

House dust mite allergen levels in dust from schools with smooth and carpeted classroom floors

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Summary

A study was conducted to investigate the levels of house dust mite allergen *Der p* I in classroom floor dust from 49 schools with smooth ($n = 18$) or carpeted ($n = 31$) floors. Schools were located in the city of Rotterdam ($n = 29$) and in a number of small communities in the Province of Gelderland ($n = 20$). Data on building characteristics of the schools were obtained. Dust samples were analysed for *Der p* I content, the major allergen of the house dust mite *Dermatophagoides pteronyssinus*. The results showed that in schools with carpeted classroom floors, larger amounts of settled dust and higher *Der p* I levels either expressed as concentrations (in ng/g) or loadings (in ng/m²) were found than in schools with smooth classroom floors. However, the levels of *Der p* I were considerably lower than in dust collected from floors in homes. Although the *Der p* I levels were low, effects of several building characteristics on the levels were found. Age of the floor cover, the number of classrooms in the school and the presence of damp spots in the building were related to *Der p* I concentrations and loadings mainly on carpeted floors. Remarkably, schools in the rural area contained significantly more dust and *Der p* I than schools in the urban area. We conclude that dust from carpeted classroom floors contains more house dust mite allergen than dust from smooth classroom floors, but much less than dust from floors in homes.

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Introduction

Exposure to house dust mite allergens is well recognized as an important risk factor for the development of asthma. High levels of mite allergen in the house increase the risk of sensitization in atopic children, as well as the provocation of acute asthmatic symptoms [1]. Allergen avoidance measures are advised to control dust mite exposure in homes. A frequently applied measure is removing carpets, mainly from the bedroom floor. It is not clear whether the type of floor cover in schools affects respiratory health of asthmatic children. A study from Denmark [2] suggested that asthmatic children from homes with low allergen exposure (a smooth bedroom floor and no pets) experienced more respiratory symptoms and used more bronchodilators if they attended schools with carpeted classroom floors.

Few investigators have studied house dust mite allergens in schools. In 1964, mites of the species *Dermatophagoides* were identified on floors of Japanese schools [3]. Dungy *et al.* [4] counted house dust mites in dust from classroom floors in Californian schools. They found only four mites of the species *Dermatophagoides farinae* and *D. pteronyssinus* on 5 m² floor area. Countings in Californian houses were 100 times higher. In a few studies, the differences between carpeted and smooth classroom floors with regard to dust and allergens were investigated. Gravesen [5] found higher amounts of settled dust and organic macromolecular components in classrooms with carpeted floors. Dyben-dal *et al.* [6] studied the presence of different aero-allergens in dust from carpeted and smooth floors in Norwegian schools. Dust samples were taken from carpeted and smooth floors in the same schools. They found no differences in concentrations of allergenic or antigenic proteins from domestic animals, tree pollen, mites and moulds between the two floor cover types. The

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level of mite allergen tended to be even higher on smooth floors. Cat allergen was detected in all samples. In a second study, however, Dybendal *et al.* [7] found slightly higher concentrations of dust mite allergens in dust from carpeted floors, under routine cleaning schedules. In a third study [8], they found that household cleaning solutions and chemical detergents did not impose denaturing effects on allergens left on carpets after cleaning. Munir *et al.* [9] found that levels of cat and dog allergen in dust from floors were lower than in dust from stables and chairs in classrooms.

As a part of a study of the effects of home and school characteristics on respiratory health of asthmatic children, we studied the levels of the house dust mite allergen *Der p 1* in dust from schools with carpeted or smooth classroom floors.

Methods

Characterization of school buildings

A total of 49 school buildings was included in the study. The schools were selected by members of the local health departments, for a study on respiratory symptoms using questionnaires. As we wanted to study effects of carpeted classroom floors on the health of asthmatic children, schools were selected so that about two-thirds of the buildings had textile floor covers in the classrooms. Schools with a majority of children of other than Dutch origin were excluded as the study protocol included completion of diaries over a 1 month period, and we had no possibilities to develop diaries in languages other than Dutch. No other selection criteria were used, and the results of the study can be taken to be representative for primary school buildings with and without carpeted classroom floors in urban and non-urban areas of the Netherlands. A more detailed description of the population selection is given elsewhere [10]. The schools were visited and building characteristics were obtained by a checklist. A member of the school staff completed a small questionnaire on data concerning the floor cover. Dust samples were taken from the classroom floors, according to an internationally recommended protocol [1]. Dust samples from 2 m² floor surface in the middle and 2 m² at the border of the classrooms were taken. The measurements were carried out with a Philips Topomatic T-518 vacuum cleaner (900 W) connected to a dust collecting device manufactured by ALK Laboratories in Denmark, with Schleicher & Schull Schwarzbund paper filters (Ø 70 mm). The sampling time was 2 min/m², and sampling was carried out before the daily cleaning. To avoid seasonal effects, and to detect maximum levels of

Table 1. Dust and *Der p 1* concentrations in 49 schools, stratified by type of floor cover

	Floor cover	n	GM	Gsd	Range
Settled dust (g/m ²)	Smooth	310	0.284	2.8	0.004–6.72
	Carpeted	464	0.475	2.2	0.044–9.30
<i>Der p 1</i> (ng/g)	Smooth	310	22.5	2.1	<5–193
	Carpeted	464	44.2	3.4	<5–18 662
<i>Der p 1</i> (ng/m ²)	Smooth	310	6.4	2.8	<1–113
	Carpeted	464	21.0	4.2	<1–5794

GM, Geometric mean. Gsd, Geometric Standard deviation.

mite allergen, all dust samples were taken within 1 month (September 1990). The late summer and early autumn are periods of the year in which maximum mite allergen levels occur in the Netherlands. The filters were weighed in advance as well after the measurements to analyse the dust gravimetrically. About 200 mg dust from each filter were analytically weighed and extracted in 2 ml 0.125 M ammonium hydrogen carbonate, by agitating for 2 h, followed by centrifuging at 1000g for 15 min. In the supernatant, *Der p 1* was determined using the Enzyme Linked Immunosorbent Assay (ALK Laboratories, Copenhagen, Denmark) following procedures previously described [11]. Amounts of settled dust and *Der p 1* (in ng/m² floor surface) and *Der p 1* concentrations in the dust (in ng/g) were calculated. The detection limit of the ELISA test was 0.5 ng/ml. For undiluted extracts, the detection limit for *Der p 1* concentrations was therefore 5 ng/g.

Statistical analyses

Data were analysed using SAS-procedures [12]. The distributions of the settled dust and *Der p 1* concentrations were right-skewed, therefore the (as in log) transformed values were used in the analyses. Analyses of variance (ANOVA) were performed to study the influence of the factors 'location of sample', 'age of floor cover', 'size of school', 'area of the country' and 'presence of damp stains and mould spots in the building'. The analyses were performed separately for data concerning smooth and carpeted floors, because preliminary analyses showed that the type of floor cover had a large influence.

Results

Of the 49 school buildings, 31 had carpeted (textile) floor covers. The age of the cover ranged from 2 to 31 years.

Table 2. Effect of school and sample characteristics on settled dust and dust mite allergen levels measured on textile classroom floors. Effects expressed as ratios with 95% confidence limits $n = 464$ samples

School/sample characteristic	Dust (g/m ²)	<i>Der p</i> I (ng/g)	<i>Der p</i> I (ng/m ²)
Sample taken from centre vs border	1.35 (1.18–1.54)†	0.88 (0.71–1.08)	1.18 (0.93–1.49)
New floor vs old floor	0.83 (0.72–0.95)†	0.77 (0.62–0.96)*	0.64 (0.50–0.81)†
Small school vs big school	1.18 (0.91–1.52)	0.74 (0.49–1.11)	0.87 (0.56–1.36)
Rural vs urban	1.47 (1.21–1.79)†	2.48 (1.81–3.40)†	3.64 (2.57–5.15)†
Dry vs damp	0.85 (0.74–0.98)*	0.91 (0.73–1.14)	0.78 (0.61–0.99)*

* $P < 0.05$. † $P < 0.01$.

The smooth floor covers were on the average older than the textile floor covers (19.6 years and 8.3 years respectively; $P < 0.01$). The number of classrooms in the buildings was on average 9.4 (range 4–19). Damp stains were present in 28 buildings; mould spots only in three buildings. These three variables did not differ between schools with smooth or carpeted floors.

Results of 848 dust samples were available for statistical analyses. Due to missing values on some variables, 774 samples were included in the multivariate statistical analyses. Dust loadings ranged from 0.004 to 9.3 g/m², *Der p* I concentrations from undetectable (<5 ng/g) to 18 662 ng/g and *Der p* I loadings from undetectable (<1 ng/m²) to 5794 ng/m². Analysis of variance with school as independent variable showed that the within-school variances were higher than the between-school variances; ratios of within to between school variances were 2.60 for settled dust, 1.28 for *Der p* I (ng/g) and 1.04 for *Der p* I (ng/m²). This analysis indicates that the variability within schools is so large that several samples need to be taken and analysed per school in order to be able to reliably classify schools in categories from low to high exposure [13].

Table 1 shows the geometric mean results for carpeted

and smooth classroom floors separately. Amounts of settled dust and *Der p* I levels, either expressed in ng/g or ng/m², were higher on carpeted floors ($P < 0.0001$). There was a good correlation between the *Der p* I concentrations in ng/g and ng/m²; Pearson's R (calculated with logarithms) was 0.75. Separately for textile and smooth floor covers, R amounted to 0.84 and 0.33 respectively. The correlation coefficients between amounts of settled dust and *Der p* I concentrations in ng/g and loadings in ng/m², were –0.05 and 0.33 respectively.

Table 2 shows the effects of various characteristics on dust and *Der p* I loadings on carpeted floors. The amount of settled dust (g/m²) was higher in the centre than at the border of the classrooms ($P < 0.01$). New floors (= less than 10 years old) contained less dust and *Der p* I than old floors. School size made no difference. Dust and *Der p* I loadings were higher in schools from the Province of Gelderland than in schools located in Rotterdam. In schools without signs of dampness, the levels were slightly lower.

Table 3 shows the effects of various characteristics on dust and *Der p* I loadings on smooth floors. The location of the sample (centre vs border) had no clear influence on the results obtained on smooth floors. New floors (= less

Table 3. Effect of school and sample characteristics on settled dust and dust mite allergen levels measured on smooth classroom floors. Effects expressed as ratios with 95% confidence limits $n = 310$ samples

School/sample characteristic	Dust (g/m ²)	<i>Der p</i> I (ng/g)	<i>Der p</i> I (ng/m ²)
Sample taken from centre vs border	1.16 (0.94–1.44)	0.87 (0.74–1.02)*	1.01 (0.83–1.23)
New floor vs old floor	0.61 (0.44–0.83)‡	1.14 (0.91–1.45)	0.70 (0.52–0.93)†
Small school vs big school	0.59 (0.46–0.75)‡	0.92 (0.76–1.11)	0.54 (0.43–0.68)‡
Rural vs urban	1.90 (1.53–2.37)‡	1.31 (1.12–1.55)‡	2.50 (2.05–3.06)‡
Dry vs damp	1.26 (0.99–1.60)*	0.99 (0.83–1.19)	1.24 (0.99–1.55)*

* $P < 0.10$. † $P < 0.05$. ‡ $P < 0.01$.

than 10 years old) contained less dust and *Der p I* than old floors, but only when *Der p I* was expressed in ng/m^2 . School size was also related to these variables (lower dust and *Der p I* loadings in small schools, with <8 classrooms). Dust and *Der p I* loadings were again higher in schools from the Province of Gelderland than in schools located in Rotterdam. In schools without signs of dampness, the levels of dust (g/m^2) and *Der p I* (ng/m^2) were slightly higher than in schools with signs of dampness.

Discussion

In this study, levels of house dust mite allergen *Der p I* were measured in dust samples from classroom floors. Levels were considerably lower than levels in dust from homes [1,14–16]. In another study we conducted using exactly the same methods of sampling and analysis, levels of *Der p I* expressed in ng/g were 15–>100 times higher in dust collected from smooth or carpeted bedroom and livingroom floors [17]. Both of these studies were conducted in the autumn of 1990, which would minimize seasonal or year-to-year influences on this comparison. When expressed in ng/m^2 , *Der p I* levels in schools are of the same order of magnitude as those found on smooth livingroom and bedroom floors, but still much lower than those found on carpeted livingroom and bedroom floors [18]. Levels of dust as well as *Der p I* content were higher in classrooms with textile floor covers, although the differences were much less than commonly found in homes. This probably reflects that although carpets provide dust mites with a better habitat than smooth floors, the climatic conditions in schools are much less favourable for mite growth than in homes. This is most likely related to the intermittent use of school buildings, and to the absence of mattresses and upholstered furniture that may serve as a mite allergen source.

In the centre of textile classroom floors, dust levels were found to be somewhat higher than at the border. This can probably be explained by the fact that pupils walk between the desks, and leave more dust and dirt behind than at the classroom borders. Old floors contained more dust and *Der p I* than new floors. In homes, a similar relationship was found [17], and this reflects a gradual build up of dust and allergen load over the years. The size of the school affected the levels of *Der p I* and settled dust, but only on smooth floors. It is not immediately obvious why levels should be lower in small schools with smooth floor covers only. We speculate that small schools may have different cleaning regimes than big schools, and these may be more effective on smooth floors. However, no detailed data on cleaning habits were collected. We did enquire

whether the cleaning was carried out by a professional cleaning company or by hired parents or other community members. In the large city, regular cleaning was predominantly carried out by the professional cleaning companies. When effect of the way of cleaning was evaluated, however, no significant effect on any exposure index was found. Our study was conducted in the autumn, but samples were taken only 3 weeks or more after the summer holidays. We have no information that would help us decide whether results would be different when samples are taken after a longer period of classroom use, after the summer holidays. In schools situated in Rotterdam, considerably lower levels of dust and *Der p I* were measured than in schools located in the Province of Gelderland. Generally, the west of our country, where Rotterdam is located, is thought to be a more humid area of the country than the eastern part where the Province of Gelderland is located. However, Gelderland is a Province crossed by the Rhine and Waal rivers, and parts of Gelderland may actually experience more humid conditions than Rotterdam. Interestingly, mattress *Der p I* levels were also found to be higher in Gelderland than in Amsterdam, also located in the west of the Netherlands [17]. Dust and *Der p I* loadings were somewhat higher on carpeted classroom floors located in schools with signs of dampness, but there was no such relationship for dust collected from smooth floors. In homes, we also found slightly higher *Der p I* levels when signs of dampness were present, and the relationship was also restricted to dust collected from carpeted floors [17]. These results suggest that only when textile floor covers are present, signs of dampness are correlated with a microclimate which promotes mite growth.

We conclude that levels of mite allergen are higher in dust from carpeted classroom floors than in dust from smooth classroom floors. When expressed in ng/g , levels were very low compared with those found in homes. When expressed in ng/m^2 , levels sometimes exceeded those found in homes with smooth floors, due to the higher dust loading in schools. Nevertheless, levels of dust mite allergens found in Dutch schools are unlikely to present problems for dust mite allergic asthmatic pupils [17,18].

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