

# Smoke exposure as a risk factor for asthma in childhood: A review of current evidence

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## ABSTRACT

*Asthma is a common chronic multifactorial disease that affects >300 million people worldwide. Outdoor and indoor pollution exposure has been associated with respiratory health effects in adults and children. Smoking still represents a huge public health problem and millions of children suffer the detrimental effects of passive smoke exposure. This study was designed to review the current evidences on exposure to passive smoke as a risk factor for asthma onset in childhood. A review of the most recent studies on this topic was undertaken to provide evidence about the magnitude of the effect of passive smoking on the risk of incidence of asthma in children. The effects of passive smoking are different depending on individual and environmental factors. Environmental tobacco smoke (ETS) is one of the most important indoor air pollutants and can interact with other air pollutants in eliciting respiratory outcomes during childhood. The increased risk of respiratory outcomes in children exposed to prenatal and early postnatal passive smoke might be caused by an adverse effect on both the immune system and the structural and functional development of the lung; this may explain the subsequent increased risk of incident asthma. The magnitude of the exposure is quite difficult to precisely quantify because it is significantly influenced by the child's daily activities. Because exposure to ETS is a likely cause for asthma onset in childhood, there is a strong need to prevent infants and children from breathing air contaminated with tobacco smoke.*

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**A**sthma is a common chronic multifactorial disease that affects >300 million people worldwide, leading to a serious public health problem.<sup>1</sup> During the last decades research all over the world has highlighted that outdoor and indoor pollution exposure has been associated with respiratory health effects in adults and children.<sup>2–5</sup>

The respiratory health risk for a child can extensively be molded by the status of the sensitive time windows of prenatal and early childhood because of adverse effects of pollutants exposure on programming of lung growth and on the maturation of innate immune cells. Therefore, an increased risk of asthma onset and allergic sensitization in early life as a consequence of these exposures may induce several alterations of the course of immune and respiratory system development.<sup>6</sup> Smoking still represents a huge public health problem and millions of children suffer the detrimental effects of passive smoke exposure<sup>7</sup> that is responsible for adverse health effects in both prenatal and postnatal life.<sup>2</sup>

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## METHODS

We searched the English biomedical literature published during the period January 2010 to December 2013 *via* PubMed and Scopus using the terms, “tobacco smoke and asthma onset,” “smoke exposure and asthma onset,” “secondhand smoke and asthma onset,” and “environmental tobacco smoke and asthma onset.” We also reviewed reference lists of identified articles for relevant citations. A review of the most recent studies on this topic was undertaken to provide evidence about the magnitude of the effect of passive smoking on the risk of incidence of asthma in children, focusing on prenatal and postnatal exposure (Fig. 1).

## Patterns of Susceptibility and Environmental Tobacco Smoke

It is well known that asthma is a multifactorial disease that develops from complex interactions between genes and environment. Hence, the etiology of this condition comes from both individual and environmental factors (such as respiratory viral infections, aeroallergens, and outdoor and indoor air pollutants) that have adverse impact on lung growth and on immune development.<sup>6</sup> Examining the risk that passive smoke may have in eliciting asthma in children, it is right to evaluate the possible interactions among tobacco smoke exposure and the patterns of susceptibility (Table 1).

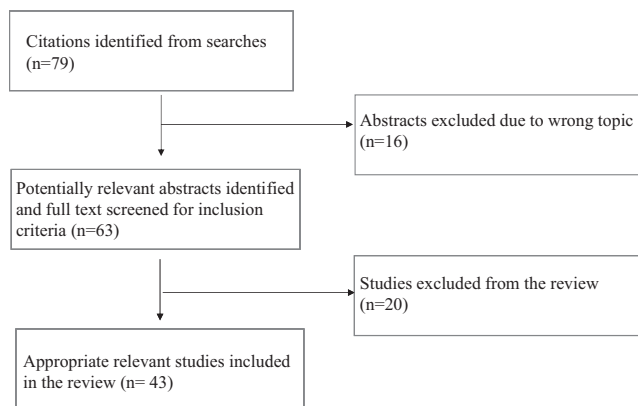


Figure 1. Flowchart for articles' inclusion in the review.

**Genetics Susceptibility.** The effects of smoking exposure may differ between individuals with different genetic predisposition. Several genetic studies focused on the interaction between smoke and genes trying to explain the differential susceptibility of children to respiratory outcomes. Gilliland *et al.*, observed that children deficient in isoforms GSTM1 and GSTT1 alleles (glutathione S-transferase) exposed *in utero* to smoke have a higher prevalence of early onset asthma that persists in later life (odds ratio, 1.6; 95% confidence interval, 1.0–2.5).<sup>8</sup> Most recently, Haley *et al.* hypothesized that the abnormal expression patterns of RUNX (Runt related) transcription factors that contribute to the increased susceptibility to asthma in children is modulated by smoke exposure during pregnancy.<sup>9</sup> RUNX transcription factors are involved in maturation of cartilage and muscle cells during the pseudoglandular and canalicular stages of lung development. The abnormal expression of RUNX proteins could be involved in an increased asthma susceptibility *via* different mechanisms. For example, the increased production of proinflammatory cytokines, such as IL-13 and IL-17, or the promotion of angiogenesis and muscle cell growth that contribute to the airway remodeling typically observed in asthma. The authors indicated that genetic polymorphisms in RUNX are associated with airway responsiveness in asthmatic children and these associations are modified by *in utero* smoke exposure; in addition, they found that maternal smoking in pregnancy tends to increase RUNX expression during early lung development.<sup>9</sup>

Genomewide association studies identified the 17q21 region to be associated with childhood asthma. This region includes many genes such as ORMDL3 (Orosomucoid like 3), IKZF3 (Ikaros family zinc finger protein 3) and GSDMA (Gasdermin A) that encode for cytoplasmic proteins of unknown function and that were associated with asthma in a variety of populations. Recently, associations between single-nucleotide polymorphisms in the 17q21 region and early onset of asthma in children exposed to environmental tobacco

smoke (ETS) were observed.<sup>10–12</sup> Moreover, Wang *et al.* showed that ETS exposure significantly increased the risk of asthma in children with a polymorphism that affect the function of a protein, E-chaderin (CDH1), which is involved in the formation and maintenance of normal epithelial tissues and in the Th2 cell differentiation.<sup>13</sup> The greater risk for asthma was in children with more ETS exposure (>5 cigarettes/day) and the CDH1 AA/CA genotypes.<sup>13</sup>

**Host Susceptibility.** Among factors related to the individual, preterm birth is an important risk factor for impaired lung function in children. In fact, preterm delivery might increase the risk of asthma because of the anatomic and immunologic immaturity of the lungs. Few studies evaluated the effect of both maternal smoking and prematurity.<sup>14</sup> Robison *et al.* recently showed a joint effect of maternal smoking during pregnancy and prematurity of recurrent wheezing suggesting that these two factors may have combined effects on early life respiratory morbidity.<sup>15</sup> The authors speculated that children exposed to both of these factors may have an increased susceptibility to viral pathogens in early life that might justify the increased risk of recurrent wheezing at a young age.<sup>15</sup> In conclusion, even if the mechanisms underlying the association between preterm birth and the increased risk of asthma are still not well clarified, prematurely born children should get special attention with respect to preventive measures against environmental determinants of asthma.

**Environmental Factors.** As already mentioned, also, environmental factors may have deleterious effects on lung growth and function. ETS is one of the most important indoor air pollutants and can it interact with other air pollutants eliciting respiratory outcomes in childhood. In this context, a recent work by Rosa *et al.* showed a significant positive interaction between prenatal polycyclic aromatic hydrocarbons and ETS and report asthma at age 5–6 years with no effects of polycyclic aromatic hydrocarbons exposure alone on this outcome.<sup>16</sup> Similarly, a recent study showed an association between long-term exposure to high levels of traffic-related particulate matter 10 (PM<sub>10</sub>) and NO<sub>2</sub> and increased risk of wheezing in the first 3 years of life in children exposed to tobacco smoke during fetal and infant life, whereas no associations were found in children not exposed to passive smoke. The authors emphasized that first-trimester adverse exposure is particularly critical for fetal lung development, because they had previously shown that children do not present an increased risk of wheezing when mothers quit smoking as soon as they knew they were pregnant.<sup>17,18</sup>

Table 1 ETS exposure and patterns of susceptibility

Author	Route of ETS Exposure	No. of Patients Included	Pattern of Susceptibility	Results	Conclusions
Haley <i>et al.</i> <sup>9</sup>	<i>In utero</i>	422 Asthmatic children (44 with a history of intrauterine smoke exposure)	SNP rs11702779 in RUNX (Run-related) gene	Airway responsiveness in asthmatic children ( $P = 0.040$ )	Genetic polymorphisms in RUNX are associated with airway responsiveness in asthmatic children and these associations are modified by <i>in utero</i> smoke exposure
Rosa <i>et al.</i> <sup>16</sup>	<i>In utero</i>	290 Children	Combined PAHs and ETS exposure	Report of asthma at age 5–6 ( $p < 0.05$ )	A significant positive interaction between prenatal PAHs and ETS and report of asthma at age 5–6 yr exists, with no effects of PAHs alone exposure on this outcome
Robison <i>et al.</i> <sup>15</sup>	<i>In utero</i>	1448 Children with a history of smoke exposure	Maternal smoking during pregnancy and prematurity	Recurrent wheezing (OR, 4.0; 95% CI, 1.9–8.6; $p < 0.001$ )	A joint effect of maternal smoking during pregnancy and prematurity on recurrent wheezing exists, suggesting that these two factors may have combined effects on early life respiratory morbidity
Sonnenschein-van der Voort <i>et al.</i> <sup>17</sup>	<i>In utero</i> and postnatal	4634 Children	Long-term exposure to high levels of traffic-related PM <sub>10</sub> and NO <sub>2</sub>	Increased risk of wheezing in the first 3 yr of life ( $p$ values for interaction: PM <sub>10</sub> -smoking, $p < 0.05$ ; NO <sub>2</sub> -smoking, $p < 0.01$ )	There is an association between long-term exposure to high levels of traffic-related PM <sub>10</sub> and NO <sub>2</sub> and increased risk of wheezing in the first 3 yr of life in children exposed to tobacco smoke during fetal and infant life, whereas there are no associations in children not exposed to passive smoke
Blekic <i>et al.</i> <sup>10</sup>	Postnatal	417 Asthmatic children	T allele homozygosis of SNP rs4795405 in the 17q21 region	Early onset of asthma ( $P = 0.02$ )	SNPs in the 17q21 region may be associated with early onset of asthma in children exposed to ETS
Wang <i>et al.</i> <sup>13</sup>	Postnatal	299 Asthmatic children	ETS exposure (>5 cigarettes/day) in children with the E-chaderin CDH1 AA/CA genotypes	Increased risk of asthma (OR, 3.03; 95% CI, 1.81–5.06)	Susceptible E-chaderin CDH1 genotypes might modulate the development of asthma, especially for children exposed to ETS

SNP = single-nucleotide polymorphism; PAHs = polycyclic aromatic hydrocarbons; ETS: = environmental tobacco smoke; OR = odds ratio.

Table 2 Maternal smoking during pregnancy and early life exposure

Author	Route of ETS Exposure	No. of Patients Included	Results	Conclusions
Dong <i>et al.</i> <sup>28</sup>	<i>In utero</i>	23,474 Children	Higher risk of asthma in boys without allergic predisposition (OR, 2.25; 95% CI, 1.48–3.44) and in girls with allergic predisposition (OR, 2.49; 95% CI, 1.33–4.67 versus OR)	Gender differences in vulnerability towards passive smoke exposure exist
Hedman <i>et al.</i> <sup>27</sup>	<i>In utero</i>	2805 Children	Increased risk of incident asthma (physician-diagnosed asthma, $p = 0.041$ )	Effects of prenatal ETS exposure on lung function may last into adolescence, probably through an impaired lung growth that may explain the subsequent increased risk of incident asthma
Carlsten <i>et al.</i> <sup>23</sup>	Early life exposure	380 Children	Increased risk of incident asthma (OR 2.7; CI, 1.1–7.1) in high-risk children exposed to both dogs and ETS	Combined early exposure to dogs and ETS may cause an increased risk of incident asthma in a high-risk birth cohort, probably skewing the immune system toward Th2 responses
Lee <i>et al.</i> <sup>25</sup>	Maternal passive smoking during pregnancy	7393 Children	Higher risk of wheeze ever (OR, 2.05; 95% CI, 1.58–2.67) and current wheeze (OR, 2.06; 95% CI, 1.48–2.86)	There is significant association between fetal exposure to maternal passive smoking and maternal active smoking with childhood asthma
Miller <i>et al.</i> <sup>26</sup>	Paternal exposure to his mother smoking during pregnancy	5915 Children (966 with asthma)	Higher asthma risk in daughters (OR, 1.39; 95% CI, 1.04–1.86)	Paternal exposure to his mother smoking during pregnancy is associated with a higher asthma risk in his daughters; this finding might be caused by transgenerational effects mediated by epigenetic mechanisms

ETS = environmental tobacco smoke; OR = odds ratio.

### Maternal Smoking during Pregnancy and Early Life Exposure

Several negative effects of nicotine exposure on structural and functional development of the fetal lung were established, such as alteration of the alveolar phase, damage of the epithelial cells of type I, inhibition of fibroblasts proliferation, reduction of the small airways caliber, increase of the muscular tone, and reduction of lung compliance (Table 2).

*Effects on Lung Function.* A meta-analysis conducted of 21 studies showed in 18 of these studies a reduction of the forced expiratory volume in 1 second (FEV<sub>1</sub>) in school

age children (percentage reduction in FEV<sub>1</sub> in children exposed compared with those not exposed, 1.4%; 95% confidence interval, 1.0–1.9), leading the authors to conclude that the exposure during pregnancy is the major cause of functional alteration persisting later in childhood.<sup>19</sup> Other studies highlighted the association between prenatal exposure and bronchial hyperreactivity, documenting its early beginning, related to a greater reduction of the FEV<sub>1</sub>. These findings show that exposure during pregnancy may be responsible for permanent modifications of the respiratory tract that can persist into adulthood and might culminate in chronic obstructive pulmonary disease.<sup>20,21</sup>

*Effects on the Immune System.* The increased risk of respiratory outcomes in children exposed to prenatal and early postnatal passive smoke might be also caused by a modulating effect on the immune system. In this context, Singh *et al.* showed in a murine model that exposure to secondhand smoke (SHS) during pregnancy promotes Th2 polarization through an up-regulated expression of factors (STAT6, Lck, and ERK1/2) that enhance the expression of GATA3, the master transcription factor for Th2 differentiation, and decreases the expression of T-bet down-regulating the Th1 cell activation.<sup>22</sup> Furthermore, a study by Carlsten *et al.* showed that combined early exposure to dogs and ETS may cause an increased risk in the incidence of asthma in a high-risk birth cohort, probably skewing the immune system toward Th2 responses.<sup>23</sup>

The negative effects of prenatal tobacco exposure during pregnancy has also been observed for maternal passive smoking.<sup>24</sup> A study by Lee *et al.* showed a significant relationship between fetal exposure to tobacco *via* maternal passive smoking and wheeze ever and current wheeze, whereas the association with asthma ever was only marginally significant.<sup>25</sup> The authors speculated that *in utero* passive smoking exposure may result in wheezing during early childhood through effects on lung function, and asthma onset probably depends on children's exposure to other triggers after birth.<sup>25</sup> Inversely, Miller *et al.* most recently showed no associations between asthma risk in childhood and maternal exposure to passive smoke during pregnancy; however, paternal exposure to his mother smoking during pregnancy was associated with a higher asthma risk in his daughters.<sup>26</sup> The authors hypothesized that this finding might be caused by transgenerational effects mediated by epigenetic mechanisms, because there is evidence that epigenetic consequences of prenatal exposure may be more evident in male subjects than in female subjects; however, this finding needs to be further investigated.<sup>26</sup>

Finally, it has been shown that the effects of prenatal ETS exposure on lung function may last into adolescence, probably through an impaired lung growth that may explain the subsequent increased risk of incident asthma.<sup>27</sup>

Of interest is the finding that gender differences in vulnerability toward passive smoke exposure exist. Dong *et al.* found that, in children without allergic predisposition, intrauterine exposure to passive smoke had a stronger effect on boys than girls.<sup>28</sup> Because there are differences between boys and girls in fetal lung development (female lungs mature earlier with regard to surfactant production) and throughout life (women have greater airway diameter in relation to the volume of the lung parenchyma), this finding could be related to boys having less mature lungs and narrower airways during childhood. Inversely, among children with allergic predisposition, girls were more susceptible to passive smoke

exposure than boys but this finding is still poorly understood and needs to be further investigated.<sup>28</sup>

In conclusion, evidence exists about no risk-free levels of exposure to SHS both in prenatal and in postnatal life.<sup>25</sup>

### Effects of Passive Smoke on Respiratory Health and Allergic Diseases in Children

Many studies tried to clarify the association between exposure to smoking and wheeze-asthma onset.<sup>29–31</sup> One of the most recent meta-analyses conducted on 79 studies showed that there is a 20–85% increased risk of asthma in children exposed to ETS, highlighting the significant burden of respiratory diseases that comes from exposure to passive smoke during childhood.<sup>29</sup> An increasing number of countries have recently issued laws to regulate smoking in public places such as restaurants, bars, and workplaces. Instead, homes remain a site where children are dangerously exposed to ETS.<sup>7</sup> Data from the 2007 National Survey of Children's Health conducted in United States showed that one-quarter of children live in households that use tobacco products and that children's exposure to smoke inside the home increases with their age (mainly in more disadvantaged conditions) and is associated with a higher risk of asthma.<sup>30</sup> In addition, it has been shown that the number of current household cigarettes smoked, the percentage of ETS exposure during a lifetime, and the number of current smokers at home are all associated with a higher risk of respiratory outcomes in a dose-response relationship. In particular, maternal ETS seems to confer the higher risk of respiratory symptoms than paternal ETS, probably because mothers have more direct contact with their children at home compared with fathers, and joint exposure appears to increase the effect<sup>31</sup> (Table 3).

*Effects on Lung Function.* Exposure to ETS has been also associated with impaired lung function in many studies. Wang *et al.* observed reduced FEV<sub>1</sub>, FEV<sub>1</sub>/forced vital capacity (FVC), and forced expiratory flow between 25 and 75% (FEF<sub>25–75</sub> of FVC) in ETS-exposed children and adolescents followed-up annually.<sup>13</sup> Another work showed that maternal smoking lowered the expected average annual increase in FEV<sub>1</sub> in a cohort of children followed-up for 7 years. In contrast, Corbo *et al.* found mainly deficits in the small airways.<sup>32</sup> In the most recent study by He *et al.*, deficits were observed in FEF but not in FEV<sub>1</sub> and FVC; the authors speculated that the effects on FEF might be more functional, because of a temporary narrowing, than structural, and this could explain why FVC (that represents overall lung capacity) was not affected.<sup>33</sup>

*Effects on the Immune System.* Evidence exists about adverse effects of passive smoke exposure on the im-

Table 3 Effects of passive smoke on respiratory health and allergic diseases

Author	Outcome	No. of Patients Included	Results	Comments
Hawkins <i>et al.</i> <sup>30</sup>	Asthma	90961 Parents	Children's exposure to smoke inside the home is associated with a higher risk of asthma (OR, 1.22; 95% CI, 1.04–1.44)	Homes remain a site where children are dangerously exposed to ETS
Tsai <i>et al.</i> <sup>31</sup>	Asthma	5019 Children	Maternal ETS confers higher risk of respiratory symptoms than paternal ETS (active asthma: OR, 1.62; 95% CI, 0.47–5.50, vs OR, 1.08; 95% CI, 0.76–1.52) and joint exposure appears to increase the effect (OR, 1.76; 95% CI, 0.77–4.01)	The number of current household cigarettes smoked and the number of current smokers at home are associated with a higher risk of respiratory outcomes in children
He <i>et al.</i> <sup>33</sup>	PFTs	1718 Children	Deficits in FEF ( $p = 0.020$ ) for high ETS exposure level	Exposure to ETS may provoke impaired lung function in children
Havstad <i>et al.</i> <sup>35</sup>	Allergic sensitization	662 Children	Association between ETS and allergic sensitization in children without a maternal history of allergic disease (OR for SPT <sup>+</sup> : 2.32; 95% CI, 1.28–4.22; OR for sIgE <sup>+</sup> , 2.53; 95% CI, 1.43–4.48)	ETS exposure may affect atopic sensitization in children depending on family history of allergic disease

ETS = environmental tobacco smoke; PFTs = pulmonary function test; SPT = skin-prick test; OR = odds ratio.

mune system, enhancing Th2 responses, mainly when exposure occurs during pregnancy. In fact, it has been shown that tobacco exposure can increase IgE levels and promote secretion of proallergic cytokines, such as thymic stromal lymphopoietin. Moreover, it can increase the permeability of the airways epithelium and reduce mucociliary clearance, promoting allergen penetration and histamine release from subepithelial sensitized basophils. A study from the BAMSE (Children, Allergy, Milieu, Stockholm, Epidemiological Survey) cohort reported an association between ETS and sensitization to food and indoor allergens, such as cat and mold, in a dose-dependent manner.<sup>34</sup> A most recent study showed opposite results, without any association between ETS and sensitization to indoor allergens, whereas the study by Havstad *et al.* suggested that ETS exposure may affect atopic sensitization depending on family history of allergic disease.<sup>35</sup> In children without a maternal history of allergic disease ETS was associated with allergic sensitization, contrary to children with a maternal history.<sup>35</sup> These disparate findings probably depend on differences in the population studied and study design. However, additional work is needed to clarify this issue.

### Markers of ETS Exposure in Children

Children are more intensely exposed to ETS than adults because of their higher relative breathing rates; however, the magnitude of this exposure is quite difficult to precisely quantify because it is significantly influenced by the child's daily activities.<sup>36</sup> Most commonly, ETS exposure is assessed by questionnaires, a rather cheap approach that covers a long period of time and that may allow retrospective evaluations.

*Nicotine and Metabolites.* Exposure to ETS can be also evaluated by measuring nicotine in indoor air, particulate matter or carbon monoxide concentrations indoor and biomonitoring through dosage of nicotine or cotinine (a major metabolite of nicotine) in urine, blood, or other biosamples.<sup>37</sup>

Measuring nicotine or cotinine concentrations in biological samples allows only the assessment for exposures occurring during a few previous hours or days. For example, cotinine has a half-life of ~16 hours and is completely eliminated from the body within ~3 days, showing a significant variability within the subject.<sup>38</sup> Blood samples provide the most accurate assess-

ment of exposure occurring in the previous 72 hours. Cotinine can be measured in the blood or, less invasively, in saliva, hair, and urine. Urinary cotinine in infants may come from three sources: nicotine inhaled by passive smoking, nicotine ingested with breast milk, or maternal cotinine ingested with breast milk. It seems that breast-feeding is a more significant determinant of urine cotinine levels in infants rather than ETS exposure by inhalation. Data published by Yilmaz *et al.* showed that tobacco smoke exposure *via* breast milk increases nicotine exposure to the baby 13.4 times compared with passive exposure by inhalation, suggesting that this route of exposure may be more harmful than others.<sup>39</sup> Moreover, a recent study conducted on children showed a positive association between average time inside the house and urinary cotinine and cotinine/creatinine ratio in those exposed to ETS ( $p = 0.07$  for ever ETS exposure at home;  $p = 0.02$  for current ETS exposure at home) and a reverse association in those without ETS exposure. This finding suggests that the major source of ETS was from parental smoking at home. However, the causal effects of ETS on asthma can not be clearly determined based on cross-sectional data and they should be further investigated in longitudinal studies, with multiple urinary cotinine measurements, to establish a stable profile of household ETS exposure.<sup>36</sup>

*NNK [4-(methylnitrosamino)-1-(3-pyridinyl)-1-Butanone] and Metabolites.* An alternative biomarker detectable in urine is 4-(methylnitrosoamino)-(3-pyridyl)1-butanol (NNAL), a tobacco-specific carcinogen, which the longer half-life (10–16 days) compared with cotinine might make it more useful in evaluating children with an intermittent pattern of exposure to ETS.<sup>38</sup> In a recent study Florek *et al.* showed a significant correlation between NNAL concentration in smoking and SHS mothers' and their newborns' urine, highlighting the usefulness of this biomarker, probably metabolized from the nitrosamine 4-(methylnitrosamino)-1-(3-pyridinyl)-1-butanone (NNK) in the placenta or in the fetal nasal mucosa, in evaluating prenatal exposure to passive smoke.<sup>40</sup> Thomas *et al.* attempted to detect *iso*-NNAL (1-[methylnitrosamino]-1-[3-pyridyl]butan-4-ol, a metabolite of the nitrosamine 1-[*N*-methyl-*N*-nitrosamino]-1-[3-pyridinyl]-4-butanol-NNA-) in the urine of children living in homes with smokers.<sup>41</sup> *Iso*-NNAL was not detected in any urine sample, probably because this metabolite appears to be less readily formed from NNA so that the low extent of formation could have limited the ability to detect it in urine.<sup>41</sup>

In light of this evidence additional research is needed to discover new and reliable biomarkers of exposure, especially in children.

## CONCLUSIONS

In light of this review, some evidence is worthy to note:

- The effects of passive smoking are different depending on individual and environmental factors.
- The increased risk of respiratory outcomes in children exposed to prenatal and early postnatal passive smoke might be caused by an adverse effect on both the immune system and the structural and functional development of the lung.
- Most commonly, ETS exposure is assessed by questionnaires and biomonitoring through dosage of nicotine or cotinine in urine, blood, or other bio-samples. However, the magnitude of this exposure is quite difficult to precisely quantify because it is significantly influenced by the child's daily activities.

Many studies clearly indicate that passive smoking does have serious effects on children's health. In particular, because exposure to ETS is a likely cause for asthma onset in childhood, there is a strong need to prevent infants and children from breathing air contaminated with tobacco smoke.<sup>36,42</sup> Because homes remain a site where children are dangerously exposed to ETS, public health policies must focus on smoking cessation in the home, where children could gain significant health benefits. In a recent study a significant trend toward reduced exposure to ETS has been established in adolescents after the implementation of smoke-free legislation and an information campaign against smoking.<sup>43</sup> Educating adults about health hazards related to passive smoke exposure in children may be useful to increase public awareness of the problem and ensure a smoke-free environment for children.

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