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Indoor Tobacco Legislation is Associated with Fewer Emergency Department Visits for Asthma Exacerbation in Children

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Keywords

Secondhand Smoke; Public Policy; Asthma; Asthma Exacerbation; Tobacco Smoke Pollution; Pediatrics; Legislation; Asthma Epidemiology; Asthma Triggers

Introduction

Over the past three decades, numerous cities and states have adopted laws that ban smoking in public indoor spaces, including hotels, workplaces, restaurants, and bars. The rationale for these policies is to protect nonsmokers from the numerous adverse health effects of second hand smoke. One population that is particularly susceptible to the adverse effects of second hand smoke exposure is children as they typically have little or no control over their surrounding environment. As approximately 8% of children now have asthma and second hand tobacco smoke is a known trigger for asthma exacerbation, these policies would ideally decrease asthma exacerbation; however, little is known of about the overall impact of these local and state policies on protecting children from severe asthma exacerbations.[1]

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Common triggers for asthma exacerbations in children include allergens, (such as animal dander, pollens, molds, and pests), weather changes, upper respiratory infections, influenza, and inhaled irritants such as tobacco smoke.[2] National campaigns have emphasized vaccinations and hand hygiene to reduce the transmission of infectious diseases that may trigger asthma exacerbations. Few other triggers, however, have potential to be controlled and/or reduced by public policy, except for indoor and outdoor air quality, particularly tobacco smoke exposure. Although national campaigns have also increased awareness of the adverse effects of smoking tobacco, children may still be adversely influenced by smoke exposure in restaurants and other public spaces. As medical expenses related to asthma now exceed $70 billion a year, the implementation of smoking bans in indoor public spaces not only has the potential to significantly decrease the incidence of asthma exacerbation in children but also to lead to an overall significant decrease in the costs associated with this disease by protecting this vulnerable population from this potent asthma trigger.[3]

This study assesses the association between municipal and state indoor smoking legislation and severe asthma exacerbation resulting in emergency department visits to pediatric hospitals. We hypothesized that despite variations in policy among cities and states, restricting smoking in public indoor spaces would be associated with an overall decrease in the incidence of emergency department visits for asthma exacerbation in children.

Methods

Study Design and Setting

This study design was a retrospective, secondary data analysis capitalizing on a natural experiment to estimate the impact of clean indoor air legislation on the rate of emergency department (ED) admissions for asthma exacerbation. The study sample was limited to children under the age of 18 who were treated at a pediatric hospital. Data from the twenty United States children's hospitals in which a complete data set was available were included covering 3 years prior to indoor smoking legislation until 3 years after implementation of indoor smoking legislation for the region surrounding the hospital. This study was approved by our local hospital Institutional Review Board and the deidentified data were analyzed.

Participants

Metropolitan areas were included if 1) the metropolitan area had a local children's hospital that contributes data to the Pediatric Health Information System (PHIS) and if 2) ED data were available in PHIS for 3 years prior to indoor smoking legislation and 3 years post indoor smoking legislation for the area surrounding the hospital. Data were not available for any metropolitan area that allowed indoor smoking in public buildings to use as "controls".

Data Sources and Variables

PHIS contains inpatient, ED, ambulatory surgery and observation data from 44 not-for-profit, tertiary care pediatric hospitals in the United States. These hospitals are affiliated with the Children's Hospital Association (Overland Park, KS), which serves as the data repository for these secondary data. Data quality and reliability are assured through a joint effort between the Children's Hospital Association and participating hospitals. The data warehouse function for the PHIS database is managed by Truven Health Analytics (Ann Arbor, MI). For the purposes of external benchmarking, participating hospitals provide discharge/encounter data including demographics, diagnoses, and procedures. Data are de-identified at the time of data submission, and data are subjected to a number of reliability and validity checks before being included in the database. It has been estimated that this database captures approximately 15% of all pediatric admissions across the country.[4–6]

We obtained data for all ED visits by children under the age of 18 with a primary discharge diagnosis of asthma (International Classification of Diseases, Ninth Revision code 493) utilizing PHIS. Date of discharge, admit age in years, gender, race, payer source, and cost of visit were also downloaded from the PHIS database.

The remaining data were retrieved from publicly available records. Dates of indoor smoking legislation for each metropolitan area were determined from the Americans for Nonsmokers' Rights website and Wikipedia then confirmed on local/regional websites.[7,8] Population estimates (<18 years of age) for each metropolitan statistical area (MSA) for each included year were obtained from the United States Census Bureau and used as the denominators in rate calculations.[9]

Measures

Dependent variable/Outcome measure: The primary outcome measure was the rate of ED visits for asthma each day. The number of ED admissions for asthma was counted for each day. As asthma exacerbations were counted rather than individuals, individual children may be included in the analyses more than once. Rates were calculated by dividing the number of ED admissions for each day by the child population of the MSA for the respective year.

Independent Variables/Covariates/Adjusters: Independent variables were as follows. A dummy variable was coded to test the impact of legislation with 0 indicating an event prior to legislation in the region surrounding the hospital and 1 indicating an event after legislation in the same region. In order to account for seasonal variation in asthma exacerbation, first and second order harmonics were included in the model as was done in a related type of analysis.[10] In order to control for secular linear time trends in asthma, a variable was created that assigned a unique number 1–163 for each month beginning January 2000 to July 2013. Results were unchanged when the linear time trend was replaced with separate indicator variables for each month in the data. Finally, gender, black race, payer source (Medicaid versus all other) and admit age were included in the adjusted model.

Statistical Analysis

Poisson regression with negative binomial distribution to account for overdispersion was used to model the rate of ED visits for asthma exacerbation for combined and local data and results are presented as rate ratios (RR). Records with missing covariates were retained in the final model. It is possible that our policy measures, which change from zero to one at the time of the smoking legislation, are just capturing temporal variations in ED rates. To mitigate this concern, we conducted a falsification test where we assigned an arbitrary date of January 1, 2007 for our policy variable in all locations. We expected to find no statistically significant policy effect in this placebo test. All analyses were conducted using SAS software version 9.3 (SAS Institute, Pacific Grove, CA).

RESULTS

For the cities that contribute to the PHIS database, indoor tobacco legislation was implemented between January 1, 1990 (Norfolk, VA) and June 4, 2012 (Birmingham, AL). Almost half of the included municipalities (19 of 43) implemented indoor tobacco legislation between the years 2006 and 2008. At the time we accessed the data (second quarter of 2014), 20 of the 44 hospitals which participate in PHIS had data available for 3 years prior to implementation of indoor smoking legislation and 3 years after implementation. These 20 hospitals were located in 14 different states plus the District of Columbia. A total of 335,588 asthma ED visits were captured from these hospitals from July 2000 to January 2014. Included hospitals, the relevant MSA, the estimated population (children <18) for the MSA at the time of smoke free ordinance, and the dates of implementation of the smoking ordinance are included in Table 1.

The impact of indoor tobacco legislation in each individual metropolitan area varied. A statistically significant reduction was found in four urban regions and ranged from 5% to 15% in adjusted analyses (secular trends, seasonality, male gender, Medicaid status, black race, and age). However, two cities had a statistically significant increase rate in ED visits for asthma in children despite indoor tobacco legislation (adjusted RR=1.14 and 1.44). These results are summarized in Table 2.

In the pooled results, indoor smoking legislation was associated with a 17% decrease in childhood ED visits for asthma exacerbation between the 3 years prior to law implementation and 3 years after law implementation after controlling for secular trends, seasonality, male gender, Medicaid status, black race, and age (adjusted RR, 0.83; 95% CI, 0.82 to 0.85; p<0.001). An appreciable and increasing rate reduction was also seen after only 1 year post law implementation (adjusted RR, 0.92; 95% CI, 0.90 to 0.94; p<0.001) as well as 2 years after law implementation (adjusted RR, 0.87; 95% CI, 0.85 to 0.88; p<0.001). These results are included in Table 3.

Results for our falsification test are included in Table 4. We found no statistically significant relationship between our placebo policy measure and ED visits in all but the 2 year estimation; however, in the case of the 2 year estimation, the rate ratio estimates are nearly one (adjusted RR, 0.96; 95% CI, 0.94 to 0.98; p<0.0001). Lack of meaningful effects in the falsification test increase our confidence that we are capturing true policy effects in our baseline models.

DISCUSSION

The objective of our analysis was to examine the impact of indoor smoking legislation in the US on pediatric asthma exacerbations that lead to emergency room visits. Considering three years pre- and post-legislation data pooled across 20 geographic locations, we found that indoor smoking legislation was associated with a 17% decrease in the incidence of severe asthma emergency room visits. Significant decreases also occurred within one year and two year time windows. The absolute degree of reduction varied across metropolitan areas.

These results overall support the importance of widespread restriction of smoking in public places on the respiratory health of children. States and metropolitan areas that have yet to implement such protective laws should consider new ordinances in order to protect the respiratory health of their children. As of January 2014, ten states remained with no general statewide ban on indoor smoking: Alabama, Alaska, Kentucky, Mississippi, Missouri, Oklahoma, South Carolina, Texas, West Virginia, and Wyoming. In addition, Oklahoma remains the only state in which state law prohibits local governments from regulating smoking more strictly than the state. As most major metropolitan areas have implemented indoor smoking bans despite the lack of a statewide ban, Oklahoma is the only state without any legislated smoking bans[7–8].

The results of this study are corroborated by similar findings from previous studies on both a national and regional level. Rayens et al reported a very similar 18% (95% CI, 4% to 29%) decline in childhood ED visits for asthma in Lexington-Fayette County, Kentucky after implementation of indoor smoking legislation. Their study also found a 24% (95% CI, 16% to 31%) decrease in adults with a total reduction across all ages of 22% (95% CI 14% to 29%).[10] A second study in 2010 by Mackay et al reported an 18.2% (95% CI, 14.7% to 21.8%) decrease in hospital admissions for asthma in Scotland in both preschool and school-age children after analyzing over 21,000 hospital admissions for asthma over a 9 year period.[11] The publication of the latter study was followed by a Letter to the Editor of the Journal which also described a 30.7% (95% CI, 22.8% to 38.6%) decrease in asthma admissions in the Lombardy region of Italy after analyzing over 15,000 asthma admissions.[12] Finally, Millett et al described a 9% (95% CI, 7% to 11%) decrease in pediatric asthma admissions after smoke-free legislation in England in 2007.[13] These results collectively support the findings of this study as well as the positive impact of indoor tobacco legislation on pediatric asthma.

To our knowledge only one study has been published that failed to find that indoor tobacco legislation had an impact on asthma exacerbation in children. In 2013, Gaudreau et al analyzed discharge data from the Prince Edward Island Discharge Abstract Database, a validated Canadian database which captures all admissions of Prince Edward Island with Provincial Health Numbers.[14] Although a decrease in acute myocardial infarction post-ban was seen, the Prince Edward Island legislation was not found to decrease pediatric or adult asthma admissions (OR 1.48 95% CI, 0.90 to 2.41). The Prince Edward Island tobacco legislation, however, was unique from legislation implemented in Scotland, England, and most United States cities in that the original 2003 ban still allowed smoking in bars and restaurants in designated smoking rooms.[15] It has been shown that separate smoking areas with or without separate ventilation does not protect nonsmokers from second hand smoke.[16,17] Presumably, restaurants are a major source of second hand tobacco exposure in children outside of the home environment, and therefore, the Canadian legislation in its 2003 form may have been inadequate to protect children (or adults) with asthma.

These data identified two cities in which emergency department visits for asthma in children increased despite legislation. One metropolitan area was struck with natural disaster near the time of implementation of indoor tobacco legislation. As such, any short term benefit of the legislation in this city was likely blunted by several environmental and social factors. The increase in emergency department visits for asthma seen at the other identified city was likely artifact due to the implementation of a marketing campaign across the respective metropolitan area advertising a new asthma center and known effort on the part of the institution to increase access to and quality of asthma care around the time of law implementation. This likely influenced families with an asthmatic child to transfer care to this institution (personal communication with local asthma center).

The strength of this paper is the innovative approach used to understand the impact of public health legislation. Because of the many variables that impact asthma exacerbations, accessing large amounts of data is essential to have appropriate power to determine if indoor smoking legislation is significantly associated with a lower rate of asthma ED admissions. This is exemplified by the inability to determine significance in the small, individual MSA datasets. The collaborative approach that many pediatric hospitals have taken by pooling their billing data into one, unified data warehouse has proven to be an effective strategy to make observations that would otherwise not be feasible.

These findings should be interpreted with full knowledge of the study’s limitations. First, this study was designed to determine association, not causation, and should therefore be interpreted as such. A randomized controlled trial, however, designed to determine causation is not feasible because of the ethical implications of knowingly subjecting children to second hand smoke. Therefore, epidemiologic studies are an essential method to determining the impact of indoor tobacco legislation. Second, this study is attempting to associate a decrease in asthma exacerbation with implementation of several unique, regional legislations. As no national indoor smoking legislation exists, a comparison of unique legislations was also necessary and exemplified by the fact that no difference in rates existed pre- and post- indoor tobacco legislation, with several of the smaller datasets obtained from one regional hospital within each MSA. This limitation is also likely to have minimal influence in the findings as the major source of variability in each policy was the inclusion or exclusion of bars, casinos, and/or other age restricted environments which are unlikely to have a significant impact on children. Third, since all of the pediatric hospitals who contribute data to PHIS are in metropolitan areas that have passed indoor smoking legislation, we did not have control locations. We attempted to address this concern by using historical comparisons and varying time windows. We also included a falsification test to address concerns about temporal trends in asthma ED visits. In addition, each hospital included was a nonprofit tertiary care pediatric hospital in an urban area, and therefore, the results may not be generalizable to all areas of the country. Finally, as each pediatric hospital which participates in PHIS has unique billing and coding systems, institutional variability in these data may exist; however, we also believe this to be a minor limitation as the PHIS system is supported by a robust data quality program.

In summary, these multi-regional data show a significant decrease in ED visits due to asthma in children is associated with the implementation of indoor tobacco legislation. Since government taxes are typically a significant contributor to fund the cost of children's healthcare, action should be considered in localities that yet remain without indoor tobacco legislation in order to both protect children of the state as well as to allow redistribution of the significant dollars spent on emergency department visits for asthma in these children.

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Abbreviations

PHIS	Pediatric Health Information System
ED	emergency department
MSA	metropolitan statistical area
CI	Confidence Interval
RR	Risk Ratio

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Table 1

PHIS Hospitals and Dates of Implementation of Indoor Smoking Legislation for the Surrounding Area

Hospital Name	Metropolitan Statistical Area	Legislation Date	Population*
Akron Children's Hospital	Akron, OH	12/7/2006	163,798
Children's Healthcare of Atlanta	Atlanta-Sandy Springs-Marietta, GA	7/1/2005	1,294,408
Lurie Children's Hospital of Chicago	Chicago, IL (excluding Naperville and Joliet)	1/1/2008	2,032,829
Cincinnati Children's Hospital Medical Center	Cincinnati-Middleton, OH-KY-IN	12/7/2006	533,094
Nationwide Children's Hospital	Columbus, OH	12/7/2006	435,127
Driscoll Children's Hospital	Corpus Christi, TX	4/14/2009	110,499
Children's Medical Center	Dallas-Plano-Irving, TX	4/10/2009	1,213,665
Children's Hospital Colorado	Denver-Aurora-Broomfield, CO	7/1/2006	614,596
Cook Children's Health Care System	Fort Worth-Arlington, TX	1/1/2008	578,061
Children's Mercy Hospitals and Clinics	Kansas City, MO-KS	6/21/2008	513,593
Le Bonheur Children's Medical Center	Memphis, TN-MS-AR	7/1/2007	353,678
Children's Hospital of Wisconsin	Milwaukee-Waukesha-West Allis, WI	7/5/2010	382,504
Children's Hospitals and Clinics of Minnesota	Minneapolis-St. Paul-Bloomington, MN-WI	10/1/2007	813,548
Children's Hospital	New Orleans-Metairie-Kenner, LA	1/1/2007	239,471
Children's Hospital & Medical Center	Omaha-Council Bluffs, NE-IA	6/1/2009	222,402
Children's Hospital of Pittsburgh of UPMC	Pittsburgh, PA	9/11/2008	482,492
Seattle Children's Hospital	Seattle-Bellevue-Everett, WA	12/8/2005	734,777
St. Louis Children's Hospital	St. Louis, MO-IL	1/2/2011	661,831
All Children's Hospital Johns Hopkins Medicine	Tampa-St. Petersburg-Clearwater, FL	7/1/2003	565,739
Children's National Medical Center	Washington-Arlington-Alexandria, DC-VA-MD-WV	1/1/2007	1,300,697

*Under 18 population at time of indoor tobacco legislation implementation

Table 2

Rate of Pediatric ED Visits for Asthma Exacerbation 3 Years After Implementation of Indoor Tobacco Legislation

Metropolitan Statistical Area	Adjusted RR**	95% CI
MSA #1	0.91 *	0.86,0.96
MSA #2	0.95 *	0.91,0.99
MSA #3	0.87 *	0.82,0.92
MSA #4	0.85 *	0.79,0.92
MSA #5	1.04	0.96,1.12
MSA #6	0.99	0.91,1.08
MSA #7	1.03	0.98,1.08
MSA #8	1.09	1.00,1.18
MSA #9	1.01	0.96,1.07
MSA #10	0.94	0.87,1.01
MSA #11	0.96	0.90,1.02
MSA #12	1.03	0.98,1.09
MSA #13	1.02	0.96,1.09
MSA #14	1.01	0.95,1.06
MSA #15	0.97	0.86,1.09
MSA #16	1.07	1.01,1.15
MSA #17	0.93	0.83,1.03
MSA #18	1.05	0.98,1.12
MSA #19	1.14 *	1.05,1.24
MSA #20	1.44 *	1.33,1.57

* $p<0.05$

** Adjusted for secular trends, seasonality, gender, race, payer source, and admit age 95% CI, 95% confidence interval; RR, Rate Ratio

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Table 3

Rate of Pediatric ED Visits for Asthma Exacerbation After Implementation of Indoor Tobacco Legislation

Metropolitan Statistical Area	Adjusted RR**	95% CI
Pooled (all MSAs)-3 years pre/post	0.83*	0.82,0.85
Pooled (all MSAs)-2 years pre/post	0.87*	0.85,0.88
Pooled (all MSAs)-1 year pre/post	0.92*	0.90,0.94

* $p<0.001$

** Adjusted for secular trends, seasonality, gender, race, payer source, and admit age 95% CI, 95% confidence interval; RR, Rate Ratio

Table 4

Falsification Tests

Metropolitan Statistical Area	Adjusted RR*	95% CI	p value
Pooled (all MSAs)-3 years pre/post	1.01	1.00,1.03	0.09
Pooled (all MSAs)-2 years pre/post	0.96	0.94,0.98	<0.0001
Pooled (all MSAs)-1 year pre/post	0.97	0.92,1.02	0.23

*Adjusted for secular trends, seasonality, gender, race, payer source, and admit age 95% CI, 95% confidence interval; RR, Rate Ratio