

## **Second hand smoke exposure in cars and respiratory health effects in children**

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**Running Title:** Passive smoking in cars in Ireland

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## **Abstract**

**Aim:** We examined potential associations of “ever” asthma, and symptoms of wheeze (past 12 months), hay fever, eczema and bronchitis (cough with phlegm) among school children exposed to second-hand-smoke (SHS) in cars, using a modified Irish International Study of Asthma and Allergies in Childhood (ISAAC) protocol.

**Methods:** 2,809 children aged 13-14 years completed the 2007 ISAAC self-administered questionnaire selected randomly from post-primary schools throughout Ireland. Adjusted odds ratios [AOR] (adjusted for gender, active smoking status of children interviewed and their SHS exposure at home) were estimated for the associations studied, using multivariable logistic regression techniques.

**Results:** Overall 14.8% (13.9% in boys, 15.4% in girls) of Irish children aged 13-14 years were exposed to SHS in cars. Although there was a tendency towards increased likelihood of both respiratory and allergic symptoms with SHS exposure in cars, wheeze and hay fever symptoms were significantly higher (AOR with 95% CI: 1.35 [1.08-1.70] and 1.30 [1.01-1.67]), respectively, while bronchitis symptoms and asthma were not significant (1.33 [0.92-1.95] and 1.07 [0.81-1.42]), respectively.

**Conclusions:** Approximately one in seven Irish school children are exposed to SHS in cars and could have adverse respiratory health effects. Further studies are imperative to explore such associations across different population settings.

**Key words:** Asthma; Bronchitis; Cars; Children; Ireland; Smoking

## **Introduction**

Second-hand-smoke (SHS) is a Group 1 carcinogen. There is no safe level of SHS exposure.<sup>1</sup> Considering that children are relatively more exposed to SHS than adults,<sup>2</sup> and are less likely to prevent their own exposure, children are at greater risk for future SHS related morbidity and mortality. The adverse health effects of SHS exposure among non-smoking children include upper and lower respiratory tract infections (eg, bronchitis and pneumonia), asthma, otitis media, and sudden infant death syndrome.<sup>3-5</sup> Children exposed to SHS also report more days of restricted activity, more days of bed confinement, and more days of school absence than those not exposed to SHS.<sup>6</sup> Exposure of children to SHS in cars increases the risk of nicotine dependence symptoms.<sup>7</sup> Reducing childhood SHS exposure should be a public health priority.

Children may be more vulnerable to SHS-induced respiratory diseases due to smaller airways and greater oxygen demand, as well as less-mature immune system.<sup>8</sup> There is no evidence quantifying SHS-induced respiratory health effects in children exposed to SHS in cars. Three recent studies that examined childhood SHS exposure in cars reported levels of 6.5% in Scotland, 26.3% in Canada, and 40.2% in Nebraska.<sup>9-11</sup> The Republic of Ireland introduced a comprehensive workplace smoking ban in March 2004,<sup>12</sup> with positive health effects being reported post the ban.<sup>12, 13</sup> At present the two domains that offer the best intervention potential are homes and cars. SHS in a car is 23 times more toxic than in a house due to the enclosed space.<sup>14</sup> In the light of such a background, the present study examines the following objectives:

- (a) To estimate the prevalence of childhood SHS exposure in cars among the Irish school-children aged 13-14 years
- (b) To examine an association between childhood SHS exposure in cars and five respiratory health effects (asthma, wheeze, bronchitis symptoms, hay fever, and eczema) among the Irish school-children aged 13-14 years

## **Methods**

We undertook a local ISAAC (International Study of Asthma and Allergies in Childhood) follow up study using the ISAAC questionnaire<sup>15, 16</sup> in 2007 and as part of that study we included an additional question on SHS exposure in cars. The ISAAC sample is a nationally representative sample. Details of the sampling design of the ISAAC studies are described elsewhere.<sup>15, 16</sup>

In brief, the population of interest was school children in the Republic of Ireland aged 13-14 years. School children in this age range were chosen to comply with the ISAAC study requirements. From each school, classes with the greatest proportion of 13 to 14 year olds were selected. The basic sampling frame consisted of all post-primary schools (n=731) excluding special disability schools and those that had less than forty students because of the impracticalities of administering the survey. Schools were selected by stratified random sampling based on school size and composition. They were also stratified by old Health Areas to allow for regional comparisons of the data. A pre-study sample size of at least 3000 children was calculated similar to the study design of a previous study examining respiratory symptoms in Ireland.<sup>17</sup> The data collection was carried out between March and April 2007 before commencement of the main grass and tree pollen season. The questionnaires were self-administered under supervision by the

researchers. A participation rate of 90% was aimed for, and strenuous efforts were made to follow-up students who were absent on the day the questionnaires were administered. School registers were checked for student absentees on the day of the survey and provision made for completed questionnaires from these students to be returned by post. Of 39 schools invited 35 schools participated in this survey. Total sample size was 3,052 respondents, with 2,809 of these being included in the final analyses, the others being excluded due to being outside the required age-group of 13 and 14 years.

### **Health outcomes**

Similar to earlier studies,<sup>15-18</sup> asthma was defined as “ever” asthma and was self-reported. Bronchitis symptoms included having both cough with phlegm during the previous 12 months. Asthmatics were excluded when considering bronchitic symptoms reducing the sample size to 2,278 for this particular health outcome. Hay fever and eczema were self-reported, as “ever” hay fever and “ever” eczema. Wheeze symptoms were ascertained using the question “Have you had wheezing or whistling in the chest in the last 12 months?” [Yes/No] Details on the ISAAC questionnaire are available in appendix I.

### **SHS exposure in cars and at home**

SHS exposure in cars was based on the self-reported question “If you travel to school by car does anyone smoke cigarettes in the car [yes/no]? SHS exposure at home was assessed using the question “Does anyone you live with smoke cigarettes regularly at home? [Yes/No]” and there are boxes referring to those who smoke: mother/father/siblings/others. No objective validation of SHS exposure was done, however, evidence suggests that self-reported SHS exposure correlates strongly with objective measurements, such as serum cotinine level measurements.<sup>19</sup>

### **Statistical analyses**

Both descriptive and multivariable logistic regression analyses were performed using SAS software (version 9.1). In order to identify whether there was an interaction between SHS exposure at home and SHS exposure in cars across the 5 respiratory health effects, stratum-specific estimates were computed stratifying by those children exposed to SHS exposure at home into two sub-groups (exposed and not exposed). The stratum-specific estimates were different and therefore an interaction term was applied to each of the multivariable logistic regression models for tests of interaction. However, in the final models the interaction terms were removed as they were not statistically significant.

First, an unadjusted estimate for each of the health outcomes was computed followed by adjustment for active smoking status of the children alone. Next, only adjustment for SHS exposure at home was performed. Finally for all the potential confounders available to the study (gender, current smoking status of the children, SHS exposure at home), we simultaneously adjusted for the associations examined to compute adjusted odds ratios (AOR) using multivariable logistic regression techniques. Hosmer-Lemeshow goodness-of-fit model was applied.<sup>20</sup> All models were  $p > 0.05$ .

### **Results**

Overall, 14.8% ( $n=417/2,809$ ) of Irish children aged 13-14 years were exposed to smoking in cars in 2007. More girls (15.4%) are exposed to SHS in cars than boys (13.9%). Table I shows childhood prevalence of various respiratory health effects (asthma, wheeze symptoms, bronchitis symptoms, hay fever and eczema) comparing those exposed to SHS in cars to those not exposed to SHS in cars. Almost 52% of girls exposed to SHS in cars have wheeze symptoms compared to 38% girls suffering from wheeze symptoms if not exposed to SHS in cars ( $p < 0.0001$ ). Overall, “ever” asthma prevalence is not significantly greater among children exposed to SHS in cars ( $p = 0.57$ ),

and no significant gender variations. 16% of girls, with no history of asthma, have bronchitis symptoms when exposed to SHS in cars when compared to 8% of girls having bronchitis symptoms if not exposed to SHS in cars ( $p=0.0002$ ). More than 21% of girls also suffer from eczema if exposed to SHS in cars compared to 15.3 % when not exposed ( $p=0.01$ ). Overall, hay fever symptoms are significantly commoner among children exposed to SHS in cars ( $p=0.03$ ).

Table II shows the multivariable logistic regression analyses looking at the associations between childhood SHS exposure in cars and the five health effects studied. On simultaneously adjusting for sex, current smoking status, and SHS exposure at home, children exposed to SHS in cars showed a 35% increased risk of having wheeze symptoms (AOR: 1.35; 95% CI: 1.08; 1.70). Such increased wheeze symptoms persisted when individuals with asthma were also accounted for (1.40; 95% CI: 1.08; 1.80). An increased risk of hay fever symptoms were observed among children exposed to SHS in cars (1.30; 95% CI: 1.01; 1.67). When non-asthmatics with bronchitis symptoms were analyzed, the estimates did not reach statistical significance (1.33; 95% CI: 0.92; 1.95), despite showing a two-fold increased risk when not adjusted for both SHS at home and active smoking status (2.06; 95% CI: 1.46; 2.92). Childhood asthma and eczema are least likely to be associated with SHS exposure in cars (table II).

## **Discussion**

To our knowledge, this is the first epidemiological study that examined potential associations of respiratory health effects in children exposed to involuntary second-hand-smoke in cars across a nationally representative sample of children of 13-14 years of age. Although the observations are less likely due to chance, the study findings are to be interpreted with caution. First, no similar evidence is available elsewhere to compare with. Second, misclassification bias in exposure assessment is always a possibility in a

cross-sectional survey. Third, residual confounding might also be a possibility because of some unmeasured/unidentified confounders.

The self-reported childhood SHS exposure in cars in Ireland at 14.8% is higher than that reported in pupils (mean age=11.4 years) in Scotland one year post the Scottish smoking ban in 2006 (6.5%),<sup>9</sup> but lower than the reported prevalence among youths of 12 and 17 years of age in Canada where a similar ban was not in place (26.3%).<sup>10</sup> SHS exposure in cars might also indirectly reflect the ‘heavy’ smoking habits of those smoking at home. Unfortunately, the Irish ISAAC 2007 question on SHS exposure in cars does not make such distinctions and thus could not be accounted for in the analyses phase. Girls were significantly more exposed to SHS in cars in the present study. Girls exposed to SHS in cars also had significantly increased odds of suffering from both wheeze and bronchitis symptoms when compared to boys of similar age. This study, however, showed that childhood asthma is not statistically associated with SHS exposure in cars.

Similar to all cross-sectional surveys, this study has methodological limitations in addition to those mentioned earlier. Smoking history (SHS both in cars and at home, and active smoking) and the health effects are self-reported, and this might introduce recall and misclassification biases. Such exposure misclassification bias would be non-differential further pushing the odds ratios towards null estimates. Empirical evidence also suggests that objective measurements using serum cotinine levels correlate well with self-reported smoking history.<sup>21</sup> Second, a causal inference cannot be drawn based on the cross-sectional design of this study. Taken together, comprehensive longitudinal long-term follow up studies are imperative. However, the strength of this study is the limited chance of a selection bias because of random probability sampling technique. Therefore, any significant findings observed could be generalized to the whole of the Irish school children and to comparable population elsewhere in Europe.

Aside from negative health effects, evidence suggests that children exposed to SHS have an increased likelihood of starting to smoke.<sup>22</sup> Some 80% of adult smokers started smoking before the age of 18 years.<sup>23</sup> Therefore, reducing childhood SHS exposure should be a public health priority. Homes and cars are the principal sources of children's SHS exposure. A recent Irish study reported 41% SHS exposure levels at home nationwide.<sup>2</sup> In this regard a recent ASH Ireland survey reported that almost 79% respondents supported legislation against smoking in private vehicles if children are present.<sup>24</sup> Before contemplating moving forward with programs and/or policies designed to reduce or eliminate SHS exposure among children in cars based on these health findings alone, further explorations are imperative.

Nonetheless, several states have initiated moves to institute smoke-free cars (for example, when children are present) based on few studies in Canada,<sup>25</sup> and in the US<sup>26</sup> that reported very high levels of pollution due to SHS in cars. Despite such improvements in a few countries worldwide, the fact that a substantial number of children continue to be exposed to SHS indicates that more needs to be done in terms of SHS prevention programming. However, little is known about which programs is effective.<sup>27</sup>

## **Conclusions**

One in seven Irish school children are exposed to SHS in cars. Despite this study showing a tendency towards an increased likelihood of respiratory and allergic symptoms in children when exposed to SHS in cars, comprehensive longitudinal studies across different population settings are imperative. Assuming a causal relation, such adverse respiratory symptoms could have a knock-on effect on school absenteeism, and also on being at greater risk for future SHS related morbidity and mortality. Evidence suggests that children exposed to SHS in places other than homes are more likely to be susceptible to initiating smoking than those not exposed,<sup>28</sup> and children particularly exposed to SHS

in motor vehicles have nicotine dependence symptoms.<sup>7</sup> These results add further support to efforts to push ahead with legislation supporting smoke-free cars in Ireland but needs to be adequately substantiated with further evidence from elsewhere..

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### **Conflicts of interests**

LC, ZK and SK are employees of a non-profit organization funded in part through a grant from the Department of Health and Children (Ireland). JH is the chief executive of the Asthma Society a non-profit organization. However, the present study findings are independent of organizational influences.

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**Table 1: Prevalence (%) of Respiratory Health Effects in children aged 13-14 years of age exposed and not-exposed to Second-Hand-Smoke (SHS) in cars in Ireland**

SHS exposure	Asthma (%) [n=2,809]		Wheeze (%) [n=2,809]		Bronchitis (%) [n=2,278]		Hay Fever (%) [n=2,809]		Eczema (%) [n=2,809]	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
<b>Overall</b>	19.9	18.7	48.2	37.4	14.7	7.7	29.5	24.5	15.8	12.7
<b>(‘p’ values)</b>	p=0.57		p<0.0001*		p<0.0001*		p=0.03*		p=0.08	
<b>Boys</b>	20.9	19.9	41.8	35.6	12.0	6.9	28.5	23.1	6.9	9.0
<b>(‘p’ values)</b>	p=0.78		p=0.14		p=0.047*		p=0.14		p=0.39	
<b>Girls</b>	19.4	17.9	51.9	38.6	16.3	8.2	30.2	25.4	21.3	15.3
<b>(‘P’ values)</b>	p=0.58		p<0.0001*		p=0.0002*		p=0.10		p=0.01*	

\*Statistically significant

**Table II: Logistic Regression Models (adjusted and unadjusted) for the associations between childhood second-hand-smoke (SHS) exposure in cars and respiratory health effects among Irish school-children aged 13-14 years**

Health Effect	<sup>a</sup> Adjusted Odds Ratios (AOR) [95% confidence intervals: CI]		<sup>b</sup> AOR [95% CI]		<sup>c</sup> AOR [95% CI]		<sup>d</sup> Unadjusted OR [95% CI]	
	Both		Passive only		Active only			
<b>Asthma</b>	1.07	[0.81; 1.42]	1.06	[0.80; 1.41]	1.09	[0.84; 1.42]	1.08	[0.83; 1.41]
<b>Wheeze symptoms</b>	1.35	[1.08; 1.70]*	1.40	[1.12; 1.75]*	1.45	[1.18; 1.80]*	1.56	[1.27; 1.92]*
<b>Bronchitis symptoms</b>	1.33	[0.92; 1.95]	1.42	[0.98; 2.07]	1.75	[1.23; 2.51]*	2.06	[1.46; 2.92]*
<b>Hay Fever symptoms</b>	1.30	[1.01; 1.67]*	1.32	[1.02; 1.69]*	1.27	[1.01; 1.60]*	1.29	[1.03; 1.63]*
<b>Eczema</b>	1.24	[0.90; 1.70]	1.27	[0.92; 1.74]	1.22	[0.91; 1.64]	1.27	[0.95; 1.70]

\*Statistically significant

<sup>a</sup> Adjusted for sex, current smoking and SHS exposure at home

<sup>b</sup> Adjusted for sex and SHS exposure at home

<sup>c</sup> Adjusted for sex and current smoking

<sup>d</sup> Adjusted for sex only