

	Adjusted Mean Difference (95% CI)	
No. Smokers in the Home	**Baseline**	**Admission**
0	Ref	Ref
1	–2.22 (–3.66, –0.78)	–1.48 (–3.75, 0.79)
≥ 2	–3.92 (–6.03, –1.81)	–3.67 (–6.98, –0.36)

Covariates included age, gender, race/ethnicity, caregiver education, insurance status, comorbidities, and healthcare visits during the past 6 months.

Abbreviation: PedsQL, Pediatric Quality of Life.

significantly lower admission scores that also met the MCID threshold (adjusted mean difference –5.71 [–10.67, –0.75]; Table 2).

To assess for potential dose-response effects of SHS exposure on HRQOL, we stratified SHS-exposed children into those with one smoker in the home (n = 513) and those with ≥2 smokers in the home (n = 215). Compared with non-SHS-exposed children, both HRQOL scores (baseline health and admission) were lower for SHS-exposed children. Consistent with a dose-response association, scores were lowest for children with ≥2 smokers in the home, both at baseline health (adjusted mean difference –3.92 [–6.03, –1.81]) and on admission (adjusted mean difference –3.67 [–6.98, –0.36]; Table 3).

DISCUSSION

Within a multicenter cohort of 2,309 children hospitalized with ARI, we noted significantly lower HRQOL scores among children exposed to SHS in the home as compared with nonexposed children. Differences were greatest for children living with ≥2 smokers in the home. In analyses stratified by diagnosis, differences in baseline health HRQOL scores were greatest for children with bronchiolitis and pneumonia. Differences in acute illness scores were greatest for children with croup.[16]

Our study provides evidence for acute and chronic impacts of SHS on HRQOL in children hospitalized with ARI. Although several studies have linked SHS exposure to reduced HRQOL in adults,[19,20] few similar studies have been conducted in children. Nonetheless, a wealth of studies have documented the negative impact of SHS exposure on clinical outcomes among children with ARI.[8,10,21-23] Our findings that home SHS exposure was associated with reduced HRQOL among our cohort of children with ARI are therefore consistent with related findings in adults and children. The observation that the effects of SHS exposure on HRQOL were greatest among children living with ≥2 smokers provides further evidence of a potential causal link between regular SHS exposure and HRQOL.

Although the magnitude and significance of associations between SHS exposure and HRQOL varied for each of the four diagnoses for baseline health and the acute illness, it is important to note that the point estimates for the adjusted mean differences were uniformly lower for the SHS-exposed children in each subgroup. Even so, only acute illness scores for croup exceeded the MCID threshold.[16] Croup is the only included condition of the upper airway and is characterized by laryngotracheal inflammation leading to the typical cough and, in moderate to severe cases, stridor. Given that chronic SHS exposure induces a proinflammatory state,[3] it is possible that SHS-exposed children with croup had more severe illness compared with nonexposed children with croup resulting in lower HRQOL scores on admission. Further, perceived differences in illness severity and HRQOL may be more readily apparent in children with croup (eg, stridor at rest vs intermittent or no stridor) as compared with children with lower respiratory tract diseases.

Of the four included diagnoses, the link between SHS exposure and asthma outcomes has been most studied. Prior work has demonstrated more frequent and severe acute exacerbations, as well as worse long-term lung function among SHS-exposed children as compared with nonexposed children.[22-24] It was, therefore, surprising that our study failed to demonstrate associations between SHS exposure and HRQOL among children with asthma. Reasons for this finding are unclear. One hypothesis is that caregivers of SHS-exposed children with asthma may be more aware of the impacts of SHS exposure on respiratory health (through prior education) and, thus, more likely to modify their smoking behaviors, or for their children to be on daily asthma controller therapy. Alternatively, caregivers of children with asthma may be more likely to underreport home SHS exposure. Thirty-eight percent of children with asthma, however, were classified as SHS-exposed. This percentage was greater than the other three conditions studied (25%-32%), suggesting that differential bias in underreporting was minimal. Given that children with asthma were older, on average, than children with the other three conditions, it may also be that these children spent more time in smoke-free environments (eg, school).

Nearly one-third of children in our study were exposed to SHS in the home. This is similar to the prevalence of exposure in other studies conducted among hospitalized children[8,10,21,25] but higher than the national prevalence of home SHS exposure among children in the United States.[26] Thus, hospitalized children represent a particularly vulnerable population and an important target for interventions aiming to reduce exposure to SHS. Although longitudinal interventions are likely necessary to affect long-term success, hospitalization for ARI may serve as a powerful teachable moment to begin cessation efforts. Hospitalization also offers time beyond a typical primary care outpatient encounter to focus on cessation counseling and may be the only opportunity to engage in counseling activities for some families with limited time or access. Further, prior studies have demonstrated both the feasibility and the effectiveness of smoking cessation interventions in hospitalized children.[27-30] Unfortunately, however, SHS exposure is often not documented at the time of hospitalization, and many opportunities to intervene are missed.[25,31] Thus, there is a need for improved strategies to reliably identify and intervene on SHS-exposed children in the hospital setting.

These findings should be considered in the context of several limitations. The observational nature of our study raises the potential for confounding, specifically with regard to socioeconomic status, as this is associated with both SHS exposure and lower HRQOL. Our modeling approach attempted to control for several factors associated with socioeconomic status, including caregiver education and insurance coverage, but there is potential for residual confounding. No single question is sufficient to fully assess SHS exposure as the intensity of home SHS exposure likely varies widely, and some children may be exposed to SHS outside of the home environment.[32] The home, however, is often the most likely source of regular SHS exposure,[33,34] especially among young children (our cohort's mean age was 3.6 years). Misclassification of SHS exposure is also possible due to underreporting of smoking.[35,36] As a result, some children regularly exposed to SHS may have been misclassified as nonexposed, and the observed associations between SHS exposure and HRQOL may be underestimated. Confirming our study's findings using objective assessments of SHS exposure, such as cotinine, are warranted. Given the young age of our cohort, the PedsQL surveys were completed by the parent or legal guardian only in >90% of the enrolled subjects, and caregiver perceptions may not accurately reflect the child's perceptions. Prior work, however, has demonstrated the validity of parent-proxy reporting of the PedsQL, including correlation with child self-report.[37] In our study, correlation between child and caregiver reporting (when available) was also very good (r = 0.72, 95% CI 0.64, 0.77). It is also possible that the timing of the HRQOL assessments (on admission) may have biased perceptions of baseline HRQOL, although we anticipate any bias would likely be nondifferential between SHS-exposed and nonexposed children and across diagnoses.

Nearly one-third of children in our study were exposed to SHS exposure in the home, and SHS exposure was associated with lower HRQOL for baseline health and during acute illness, providing further evidence of the dangers of SHS. Much work is needed in order to eliminate the impact of SHS on child health and families of children hospitalized for respiratory illness should be considered a priority population for smoking cessation efforts.

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