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Exploring the associations between parent-reported biological indoor environment and airway-related symptoms and allergic diseases in children

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ABSTRACT

Objectives: Asthma and allergic rhinitis are diseases which require special attention in childhood. Risk factors for these diseases are manifold and include environmental factors. Previous studies have shown associations between indoor mould and respiratory diseases in children. Besides indoor mould, organic waste storage, potted plants, pets and crowding could influence the microbial indoor environment at home and the respiratory health of children. Our aim was therefore to explore the associations of these factors with airway-related symptoms and respiratory diseases in preschoolers.

Methods: In this cross-sectional study we evaluated data based on parent-questionnaires regarding the health of their children from the 2014/2015 Health Monitoring Units (GME) in Bavaria. Bivariate and multivariate odds ratios (OR) with 95% confidence intervals (95%-CI) were calculated with logistic regression to explore associations between exposures (visible mould, organic waste storage, potted plants, pets and crowding) and outcome variables (doctor diagnosed allergic rhinitis with symptoms in the last 12 months, doctor diagnosed asthma with symptoms in the last 12 months, 12 month prevalence of symptoms such as dry cough at night without a cold, wheeze, wheeze attacks and allergic rhinitis symptoms).

Results: We analysed data from 4732 children (response rate 56.7%) with a mean age of 5.3 years. Visible mould was present in 4.7% of all households and associated with doctor diagnosed asthma with symptoms in the last 12 months [aOR 2.16 (95%-CI 1.01–4.63)], wheeze in the last 12 months [aOR 1.60 (95%-CI 1.0–2.50)] and allergic rhinitis symptoms in the last 12 months [aOR 1.75 (95%-CI 1.07–2.87)]. Crowding was associated with dry cough at night without a cold in the last 12 months [aOR 1.71 (95%-CI 1.42–2.05)]. The other indoor factors showed no association with respiratory health of the children.

Conclusion: Our results, in line with previous studies, showed positive associations between visible mould at home and airway-related symptoms and allergic diseases in children irrespective of the effect of the other considered indoor exposures. Despite the low prevalence of mould exposure in our study population, our results suggest intervention should be taken for those who do have visible mould exposure at home.

1. Introduction

Asthma and allergic rhinitis are common chronic diseases in childhood with a great impact on the patients' quality of life (Böcking et al., 2012; Cibella et al., 2015; von Mutius, 2000). Risk factors for these diseases are manifold and include genetic and environmental factors

(Asher et al., 2010; Kazani and Israel, 2011). Among the latter are microorganisms such as fungi or bacteria and their components or products which can be found ubiquitously. It is supposed that microbial exposure in infancy can be protective for developing asthma and allergies, which is known as the hygiene hypothesis. This preventive effect seems to depend not exclusively, but also on the kind of microbial

Abbreviations: CI, confidence interval; GME, Gesundheits-Monitoring-Einheiten (Health Monitoring Units); ISAAC, International Study of Asthma and Allergies in Children; KiGGS, Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland (German Health Interview and Examination Survey for Children and Adolescents); OR, odds ratio; aOR, adjusted odds ratio; aOR1, adjusted odds ratio (model 1); aOR2, adjusted odds ratio (model 2); SD, standard deviation

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¹ Complete details for GME Study Group can be found in Appendix A.

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factors, their mixture and diversity (Ege et al., 2011; Smits et al., 2016; Strachan, 1989; von Mutius, 2016).

However, indoor mould has shown to be a microbial mixture which has almost consistently been associated with adverse respiratory health effects, especially allergic rhinitis, cough, wheeze and asthma (Jaakkola et al., 2013; WHO, 2009). Mould in this context is a mixture of different dampness-related agents including fungi and bacteria (Breuer et al., 2016).

Apart from visible mould, further indoor factors may have an influence on indoor microbial exposure. Organic waste storage at home was found to increase indoor microbial contamination (Wouters et al., 2000). Potted plants could possibly influence the indoor environment by releasing humidity and fungal allergens (Breuer et al., 2016; IOM, 2000). Studies about respiratory health effects of indoor plants have shown inconsistent results so far (Fagbule and Ekanem, 1994; Mo et al., 2003). Studies about pet ownership at home and effects on asthma or allergic rhinitis in children showed results ranging from adverse health effects to no association or even suggesting a protective effect (Chen et al., 2010). On the one hand, pets are sources of animal allergens that can lead to sensitization (Chen et al., 2010). On the other hand, pets at home can lead to an increased exposure with microbial factors that might explain a protective effect (Dunn et al., 2013; Fujimura et al., 2010). Moreover, residents at home could have an impact on indoor microbial factors (Hospodsky et al., 2012). Crowding may lead to increased humidity and microbial exposure (Antova et al., 2008; von Mutius, 2016). Studies about the effect of crowding on asthma and allergies are inconclusive and need further research (Cardoso et al., 2004; Gray, 2001).

As people spend much time indoors, assessment of indoor environmental risk factors for respiratory diseases is an important public health issue (WHO, 2009). Children are an important target group as they are more susceptible to effects of environmental factors on respiratory health (Hutter et al., 2009).

The current relevance of visible mould, organic waste storage, potted plants, pets and crowding for respiratory diseases in preschoolers in Bavaria is not known. Our aim therefore was to assess how often this population is exposed to these factors at home and analyse their associations to airway-related symptoms and allergic diseases.

2. Material and methods

2.1. Data collection

This cross-sectional study is part of the Health Monitoring Units (GME) which take place in six different regions in Bavaria, three rural and three urban regions (for more details see Bolte et al., 2007). All parents of children invited for the obligatory school entrance examinations were asked to fill out a questionnaire. The 2014/2015 survey contained questions already used in other studies (ISAAC, KiGGS) about home environment and children's health (Kurth et al., 2002; Weiland et al., 1999). Approval from the local ethics committee was obtained (Bolte et al., 2007).

2.2. Exposure to indoor environmental factors

The variable visible mould at home (no/yes) was created to encompass the following areas: child's room, living room, parents' bedroom, kitchen, bath and hallway. The variable organic waste storage for more than two days (no/yes) included organic waste storage in the kitchen, the storeroom or the hallway. Potted plants at home were categorized in no plants, 10 or less plants or more than 10 plants. Pets at home (no/yes) included any kind of pet at home. Crowding was defined as more than 1 person per room (including kitchen but not counting bathroom) or less than 20 sqm living space per person (including kitchen and bathroom) as described in previous GME-surveys (Weber et al., 2016).

2.3. Airway-related symptoms and allergic diseases

Parents were asked if a doctor had ever diagnosed asthma (no/once/several times) in their child. This variable was dichotomized into no versus yes. Related symptoms for asthma were assessed asking for a 12 month prevalence of: dry cough at night without a cold (no/yes), wheezing in the chest (no/yes) and frequency of wheeze attacks (none/1 to 3/4 to 12/ > 12). Wheeze variable for number of attacks was dichotomized in less than four attacks versus four or more attacks as done in previous GME-studies (Weber et al., 2016). The variable "doctor's diagnosed asthma with symptoms in the last 12 months" was a combination of doctor's diagnosis of asthma ever and dry cough at night in the last 12 months and/or wheeze in the last 12 months.

Additionally, parents were asked if a doctor had ever diagnosed allergic rhinitis (no/yes) in their child. For allergic rhinitis related symptoms in the last 12 months, parents were asked if their child had a problem with sneezing or a runny or blocked nose when he/she did not have a cold or the flu (no/yes) and if these symptoms were accompanied by itchy-watery eyes (no/yes). Allergic rhinitis symptoms were defined as a positive answer to both questions. The variable "doctor's diagnosed allergic rhinitis with symptoms in the last 12 months" was a combination of doctor's diagnosis of allergic rhinitis with the above mentioned nasal and eyes-symptoms in the last 12 months.

2.4. Confounders

As confounders, the following parameters were taken into account: children's age, sex, older siblings, country of birth, rural/urban residency, parents' education and current second hand smoking as reported in earlier GME publications (Weber et al., 2016).

The country of birth of the child was dichotomized into "Germany" versus "other country". Rural or urban residency region was grouped as described in previous GME-surveys (Bolte et al., 2007). Parent education was defined as the highest graduation of mother or father and was divided into 3 categories: high defined as "Abitur" (A-level), middle as "Realschulabschluss" (middle school) and low as "Hauptschulabschluss" (secondary school) or none. Current second hand smoking was defined as smoking of third persons at home in the presence of the child (no/yes).

2.5. Statistical analysis

Reported indoor factors and airway-related symptoms or allergic diseases were described using absolute and relative frequencies.

Correlations among exposure variables and possible confounders were tested to avoid multicollinearity (Spearman for ordinal variables, Cramers V for nominal variables, threshold for both > 0.3).

ORs and 95%-CI were calculated with logistic regression to estimate associations between these parameters. Multiple logistic regression was used to control for possible confounders. Outcomes of the models were the aforementioned airway-related symptoms and allergic diseases. In a first model (model 1) we adjusted for age, sex, older siblings, country of birth, rural/urban residency, parents' education and second hand smoking. A second model (model 2) was calculated including all exposures (visible mould, organic waste storage, potted plants, pets and crowding) and the aforementioned confounders. Therefore with model 2 the independent association of the respective indoor exposures could be observed also in contrast to model 1 which includes just socio-economic parameters.

Statistical analysis was performed with SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 1
Characteristics of the study population GME 2014/2015.

	GME-2014/ 2015 population n = 4732 (100%)	doctor diagnosed allergic rhinitis with symptoms in the last 12 months ^c n = 106 (2.39%)	doctor's diagnosed asthma with symptoms in the last 12 months ^d n = 97 (2.29%)	allergic rhinitis symptoms in the last 12 months ^e n = 296 (6.49%)	dry cough at night without a cold in the last 12 months n = 1174 (25.57%)	wheeze in the last 12 months n = 401 (8.79%)	4 or more wheeze attacks in the last 12 months n = 61 (1.34%)
	% ^f	% ^f	% ^f	% ^f	% ^f	% ^f	% ^f
age 5 years or younger	66.35	55.66	58.76	58.64	66.52	62.25	52.46
age older than 5 years	33.65	44.34	41.24	41.36	33.48	37.75	47.54
sex male	51.47	64.76	68.04	63.73	52.98	62.34	62.30
older siblings	47.28	32.08	60.82	35.47	46.27	48.99	52.46
country of birth							
Germany	94.51	96.23	93.81	95.61	93.02	96.01	98.36
any other	5.49	3.77	6.19	4.39	6.98	3.99	1.64
residency region urban	53.14	44.34	54.64	50.00	51.87	48.88	45.90
parents' education ^a							
high	50.22	48.57	43.16	45.86	40.76	40.66	40.00
middle	31.18	35.24	42.11	32.07	33.77	39.14	40.00
low	18.60	16.19	14.74	22.07	25.47	20.20	20.00
current second hand smoking	4.08	1.96	1.05	5.50	6.22	5.08	3.33
visible mould at home ^b	4.68	4.76	8.25	7.17	6.36	6.27	8.20
organic waste storage for > 2 days at home	11.49	15.38	9.38	12.41	11.83	9.77	13.11
potted plants at home							
none	20.20	15.24	19.59	20.69	21.50	19.70	18.03
≤ 10	65.50	68.57	67.01	67.24	65.52	64.84	70.49
> 10	14.30	16.19	13.40	12.07	12.98	15.46	11.48
pets at home	34.33	32.69	39.58	31.51	33.08	34.92	40.98
crowding (> 1 person/ room or < 20 sqm/ person)	19.66	13.27	22.92	21.66	26.91	18.77	21.67

Abbreviations: N = number of respondents.

^a high defined as 'Abitur'(A-level), middle as "Realschulabschluss"(middle school) and low as "Hauptschulabschluss"(secondary school) or none.

^b including living room, parents' bedroom, child's room, kitchen, bath, hallway.

^c doctor's diagnosis of allergic rhinitis ever with nasal and eyes-symptoms in the last 12 months.

^d doctor's diagnosis of asthma ever and cough or wheeze in the last 12 months.

^e sneezing or a runny or blocked nose apart from a cold or the flu combined with itchy-watery eyes.

^f including missing values.

3. Results

3.1. Descriptive analysis

We analysed data from 4732 children (response rate 56.7%). Table 1 shows population characteristics. The mean age was 5.3 (SD 0.5). There was a slight predominance of males (51.5%) and of urban households (53.1%). About 50% of the parents who filled out the questionnaire had an A-level education.

Visible mould was shown in 4.7% of the households. Storing organic waste for longer than 2 days at home was reported by 11.5% of the parents. Potted plants at home were the most frequent exposure with 65.5% for up to 10 plants and 14.3% with more than 10 plants. Crowded housing conditions were reported by 19.7% of the parents.

Prevalence of airway-related symptoms and allergic diseases ranged from 1.3% for four or more wheeze attacks in the last 12 months to 25.6% for dry cough at night without a cold in the last 12 months.

3.2. Logistic regression

Table 2 shows bivariate ORs and adjusted ORs of the model 2 for associations between biological indoor factors and airway-related

symptoms and allergic diseases. In model 2 mould was associated with doctor diagnosed asthma with symptoms in the last 12 months [aOR2 2.16 (95%-CI 1.01–4.63)], wheeze [aOR2 1.60 (95%-CI 1.03–2.50)] and allergic rhinitis symptoms [aOR2 1.75 (95%-CI 1.07–2.87)]. Crowding was associated with dry cough at night in model 2 [aOR2 1.7 (95%-CI 1.42–2.05)]. No associations were found between the exposures to organic waste storage for more than two days, potted plants and pets and airway-related symptoms and allergies in model 2.

Except for visible mould, results from our multivariate analyses were only slightly different between model 1 and model 2. Therefore data from model 1 is only shown in Fig. 1.

Fig. 1 shows bivariate ORs and adjusted ORs for model 1 and model 2 for associations between reported visible mould and airway-related symptoms and allergic diseases. Association was found between mould and allergic rhinitis symptoms [OR 1.70 (95%-CI 1.07–2.72)] and between mould and dry cough at night without a cold [OR 1.58 (95%-CI 1.18–2.11)] in the bivariate analyses. Adjustment for confounders (model 1) changed these results slightly for allergic rhinitis symptoms [aOR1 1.76 (95%-CI 1.08–2.86)] and for dry cough at night without a cold [aOR1 1.51 (95%-CI 1.11–2.04)]. After adjustment for confounders and biological indoor factors (model 2) association between mould and allergic rhinitis symptoms remained [aOR2 1.75 (95%-CI

Table 2
Bivariate and adjusted OR for association between parent-reported biological indoor environmental factors and parent-reported airway-related symptoms and allergic diseases in pre-schoolers.

	doctor diagnosed allergic rhinitis with symptoms in the last 12 months ^a			doctor diagnosed asthma with symptoms in the last 12 months ^c			allergic rhinitis symptoms in the last 12 months ^d			dry cough at night without a cold in the last 12 months			wheeze in the last 12 months			4 or more wheeze attacks in the last 12 months		
	OR (95%-CI)	aOR2 § (95%-CI)	n = 106	OR (95%-CI)	aOR2 § (95%-CI)	n = 97	OR (95%-CI)	aOR2 § (95%-CI)	n = 296	OR (95%-CI)	aOR2 § (95%-CI)	n = 1174	OR (95%-CI)	aOR2 § (95%-CI)	n = 401	OR (95%-CI)	aOR2 § (95%-CI)	n = 61
visible mould at home ^a	1.07 (0.43–2.65)	1.30 (0.51–3.28)		1.87 (0.90–3.92)	2.16 (1.01–4.63)		1.70 (1.07–2.72)	1.75 (1.07–2.87)		1.58 (1.18–2.11)	1.28 (0.93–1.75)		1.42 (0.92–2.18)	1.60 (1.03–2.50)		1.85 (0.73–4.67)	2.03 (0.78–5.3)	
organic waste storage for > 2 days	1.41 (0.82–2.42)	1.11 (0.6–2.03)		0.78 (0.39–1.56)	0.88 (0.43–1.79)		1.09 (0.76–1.57)	1.06 (0.71–1.56)		1.03 (0.84–1.27)	1.23 (0.98–1.53)		0.81 (0.57–1.14)	0.89 (0.63–1.27)		1.15 (0.54–2.43)	1.32 (0.61–2.85)	
no potted plants at home (reference)	1	1		1	1		1	1		1	1		1	1		1	1	
≤ 10 potted plants	1.35 (0.78–2.33)	1.10 (0.61–1.98)		1.04 (0.62–1.75)	1.01 (0.58–1.78)		0.98 (0.73–1.32)	0.94 (0.68–1.3)		0.90 (0.76–1.06)	1.04 (0.87–1.26)		1.00 (0.76–1.30)	0.94 (0.71–1.26)		1.18 (0.61–2.31)	1.01 (0.5–2.02)	
> 10 potted plants	1.47 (0.74–2.93)	1.25 (0.59–2.63)		0.95 (0.46–1.93)	0.94 (0.44–2.05)		0.80 (0.52–1.22)	0.77 (0.48–1.23)		0.79 (0.63–1.00)	0.97 (0.75–1.26)		1.10 (0.77–1.55)	1.04 (0.71–1.52)		0.88 (0.34–2.28)	0.66 (0.24–1.81)	
pets at home	0.92 (0.61–1.40)	0.94 (0.6–1.48)		1.25 (0.83–1.90)	1.17 (0.74–1.84)		0.87 (0.67–1.12)	0.91 (0.68–1.2)		0.92 (0.8–1.06)	0.87 (0.74–1.02)		1.02 (0.82–1.27)	0.90 (0.71–1.14)		1.33 (0.80–2.22)	1.34 (0.78–2.32)	
crowding (> 1 person/room or < 20 sqm/person)	0.64 (0.36–1.16)	0.92 (0.49–1.73)		1.25 (0.77–2.02)	1.26 (0.72–2.18)		1.16 (0.86–1.56)	1.30 (0.93–1.82)		1.82 (1.55–2.13)	1.71 (1.42–2.05)		0.95 (0.73–1.24)	0.95 (0.71–1.28)		1.14 (0.62–2.12)	1.32 (0.66–2.63)	

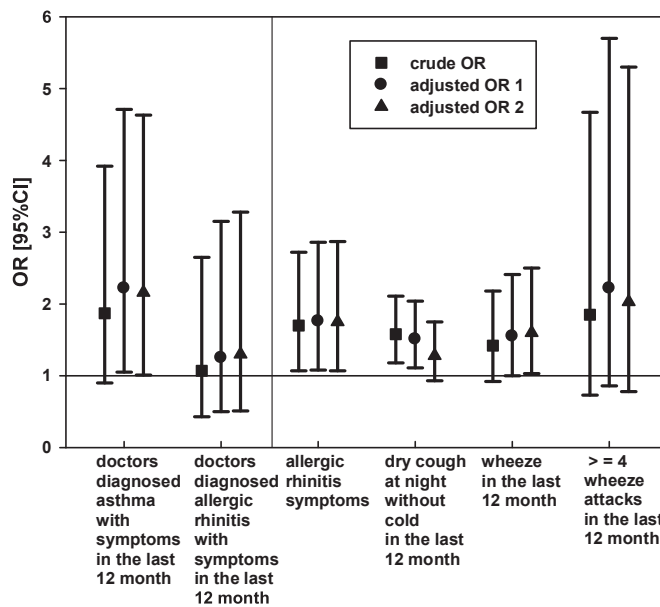
aOR §: adjusted OR for age, sex, country of birth, older siblings, rural/urban residency, parents education, current second hand smoking, mould, organic waste storage, plants, pets and crowding. Significant results are marked in bold.

^a including living room, parents' bedroom, child's room, kitchen, bath, hallway.

^b doctor's diagnosis of allergic rhinitis ever with nasal and eyes-symptoms in the last 12 months.

^c doctor's diagnosis of asthma ever and cough or wheeze in the last 12 months.

^d sneezing or a runny or blocked nose apart from a cold or the flu combined with itchy-watery eyes, OR: odds ratio, bivariat.



aOR1: adjusted for age, sex, older siblings, country of birth, rural/urban residency, parents' education and current second hand smoking

aOR2: adjusted for age, sex, older siblings, country of birth, rural/urban residency, parents' education, current second hand smoking, visible mould, organic waste storage, plants, pets and crowding

Fig. 1. Bivariate and adjusted OR for association between reported visible mould and parent-reported airway-related symptoms and allergic diseases in pre-schoolers.

1.07–2.87]) but no association was seen between mould and dry cough at night [aOR2 1.28 (95%-CI 0.93–1.75)].

4. Discussion

The frequency of visible mould in households with preschool children in Bavaria seems to be relatively low. Aside from mould and crowding, no biological indoor factors (organic waste storage, potted plants and pets) were positively associated with airway-related symptoms and allergic diseases in pre-schoolers.

In comparison to representative data for Germany which showed visible mould in almost 15% of the households (Szewzyk et al., 2011), reported visible mould was relative low in the GME-population.

Our results, which suggest that visible mould was positively associated with airway related symptoms and allergic diseases, are comparable with the results from 12 pooled cross-sectional studies of 6–12 year-old children, which found that recent indoor mould was associated with asthma [OR 1.23 (95%-CI 1.07–1.41)] and wheeze [OR 1.46 (95%-CI 1.31–1.61)] (Antova et al., 2008). A systematic review described visible mould was associated with asthma [OR 1.49 (95%-CI 1.28–1.72)], wheeze [OR 1.68 (95%-CI 1.48–1.90)] and allergic rhinitis [OR 1.39 (95%-CI 1.28–1.51)] (Tischer et al., 2011) which is in line with our results. However, we did not see an association between visible mould and a doctor diagnosed allergic rhinitis with symptoms in the last 12 months. Our data did show an association with allergic rhinitis symptoms in the last 12 months, similar to what was seen in other studies for an association between current mould and current allergic rhinitis [OR 1.7 (95%-CI 1.4–2.1)]. The authors conclude that early exposure to allergens could be important for the development of allergic disease (Kim et al., 2012).

As could be seen from Fig. 1, the odds ratios for the associations between visible mould and airway-related symptoms and allergic diseases changed after including socioeconomic variables. This underlines the need for including socioeconomic factors in such analysis, as we did in the logistic regression model.

In the GME-population, 11.5% of the parents reported to store organic waste for more than two days and results suggest that organic waste storage at home was not associated with respiratory symptoms in children.

A German study described that almost 22% of households stored organic waste for longer than two days at home (Herr et al., 2004). The authors found, for adults, an association between organic waste storage

and skin symptoms. However, no association was found for respiratory symptoms and organic waste storage for more than two days (Herr et al., 2004) as in our study.

Microbial contamination was shown to increase with duration of storage of organic waste (Wouters et al., 2000). The difference of exposure to microbial factors in our study-population may have been too small between the compared groups. Further research could take more detailed categories into account. However, asking for organic waste storage for more than one week at home may rather be a question addressing hygiene aspects.

Plants were the most frequent exposure in our study population but we are not aware of comparable data for Germany.

We could not find an association between potted plants and airway-related symptoms or allergic diseases in pre-schoolers. A case-control study in Nigeria found a protective effect of indoor plants [OR 0.5, $p < 0.01$] on asthma in children (Fagbule and Ekanem, 1994). Data from the "Student Lung Health Survey" from Canada described plants in the household as a risk factor for asthma [OR 1.72 (95%-CI 1.22–2.75)]. They included school children from 5 to 19 years (Mo et al., 2003). We cannot confirm any of these results. Differing living conditions of the population in Nigeria with those in our study population and different age groups in the study-population in Canada could explain the difference in results.

According to representative data for Germany about 46% of households kept pets at home (Laußmann et al., 2012). In comparison to this, keeping pets at home was less frequent (34.3%) in our study population.

In our adjusted model 2 no associations were seen between pets at home and airway-related symptoms and allergic diseases in children. Our results are in line with results from the KiGGS-study which found no association between pet exposure and a 12 month prevalence of asthma (Laußmann et al., 2012). Other studies have shown controversial results about respiratory health effects of pet-keeping at home (Chen et al., 2010; Fretzayas et al., 2013). One possible reason for different results could be that we did not ask for a family history of diseases or allergies which might have led to pet avoidance in our study population. Pet avoidance was shown to be quite frequent and may have biased our results (Bertelsen et al., 2010; Bornehag et al., 2003).

Almost 20% of parents reported to live in crowded homes in our study population which was less than in a socio-economic panel study from 1999 which showed household crowding in 34.2% of German households (Pollack et al., 2004).

Our results indicate a positive association between crowding and dry cough at night without a cold but not with wheeze. A result of a previous study showed crowding was positively associated with wheeze in small infants in their first year of life [OR 1.26 (95%-CI 1.06–1.49)] (Baker et al., 1998). Baker et al. (1998) used a similar definition of crowding. These differences in results may be due to different age groups between the study populations. In another study, crowding was reported to be positively associated with respiratory infections and inversely associated with asthma (Cardoso et al., 2004). As in our study almost 25% of all parents reported that their children had a dry cough at night without having a cold, this could rather be interpreted as infectious disease.

We had a reasonable response rate of 56.7% and were therefore able to analyse data of a large sample of 4732 pre-schoolers in Bavaria. A special strength of our study is that different biological indoor factors were taken into account in one exploration.

The cross-sectional study design does not allow for reporting of causal effects. Use of questionnaires can produce different kinds of bias. We did not have the possibility to assess data from non-responder households. In our study population 50% of the parents had a high education level, which could have led to a lower frequency of exposures like crowding and visible mould, compared to other populations. These parameters might be more frequent in homes with parents reporting a low education level. Moreover, assessment of mould by questionnaire might lead to underreporting of mould (Dales et al., 1994). However, assessment of mould by questionnaires is commonly used in epidemiological studies (WHO, 2009). There also might be a tendency that parents of children suffering from diseases could be more concerned to fill out health questionnaires. Additionally, these parents may remember potential risk factors better than other parents. Selection and recall bias should therefore be taken into account while interpreting this data.

Data collection did include neither any measurement of microbial factors, such as fungi or components of microorganisms, nor did it confirm diagnosis of diseases or symptoms by further investigations, for example a medical examination. This might have led to misclassification of exposures and outcomes. We tried to minimize this by using questions that already have been applied in other studies (KiGGS, ISAAC).

Doctor's diagnosis of asthma and allergic rhinitis were only assessed asking for a lifetime prevalence. Assessment of a 12 month prevalence might be more accurate (longer periods might include more risk of recall bias) (Asher et al., 2010). We therefore additionally considered a 12 month prevalence of related respiratory symptoms.

Confounding may have influenced our results, we therefore adjusted for socioeconomic factors and explored exposures in our multiple logistic regression model.

Exposures to indoor risk factors in other buildings besides home or exposure to outdoor risk factors, which could additionally have adverse respiratory health effects, were not questioned. It is not practical to assess all possible factors that may influence respiratory health in pre-schoolers within one questionnaire. It is known that there is a complex interaction of risk factors in development of asthma and allergic rhinitis. Influences of environmental factors on these diseases depend on each person's genetic disposition to react to the allergen (Nieto et al., 2014). Family history of atopic diseases is an important risk factor for development of allergic diseases (Laußmann et al., 2012). However, we have assessed environmental factors in the 2014/2015 GME survey but were not able to take the genetic aspect and family history into account.

5. Conclusion

This study explored the associations between biological indoor factors and airway-related symptoms and allergic diseases in pre-schoolers. Aside from visible mould and crowding, no associations were found between organic waste storage, potted plants or pets and

aforementioned outcomes. Despite the low prevalence of mould exposure in our study population, our results suggest intervention should be taken for those with visible mould exposure at home due to the reported positive associations (irrespective of the other considered biological indoor factors) with respiratory symptoms and diseases in children.

Key messages

- Our results indicate positive associations between reported visible mould at home, irrespective of the effect of organic waste storage, potted plants, pets at home and crowding, and airway-related symptoms and allergic diseases in pre-schoolers.
- Aside from crowding, which showed a positive association with dry cough at night without a cold, exposure to organic waste storage for more than two days, potted plants or pets was not associated with airway-related symptoms and allergic diseases in pre-schoolers.

Appendix A

Health Authority of the District Office of Bamberg (Wiltrud Doerk, Angelika Pfister, Rosemarie Sittig, Winfried Strauch, Heidi Thamm, Anita Wunder); Health Authority of the District Office of Günzburg (Tatjana Frieß-Hesse, Franziska Lang, Dagmar Rudolph, Roland Schmid, Gudrun Winter); Health Authority of the City Ingolstadt (Isabella Bockmann, Christine Gampenrieder, Margot Motzet, Elisabeth Schneider, Traudl Tontsch, Gerlinde Woelke); Department of Health and Environment, City of Munich (Sylvia Kranebitter, Heidi Mayrhofer, Gertraud Rohrhirsch, Brigitte Weise, Luisa Wolf); Health Authority of the District Office of Schwandorf (Kornelia Baranek, Gitte Koch-Singer, Maximilian Kühnel); Institute of Social Pediatrics and Adolescent Medicine, Ludwig-Maximilian-University Munich (Ladan Baghi, Otmar Bayer, Rüdiger von Kries); Bavarian Health and Food Safety Authority, Munich and Oberschleissheim (Gabriele Bolte, Hermann Fromme, Annette Heißenhuber, Stefanie Heinze, Lana Hendrowarsito, Caroline Herr, Gabriele Hölscher, Martina Kohlhuber, Joseph Kuhn, Bernhard Liebl, Anja Lüders, Nicole Meyer, Christine Mitschek, Gabriele Morlock, Michael Mosetter, Uta Nennstiel-Ratzel, Dorothee Twardella, Manfred Wildner, Angelika Zirngibl)

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