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# Exposure to environmental factors and relationship to allergic rhinitis and/or asthma

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## Abstract

**Introduction and objectives.** Studies analyzing risk factors, multiple indoor and outdoor factors related to asthma and/or allergic rhinitis (AR) in childhood, are very rare. The presented study was carried out to simultaneously assess host-related, indoor and particulate matter exposure with current allergic rhinitis (AR) and/or asthma in children (6–7 years) and adolescents (13–14 years).

**Material and methods.** The method was a cross-sectional population-based study in which participants were diagnosed by means of the International Study of Asthma and Allergies in Childhood (ISAAC) written questionnaire.

**Results.** Exposure to indoor risk factors were verified in 1,302 individuals, in which the prevalence of AR, asthma and AR-asthma comorbidity were 37.3%, 28.4%, and 16%, for children and 31.5%, 16.2%, and 10.5% for adolescents, respectively. Smoking during pregnancy was associated with current asthma (OR=1.5), second-hand smoking with AR-asthma comorbidity (OR=1.4) and visible mold on the walls with current AR, asthma, and AR-asthma comorbidity (OR=1.6). In a subgroup of 590 children, in addition to the indoor risk factors, exposure to PM10 was assessed. In this joint analysis, there was association with the same previously mentioned risk factors ($p$ values $\leq 0.5$) and a negative association to PM10 ($p \leq 0.002$).

**Conclusion.** The results suggest that avoidance of smoking during pregnancy, second-hand smoking and exposure to mould at home can contribute to reducing current AR and/or current asthma. Exposure to PM10 was not associated with the prevalence rate of these diseases.

## Key words

Allergic rhinitis, asthma, prevalence, risk factors, air pollutants, tobacco exposure

## INTRODUCTION

Allergic rhinitis (AR) and asthma are the most prevalent chronic diseases in the pediatric age group [1]. Prevalence can vary from 10 – 20-fold in countries at different latitudes, suggesting the important role of indoor and outdoor environmental factors in their pathogenesis [1].

Previously published population-based studies have shown an association between dog allergen (OR=2.2) [2], visible mould (OR=3.8) [3], and passive smoking exposure (OR=2.7) [4] with AR. On the other hand, sensitization to house dust mite (OR=8.1) [5], cat – Feld 1 – (OR=5.3) [5] and dog allergen (OR=5.2) [6], as well as smoking during pregnancy, (OR=1.8) [7], second-hand smoking (OR=1.4) [8], visible mould exposure (OR=1.3) [7], and cockroach allergen (OR=1.2) [7], have all been associated with asthma. Other studies, however, did not obtained similar results and have not shown any association between sensitization to house dust mite and asthma (OR=0.7) [9], or exposure to cat allergen and asthma (OR=0.9) [5] and AR (OR=0.7) [10].

As for outdoor factors, there has been an association between particulate matter and AR and asthma in some studies. For instance, in Brazil, Rios et al. concluded that asthma prevalence in adolescents was directly related to air pollution, ($p=0.002$) [11], and similar results in Holland associated with prevalence (OR=1.3) and asthma exacerbations (OR=1.2) [12]. However, there was no association between concentration of outdoor pollutants and increase in asthma prevalence (OR=0.7) [13].

Since children and adolescents are exposed daily to indoor and outdoor risk factors potentially associated to AR, asthma, and AR-asthma comorbidity, it is advisable that these factors should be assessed simultaneously in the same study. Probably due to the complexity of this design, only two other studies assessing the association between indoor and outdoor risk factors and asthma were found in our bibliographic search. The first, a cross-sectional study

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carried out in Taiwan, involved 35,036 children aged 6–15 years, in which current asthma was related to the presence of cockroaches (OR=1.3), visible mould (OR=1.2) and air pollution (OR=1.4) [14]. The second study was carried out in Poland with 1,130 adolescents, aged 13–15 years, in which physician-diagnosed asthma was associated with second-hand smoking (OR=1.4), mould exposure (OR=1.9), and traffic-related air pollution (OR=1.9) [15].

Another, recently published study, assessed the levels of environmental pollution at home and in schools, and its effect on wheezing children. There was an association between PM10 exposure with the worsening of pulmonary function and a significant decrease in $FEV_1$ values [16].

The identification of the risk factors related to the development and worsening of allergic rhinitis and asthma, as isolated or associated disorders, is critical for understanding the pathogenesis of these diseases due to the possibility of adopting preventive measures, and consequently the reduction of exacerbations, epidemiological and socioeconomic impacts and improvement in the quality of life. However, the actual contribution of both indoor and outdoor environmental factors has been difficult to demonstrate scientifically, and is still the subject of controversy, since the studies have not yet demonstrated the effectiveness of environmental control measures to reduce the current prevalence or worsening of the symptoms [1].

Additionally, our literature review did not find any work analyzing the simultaneous association of host-related and indoor risk factors, and environmental pollutants with current AR and asthma, and with AR-asthma comorbidity. The presented study was carried out to verify association between indoor and outdoor risk factors and the prevalence rate of these diseases.

## MATERIALS AND METHOD

**Study design, studied population, period, setting and inclusion criteria.** A cross-sectional population-based study was carried out in the municipality of Ibirité, (approx. 130,000 inhabitants) located in the metropolitan region of Belo Horizonte, Minas Gerais State, Brazil (overall population of over 4 million inhabitants). Children aged 6–7 years and adolescents aged 13–14 years were recruited from 13 randomly-selected schools, living in the same town for at least a year, and in a household at a distance of less than 2 km from their schools.

**Questionnaire and operational definitions.** ISAAC written questionnaire (1) was used with additional questions, such as host-related (specially smoking during pregnancy) and indoor risk factors, such as second-hand smoking, number of people/room density, and allergen exposure: visible mould on walls, carpets, curtains or plush toys, and pet exposure.

In children aged 6–7 years, the standardized ISAAC questionnaire (1) was administered by trained health professionals to parents or legal guardians during home visits, when the above-mentioned indoor risk factors were directly verified. According to the ISAAC protocol, the questionnaire was self-applied by the school to teenagers (13–14 years), while indoor risk factors were later verified during home visits.

**PM10 assessment.** To measure the exposure to outdoor air pollution, i.e., the background level and locally generated emissions, concentrations of PM10 were collected in 6 out of the 13 randomly- selected schools by means of Green Dust Monitor® (Green Dust, Ainring, Germany) in a central and open spot.

**Statistical aspects.** Sample size was based on the mean prevalence of symptoms associated with asthma in children and adolescents living in other metropolitan areas of Brazil, aged 6–7 years (24%) and 13–14 years (19%), from the current asthma diagnosis [17]. 1,145 subjects aged 6–7 years and 1,077 subjects aged 13–14 years were eligible. There was a ± 2% margin of error and 5% alpha error. Thus, 657 and 588 subjects aged 6–7 years, and 13–14 years, respectively (a minimum of 1,245) should be recruited. A 20% estimative was added for potential non-respondents, adding up to 1,493 subjects, out of which 788 were aged 6–7 years, and 705 aged 13–14 years.

Crude and logistic regression adjusted odds ratios were used as measures of association between indoor risk factors and current AR, asthma and AR-asthma comorbidity for subjects enrolled in the 13 schools. The same statistical tests were used to assess the diseases and simultaneous exposure to indoor risk factors and PM10 in children enrolled in 6 out of the 13 schools.

Univariate analysis was performed for PM10 and current AR, asthma and AR-asthma comorbidity. PM10 was analyzed dichotomous, continuous and dose-response gradient. All analyses were performed under software R, version 2.9.0 (Free Software Foundation, Boston, MA, USA, 2009) [18].

**Ethical aspects.** The protocol and informed consent were both approved by the Ethics in Research Committee of the Federal University of Minas Gerais (UFMG).

## RESULTS

Of the 1,493 eligible subjects, 1,302 took part in the study, (706 aged 6–7 years and 596 aged 13–14), exceeding the minimal sample size of 57 subjects. A subgroup of 590 of the 1,302 studied children (45.3%) had PM10 concentration data collected in schools, thus allowing a simultaneous analysis with smoking during pregnancy, indoor risk factors, and association to current AR, asthma, and AR-asthma comorbidity (Table 1).

The studied sample comprised children aged 6–7 years, (54.2%) and 13–14 years (45.8%), with a slight predominance of males (52.3%). Prevalence of current AR, asthma, and AR-asthma comorbidity was 37.3%, 28.5%, and 16.0% among the 6–7 years age group, and 31.5%, 16.3%, and 10.6% in the 13–14 years age group, respectively.

Potential risk factors in most homes were identified, mainly among individuals suffering from current AR, except for second-hand smoking, which was proportionally higher among children and adolescents with current asthma. As for indoor risk factors, the most common were smoking during pregnancy (35.3%), second-hand smoking (46.9%), and visible mould on walls (40.7%).

In the 6 schools assessed, the mean concentration of PM10 ranged from 82.15 μg/m³ – 464.8 μg/m³. In other words, participants were exposed to a wide range of PM10

**Table 1.** Descriptive characteristics of the studied population (N=1,302)

| Variables | Current AR n/total (%) | Current asthma n/total (%) | Current AR-asthma comorbidity n/total (%) |
|---|---|---|---|
| Age (years) | | | |
| 6–7 | 263/706 (37.3) | 201/ 706 (28.5) | 113/706 (16) |
| 13–14 | 188/596 (31.5) | 97/596 (16.3) | 63/596 (10.6) |
| Gender | | | |
| Male | 232/ 681 (34.1) | 158 /681 (23.2) | 93/681 (13.7) |
| Female | 219/621 (35.3) | 140 / 621(22.5) | 83/ 621 (13.4) |
| Parents' schooling (years) | | | |
| 1–2 | 10/36 (27.8) | 8/36 (22.2) | 5 / 36 (13.9) |
| 3–4 | 362/1058 (34.2) | 242/1058 (22.9) | 141/1058 (13.3) |
| > 5 | 78/207 (37.7) | 47/207 (22.7) | 29 /207(14) |
| Smoking during pregnancy | | | |
| Yes | 82/232 (35.3) | 70/232 (30.2) | 40/232 (17.2) |
| No | 358/1038 (34.5) | 223/1038 (21.5) | 133/1038 (12.8) |
| Second-hand smoking | | | |
| Yes | 199/535 (37.2) | 137/535 (46.9) | 86/535 (16.1) |
| No | 241/740 (32.6) | 155/740 (53.1) | 86/740 (11.6) |
| People/room density | | | |
| <2 | 414/1205(34.4) | 269/1205 (22.3) | 158/1205 (13.1) |
| >2 | 32/88 (36.4) | 26/88 (29.5) | 15/88 (17.1) |
| Visible mould on walls | | | |
| Yes | 193/474 (40.7) | 135/474 (28.5) | 85/474 (17.9) |
| No | 254/818 (31) | 163 /818(19.9) | 91/818 (11.1) |
| Carpeting | | | |
| Yes | 186/534 (34.8) | 118/534 (22.7) | 68/534 (12.7) |
| No | 265/768 (34.5) | 180/768 (23.4) | 108/768 (14.1) |
| Curtains | | | |
| Yes | 246/740 (33.2) | 160/740 (21.6) | 94/740 (12.7) |
| No | 204/559 (36.5) | 137/559 (24.5) | 81/559 (14.5) |
| Plush toys | | | |
| Yes | 234/690 (33.9) | 164/690 (23.8) | 94/690 (13.6) |
| No | 216/610 (35.4) | 133/610 (21.8) | 82/610 (13.4) |
| Pets | | | |
| Yes | 340/956 (35.6) | 216/956 (22.6) | 134/956 (14) |
| No | 111/345 (32.2) | 82/345 (23.8) | 42/345 (12.2) |
| PM10 µm (µg/m$^3$) | | | |
| <150 | 137/305 (44.9) | 107/305 (35.1) | 69/305 (22.6) |
| >150 | 84/285 (29.5) | 51/285 (17.9) | 33/285 (11.58) |

µm: micrometter; µg/m$^3$: microgram per cubic meter

**Table 2.** Univariate analysis for association between host-related and indoor risk factors with current AR, asthma and AR-asthma comorbidity

| Variables | Current AR OR (95% CI) | Current asthma OR (95% CI) | Current AR-asthma comorbidity OR (95% CI) |
|---|---|---|---|
| Gender | | | |
| Male | 1.0 (0.8–1.2) | 1 (0.8–1.3) | 1.0 (0.7–1.4) |
| Female | | | |
| Parents' schooling (years) | | | |
| 1–2 | 0.6 (0.3–1.5) | 0.9 (0.2–3.9) | 1.0 (0.3–3.0) |
| 3–4 | 0.9 (0.6–1.2) | 0.9 (0.6–1.6) | 0.9 (0.6–1.5) |
| > 5 | 1.0 | 1.0 | 1.0 |
| Smoking during pregnancy | 1.0 (0.8–1.4) | 1.6 (1.1–2.2) * | 1.4 (1.0–2.1) |
| Second-hand smoking | 1.2 (1.0–1.6) | 1.3 (1.1–2.2) * | 1.5 (1.0–2.0) * |
| People/room density | | | |
| <2 | 0.9 (0.6–1.5) | 0.7 (0.4–1.1) | 0.7 (0.4–1.4) |
| >2 | | | |
| Visible mould on walls | 1.5 (1.1–1.9) * | 1.6 (1.2–2.1)* | 1.8 (1.3–2.4) * |
| Carpeting | 1 (0.8 -1.3) | 0.9 (0.7–1.2) | 0.9 (0.6–1.3) |
| Curtains | 0.9 (0.7–1.1) | 0.9 (0.7–1.1) | 0.9 (0.6–1.2) |
| Plush toys | 0.9 (0.7–1.2) | 1.2 (0.9–1.5) | 1.0 (0.7–1.3) |
| Pets (cats, dogs, birds) | 1.2 (0.9–1.5) | 0.9 (0.7–1.3) | 1.2 (0.8–1.7) |

*$p < 0.05$

**Table 3.** Multivariate analysis of host-related and indoor risk factors for current allergic rhinitis (AR), asthma, and AR and asthma comorbidity

| Variables | Current AR OR (95% CI) p value (451 / 1,302) | Current asthma OR (95% CI) p value (298 / 1,302) | Current AR-asthma comorbidity OR (95% CI) p value (176 / 1,302) |
|---|---|---|---|
| Smoking during pregnancy | NS | 1.5 (1.1–2.1) p = 0.009 | NS |
| Second-hand smoking | NS | NS | 1.4 (1.01–1.9) p = 0.045 |
| Visible mold in walls | 1.5 (1.2–1.8) p <0.001 | 1.5 (1.2 – 1.8) p = 0.008 | 1.7 (1.2 – 2.4) p = 0.001 |

NS = no significant statistical difference

concentration, a suitable condition for the analysis of different levels of exposure.

**Association of indoor risk factors with current AR, asthma and AR-asthma comorbidity.** Table 2 presents the univariate analysis of the indoor risk factors for the studied diseases among the 1,302 studied children and adolescents. Among them, 451 (34.6%), 298 (22.8%) and 176 (13.5%) suffered from AR, asthma and AR-asthma comorbidity.

Current asthma was the most common, statistically significant disease associated with smoking during pregnancy, second-hand smoking, and mould exposure. There was also an association between mould exposure and current AR and AR-asthma comorbidity. There was no association between carpeting, curtains, plush toys and the presence of pets with the studied diseases.

In Table 3, the multivariate analysis for host-related/indoor risk factors among the 1,302 children is shown.

After multivariate analysis, visible mould on walls was associated with all 3 studied conditions, with OR value ≈ 1.5. On the other hand, smoking during pregnancy and second-hand smoking were associated only with current asthma and current AR-asthma comorbidity, respectively.

**Association between PM10 exposure and current AR, asthma, or AR-asthma comorbidity.** In the subgroup of 590 of 1,302 studied children (45.3%), PM10 concentration data were collected in 6 of the 13 schools. As previously mentioned, the mean concentration of PM10 ranged from 82.15 µg/m$^3$ – 464.8 µg/m$^3$, whereas the concentration measured 90% of the time ranged from 62.97 µg/m$^3$ – 323.97 µg/m$^3$.

Table 4 shows the univariate analysis of PM10 concentration, grouped into 2 categories, and the association with current AR, asthma, and AR-asthma comorbidity. Table 4 also shows a negative association between PM10 concentration and the studied diseases. In addition, negative association was found when PM10 was analyzed as a continuous variable (data not shown).

**Association between indoor risk factors and simultaneous PM10 exposure with current AR, asthma, and AR-asthma comorbidity.** Within this subgroup of 590 subjects, a

**Table 4.** Univariate analysis of PM10 exposure and association with current AR, asthma, and AR-asthma comorbidity.

| PM10 concen-tration (μg/m³) | No. of children exposed | Current AR OR (95% CI) (221subjects out of 590) | Current asma OR (95% CI) (158 subjects out of 590) | Current AR-asthma comorbidity OR (95% CI) (102 subjects out of 590) |
|---|---|---|---|---|
| < 150 | 305 | 1.0 | 1.0 | 1.0 |
| > 150 | 285 | 0.5 (0.4 – 0.7)* | 0.4 (0.3–0.6)* | 0.5 (0.3–0.7)* |
| < 90 | 166 | 1.0 | 1.0 | 1.0 |
| 100–199 | 139 | 0.7 (0.5–1.1) | 0.7 (0.4–1.3) | 0.8 (0.5–1.4) |
| > 200 | 285 | 0.4 (0.3–0.7)* | 0.5 (0.3–0.7)* | 0.4 (0.3–0.7)* |

*p values were < 0.001; PM 10 (μg/m³): concentration of particles with an aerodynamic diameter of 10 μm or less

simultaneous analysis of association of concentration up to or higher than 150 μg/m³ and host related/indoor risk factors with current AR, asthma, and AR-asthma comorbidity was carried out (Tab. 5).

**Table 5.** Final model, multivariate analysis by logistic regression of host-related, indoor risk factors, and PM10 and their association with current AR, asthma, and AR-asthma comorbidity

| Variables | Current AR OR (95% CI) p value (n=590) | Current asthma OR (95% CI) p value (n=590) | AR-asthma comorbidity OR (95% CI) p value (n=590) |
|---|---|---|---|
| Smoking during pregnancy | NS* | 1.6 (1.01–2.5) p = 0.035 | NS |
| Second-hand smoking | NS | NS | 1.7 (1.1–2.6) p = 0.02 |
| Visible mould on walls | 1.7 (1.2–2.5) p = 0.002 | 1.6 (1.1–2.4) p = 0.017 | 2.1 (1.3–3.2) p = 0.001 |
| PM10 exposure** (μg/m³) >150 | 0.5 (0.4–0.7) p <0.001 | 0.5 (0.3–0.8) p = 0.002 | 0.5 (0.3–0.7) p = 0.001 |

* NS = no significant statistical difference
** PM 10 (μg/ m³): concentration of particles with an aerodynamic diameter of 10μm or less

After multivariate analysis, the independent risk factors for current AR, asthma and AR-asthma comorbidity were: smoking during pregnancy, second-hand smoking, and visible mould on walls, even after considering outdoor exposure to PM10. Blank cells indicate that the risk factor did not appear on the final multivariate analysis model for that disease.

## DISCUSSION

The presented study shows that the prevalence of current AR, asthma, and AR-asthma comorbidity in the town of Ibirité is similar to the prevalence found in other Brazilian cities and metropolitan regions, including Belo Horizonte city.

The prevalence of current AR is 25.7% and 29.6% for schoolchildren and teenagers, respectively, and for current asthma, 24.3% and 19% for schoolchildren and adolescents, respectively [17]. For AR-asthma comorbidity, prevalence was 8.4% in a study carried out in Belo Horizonte with adolescents aged 13–14 years, using the ISAAC questionnaire [19], against 10.5% in the presented study. Therefore, potential selection biases, in part, can be ruled out because of similar prevalence rates in other Brazilian cities, as well as biases related to the epidemiological diagnosis of asthma and AR. Thus, the role played by environmental factors, including particulate matter in the genesis of current AR, asthma, and AR-asthma comorbidity in this specific population, was suitable for the study aims.

Association between indoor risk factors and asthma has been shown in a number of studies, e.g. a cohort study with 3,535 American children, in which asthma risk was related to mould (RR=1.7) and pet exposure (RR=1.6), accounting for an increase of 32% in new cases of asthma [20]. In the presented study, however, there was no association between pet exposure and current AR and/or asthma.

Mould can be directly observed on walls (as in the presented study), without the need for direct measurement of spores [21]. A meta-analysis that enrolled studies totalling 58,000 children, found association between mould and development of asthma (OR=1.4) [22].

Studies have pointed out the validity of questionnaires as a cost-effective way of measuring second-hand or smoking during pregnancy, against measuring of cotinine in urine [23]. In the presented study, 14.7% of mothers smoked during pregnancy, a factor associated with current asthma. Approximately 32.4% of the participants were exposed to second-hand smoking, and an association was found between current AR and asthma. Smoking during pregnancy (OR=1.8) [7] and second-hand smoking during infancy (OR=1.4) [8] have consistently been documented in the literature.

Studies have found a negative association between PM10 concentration and current asthma (OR=0.4). For instance, there was no association between air pollution and AR (OR=0.8) or asthma (OR=0.7) in a study carried out by von Mutius et al. [24] in Germany, who assessed 2 areas with different levels of air pollution. Likewise, there was a negative association between air pollutants and asthma after assessing half a million children with the ISAAC questionnaire and measuring pollutants by a monitoring station. The mean concentration of PM10 was 37μg/m³ [25]. However, published studies reported association between both PM10 and asthma in adolescents [11], and reduced pulmonary function [16].

Only 2 other published works found impact of both indoor risk factors and pollutants [14, 15] in asthma. The first was carried out in Taiwan with 35,036 children, aged 6–15 years, diagnosed with asthma by the ISAAC questionnaire. Asthma was related to indoor risk factors, such as cockroaches, visible mould on walls, and air pollutants [14]. Unlike our study, the Taiwanese study might be limited due to the use of subjective environmental pollution levels, (as perceived by the parents) in conjunction with data from monitoring stations, and then compared to the prevalence of asthma. The levels found in the study, however, were lower than those in the presented study (increase of 10 μg/m³ of PM10, a mean of 17.9 μg/m³), and even with lower PM10 concentrations there was positive association with asthma [14]. Another study, carried out in Poland between 2005 and 2006, encompassed 1,130 adolescents aged 13–15 years. Physician-diagnosed asthma was associated with second-hand smoking (OR=1.4, $p<0.05$), mould on walls (OR=1.95; $p<0.05$), and since PM10 was not measured, the proximity to areas of heavy traffic was used (OR=1.93; $p<0.05$) [15]. The scarcity of works simultaneously assessing the relationship between indoor and outdoor risk factors with asthma and/or AR, has noticeably hindered more detailed comparisons with the presented results.

The current study rekindles a controversy in the literature by, on the one hand, concurring with the literature, and on the other, diverging from it. The cross-sectional design might have been a limiting factor, since prospective studies are more suited to assess this causality. On the other hand, it was a randomized population-based study, using widely-recognized ISAAC standardized definitions, methodology, and questionnaires. A proper analysis was made possible by direct, on-site verification of indoor risk factors and PM10 concentration as a marker of outdoor pollution.

In conclusion, even in the face of conflicting results of indoor risk factors of current AR and asthma, it seems prudent that measures of host-related, indoor, and outdoor avoidance should be taken, especially those related to second-hand smoking, smoking during pregnancy and exposure to mould.

## REFERENCES

1. Worldwide variations in the prevalence of ashma symptoms: the International Study of Asthma and Allergies in Childhood. ISAAC Steering Committee. Eur Respir J. 1998; 12: 315–325.
2. Wright AL, Holberg Cj, Halonen M, Martinez FD, Morgan W, Taussig LM. Epidemiology of physician-diagnosed allergic rhinitis in childhood. Pediatrics. 1994; 6: 895–901.
3. Jaakkola JJK, Hwang BF, Jaakkola MS. Home dampness and molds as determinants of allergic rhinitis in childhood: a 6 year, population-based cohort study. Pediatrics. 2001; 108: 1149–1504.
4. Biagini JM, LeMasters GK, Ryan PH, Levin L, Reponen T, Bernstein DI et al. Environmental risk factors of rhinitis in early infancy. Pediatr Allergy Immunol. 2006; 17: 278–284.
5. Arshad SH, Tariq SM, Matthews S, Hakim E. Sensitization to common allergens and its association with allergic disorders at age 4 years: a whole population birth cohort study. Pediatrics. 2001; 108(8): 33.
6. Korppi M, Hyvrinen M, Kotaniemi-Syrjnen A, Piipo-Savolainen E, Reijonen T. Early exposure and sensitization to cat and dog: different effects on asthma risk after wheezing in infancy. Pediatr Allergy Immunol. 2008; 19: 696–701.
7. Han YY, Lee YL, Guo YL. Indoor environmental risk factors and seasonal variation of childhood asthma. Pediatr Allergy Immunol. 2009; 20: 748–756.
8. Tsai CH, Huang JH, Hwang BF, Lee YL. Household environmental tobacco smoke and risks of asthma, wheeze and bronchitic symptoms among children in Taiwan. Respir Res. 2010; 11: 11–20.
9. Torrent M, Sunyer J, Garcia R, Harris J, Iturriaga MV, Puig C et al. Early-life allergen exposure and atopy, asthma and wheeze up to 6 years of age. Am J Respir Crit Care Med. 2001; 176: 446–453.
10. Von Mutius E, Schmid S, PASTURE Study Group. The PASTURE project: EU support for the improvement of knowledge about risck factors and preventive factors for atopy in Europe. Allergy. 2006; 61: 407–413.
11. Rios JLM, Boechat JL, Sant´Anna CS, França AT. Atmospheric pollution and the prevalence of asthma: study among schoolchildren of 2 areas in Rio de Janeiro, Brazil. Ann Allergy Asthma Immunol. 2004; 92: 629–634.
12. Gehring U, Wijga AH, Brauer M, Fischer P, de Jongste JC, Kerkhof M et al. Traffic-related air pollution and the development of asthma and allergies during the first 8 years of life. Am J Respir Crit Care Med. 2010; 181: 596–603.
13. Von Mutius E, Fritzsch C, Weiland SK, Röll G, Magnussen H. Prevalence of asthma and allergic disorders among children in United Germany: a descriptive comparison. BMJ. 1992; 305: 1395–1399.
14. Lee YL, Lin YC, Hsiue TR, Hwang BF, Guo YL. Indoor and outdoor environmental exposures, parental atopy and physician diagnosed asthma in Taiwanese schoolchildren. Pediatrics. 2003; 112: 389–396.
15. Kasznia-Kocot J, Kowalska M, Górny RL, Niesler A, Wypych-Ślusarska A. Environmental risk factors for respiratory symptoms and childhood asthma. Ann Agric Environ Med. 2010; 17: 221–229.
16. Martins PC, Valente J, Papoila AL, Caires I, Araújo-Martins J, Mata P et al. Airways changes related to air pollution exposure in wheezing children. Eur Respir J. 2012; 39: 246–253.
17. Solé D, Wandalsen GF, Nunes ICC, Naspitz CK, ISAAC – Grupo Brasileiro. Prevalence of symptoms of asthma, rhinitis, and atopic eczema among Brazilian children and adolescents identified by the International Study of Asthma and Allergies in Childhood (ISAAC) – Phase 3. J Pediatr (Rio J). 2006; 82: 341–346.
18. R Development Core Team. A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna 2010. http://www.R-project.org (access: 20.09.2012).
19. Andrade CR, Ibiapina CC, Alvim CG, Fontes MJF, Lasmar LMLBF, Camargos PAM. Asthma and allergic rhinitis co-morbidity: a cross-sectional questionnaire study on adolescents aged 13–14 years. Prim Care Respir J. 2008; 17: 222–225.
20. McConnell R, Berhane K, Gilliland F, Islam T, Gauderman WJ, London SJ et al. Indoor risk factors for asthma in a prospective study of adolescents. Epidemiology. 2002; 13: 288–295.
21. Engvall K, Norrby C, Norback D. Asthma symptoms in relation to building dampness and odour in older multifamily houses in Stockholm. Int J Tuberc Lung Dis. 2001; 5: 468–477.
22. Antova T, Pattenden S, Brunekreef B, Heinrich J, Rudnai P, Forastiere F et al. Exposure to indoor mould and children's respiratory health in the PATY study. J Epidemiol Community Health. 2008; 62: 708–714.
23. Gehring U, Leaderer BP, Heinrich J, Oldenwening M, Giovannangelo MECA, Nordling E et al. Comparison of parental reports of smoking and residential air nicotine concentrations in children. Occup Environ Med. 2006; 63: 766–772.
24. Von Mutius E, Sherrill DL, Fritzsch C, Martinez FD, Lebowitz MD. Air pollution and upper respiratory symptoms in children from East Germany. Eur Respir J. 1995; 8: 723–728.
25. Anderson HR, Ruggles R, Pandey KD, Kapetanakis V, Brunekreef B, Lai CKW et al. Ambient particulate pollution and the world-wide prevalence of asthma, rhinoconjunctivitis and eczema in children: Phase One of the International Study of Asthma and Allergies in Childhood (ISAAC). Occup Environ Med. 2010; 67: 293–300.