

Indoor allergen exposure in primary school classrooms in New Zealand

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ABSTRACT

AIM: Indoor allergens exposure is a risk factor for respiratory symptoms in sensitised children. There is limited data on indoor allergen exposures in New Zealand schools.

METHODS: Vacuumed floor dust samples were collected from 136 classrooms in 12 primary schools and analysed for allergens from the house dust mite *Dermatophagoides pteronyssinus* (Der p 1), cat dander (Fel d 1), cockroach (Bla g 2), cow dander (Bos d 2), horse dander (Equ c 4) and peanut (Ara h 2) by ELISA.

RESULTS: House dust mite, cat, cockroach, cow and horse allergens were detected in 96.4%, 100%, 2.2%, 27.0% and 59.9% respectively in the classrooms dust samples. Thirty-one (22.6%) classrooms had Fel d 1 levels of >8.0 μ g/g while none had Der p 1 levels of >10.0 μ g/g. Only one classroom had detectable levels of peanut allergen.

CONCLUSIONS: House dust mite allergen levels were low in New Zealand classrooms while about a quarter of classrooms had cat allergen levels that may be associated with respiratory symptoms.

Exposure to indoor allergens in the domestic environment is a risk factor for the severity of respiratory symptoms in sensitised children.¹ Numerous studies worldwide have characterised domestic indoor allergen levels, predominantly allergens from house dust mites and domestic animals (cat, dog). Although children spend prolonged periods of their time in the domestic environment, they also spend a large percentage of time in the school or daycare environment where they potentially are further exposed to indoor allergens.

A number of studies have characterised school or daycare indoor allergens around the world; however, most of these studies have been performed in the US and Scandinavian countries with varying results.² For instance, in the US house dust mite allergen levels in schools have generally been much lower compared to the domestic environment while levels of mouse allergens have been at levels associated with respiratory symptoms in those sensitised to these allergens.

Levels of house dust mite allergens in New Zealand are regarded as some of the highest

in the world³ and high cat ownership has been associated with high cat allergen levels in both the home environment and in schools.^{4,5} To date there is however limited information on allergen levels in schools and daycare centres in New Zealand. One study determined cat allergen levels in primary schools,⁵ while another study determined house dust mite, and cat and dog allergen levels in daycare centres.⁶ These studies showed that some indoor allergen levels in these environments could potentially be problematic for sensitised children.

To our knowledge no studies have determined house dust mite allergens in primary schools in New Zealand. We thus undertook a study to determine these levels along with an array of other common allergens found domestically. We included cat, dog and cockroach allergens in our analyses plus allergens from peanut, horse and cow. Peanut and horse allergens have been demonstrated in the school environment,^{7,8} but to our knowledge, no studies have reported on cow allergen in the school environment.

Methods

Dust samples were collected from all classrooms (total 136, range: 7–19 per school) from 12 primary schools in Wellington (n=7) and Whanganui (n=5) in New Zealand. A 1M² central area in each classroom was vacuumed using a Hitachi CV-2800 vacuum cleaner for one minute and dust captured through a small furniture head into a 25µm pore-sized nylon mesh bag as previously described.⁹ The furniture head was cleaned between each classroom dust sample collection to avoid cross contamination. All classrooms were carpeted.

Details were recorded for each school, including building age, cleaning frequency and mode of cleaning of classrooms, main ventilation, floor covering of classrooms and visible presence of moulds or mouldy smell.

100mg aliquots of the dust samples were extracted with 1.0ml of phosphate-buffered saline containing 0.02% Tween-20 for one hour at room temperature. After centrifugation for 10 minutes at 4,000rpm supernatants were removed and the aliquots stored at -20°C prior to allergens quantification.

Allergens from the house dust mite *Dermatophagoides pteronyssinus* (Der p 1), cat dander (Fel d 1), cockroach (Bla g 2), cow dander (Bos d 2), horse dander (Equ c 4) and peanut (Ara h 2) were quantitated in the dust extracts by double monoclonal/polyclonal antibody ELISA by commercial kit sets (Indoor Biotechnologies, USA) according to the manufacturer's instructions.

Allergen results were expressed in µg/g (U/g for Equ c 4). Undetectable levels were assigned one half of the lower limit of detection. As allergen levels were not normally distributed, results were log transformed and results are presented as geometric means with 95% confidence intervals.

Table 1: Levels of indoor allergens in 136 classrooms.

Allergen	Geometric mean (95% CI)	Range of levels
Der p 1µg/g	0.65 (0.50–0.84)	0.02–8.87
Fel d 1µg/g	3.55 (3.04–4.15)	0.29–22.06
Bos d 2µg/g	0.006 (0.005–0.008)	0.002–0.058
Equ c 4U/g	0.004 (0.003–0.005)	0.001–0.226

The Northern A Health and Disability Ethics Committee approved the study (reference: 16/NTA/118). Principals of the schools gave written informed consent for the study.

Results

House dust mite, cat, cow and horse allergens were detected in 96.4%, 100%, 27.0% and 59.9% respectively in the classrooms dust samples. Geometric mean levels with 95% confidence intervals and range of values are shown in Table 1. Thirty-one out of 137 (22.6%) classrooms had Fel d 1 levels of >8.0µg/g, levels of which have been demonstrated to be associated with symptoms in cat allergen sensitised asthmatics. None of the dust samples had levels of Der p 1 >10.0µg/g, also known to associated with symptoms in house dust mite sensitised asthmatics.

Thirty-seven classrooms (27.0%) had detectable levels of cow dander allergen, while 82 (59.9%) classrooms had detectable horse dander allergen. Their geometric mean levels with 95% confidence intervals and range of values are also shown in Table 1.

Only one classroom had a barely detectable, but very low level of the peanut allergen Ara h 2 (0.54µg/g), while three classrooms had barely detectable but also very low levels of the cockroach allergen Bla g 2.

Discussion

In our study we detected the presence of the house dust mite allergen, Der p 1 in virtually all carpeted classrooms. Der p 1 is the major group 1 allergen from the house dust mite *Dermatophagoides pteronyssinus* which is the dominant house dust mite in New Zealand.¹⁰ However, the levels found were quite low compared to domestic dwellings where previously in Wellington a geometric mean level of 40.0µg/g (95% CI: 31.9–50.2) was found in 78 carpeted

living rooms.¹¹ Der p 1 levels of >10 $\mu\text{g}/\text{g}$ can induce respiratory symptoms in subjects sensitised to *Dermatophagoides pteronyssinus*, but in our study, all classroom had Der p 1 levels below 10 $\mu\text{g}/\text{g}$. Therefore, at least in the schools studied, the levels we found are unlikely to be problematic to sensitised children. The reason why Der p 1 levels are quite low in classrooms compared to domestic dwelling in New Zealand is likely due to the rigorous cleaning regime in these schools. All school vacuumed the classrooms on a daily basis (Monday to Friday). In a pilot study we have previously shown a mean reduction of 48.0% in Der p 1 levels after daily vacuuming for five weeks, with levels increasing back to base line levels five weeks after cessation of daily vacuum cleaning.¹² Similarly, daily vacuuming of mattresses for eight weeks showed a mean % reduction of 85.1% of house dust mite allergens (Der p 1 + Der f 1).¹³

The cat allergen, Fel d 1, is readily distributed in the environment due to its aerodynamic properties and also due to transfer from clothing. In the only study of Fel d 1 in classrooms in New Zealand, Patchett et al, a geometric mean level of 2.61 $\mu\text{g}/\text{g}$ was found in 11 primary school classrooms,⁵ a level similar to our results (3.55 $\mu\text{g}/\text{g}$). In our study we found that about a quarter of classrooms had Fel d 1 levels of >8.0 $\mu\text{g}/\text{g}$, levels of which can cause respiratory symptoms in those sensitised to this allergen. Recently, Stelmach et al showed that exposure to cat allergens in schools can also increase the risk of exercise-induced bronchoconstriction in children not sensitised to cat allergen.¹⁴ Patchett et al also found that seven out of the 11 classrooms studied also had Fel d 1 levels of >8.0 $\mu\text{g}/\text{g}$.⁵ Those authors also studied Fel d 1 levels on clothing from the children attending those classrooms and found a strong relation between clothing levels and classroom levels and concluded that the classroom Fel d 1 levels were primarily due to transfer from the pupils clothing. They also found that carpeted classrooms had significantly higher levels of Fel d 1 compared to smooth flooring and advised, that in order to reduce classroom exposure to Fel d 1, schools should look at the option to remove carpets from their classrooms.

Until recently it has been assumed that exposure to horse allergen predominantly occurs in areas where there is high horse ownership. However, lately horse allergen has also been detected in classrooms with no immediate proximity to horse environments. In a study in Sweden, horse allergen was detected in classrooms and levels were higher if pupils had regular horse contact out of school.¹⁵ In another study allergen levels were compared between Korean and Swedish primary schools.¹⁶ Horse allergen was also quantitated and only one out of 68 classrooms in Korea had detectable horse allergen, while most of the Swedish schools had detectable horse allergen. The authors suggested this difference was due to high recreational contact to horses in Sweden, compared to virtually no contact in Korea. In our study we detected horse allergen in nearly two thirds of classrooms, albeit at very low levels. No comparison between published levels with ours was possible given the differences in analytical techniques and dust collection techniques.

To our knowledge, there are no published studies on cow dander allergens in classrooms. In our study we detected the cow dander allergen in about a quarter of classrooms, albeit in low levels. Bos d 2 levels have been detected in domestic home. In a study from the US, Williams et al measured Bos d 2 in domestic homes without resident dairy workers or cows on the property, and in commercial dairy facilities.¹⁷ Bos d 2 was detected in 46–80% of homes dependent on their proximity to the dairy facilities with a concentration gradient extending as much as 4.8km away. Bos d 2 levels in our study were much lower than in the US study, most likely due to a greater distance from dairy facilities, although we did not specifically collect that information.

Exposure to peanut allergen can cause severe and life-threatening allergic reactions in subjects sensitised to this allergen. Peanut allergens have been detected in domestic dwellings where levels are generally determined by means of hand transfer after exposure to peanut products.¹⁸ One study determined peanut allergen levels in schools.⁷ Wipe samples were taken from school cafeteria tables and desks and the peanut allergen Ara h 1 was undetectable,

thus these surfaces were unlikely to be a significant exposure source. The authors also showed that careful cleaning of surfaces with common household cleaning products or water removed peanut allergen from artificially contaminated surfaces. In our study we quantitated the peanut Ara h 2 allergen in settled dust samples from carpeted floors where levels of allergens can potentially increase over time. We were pleased to find that only one out of 137 classrooms studied showed a measurable Ara h 2 level, but at just above the detection limit. Most schools in New Zealand advise parents to avoid peanut products in their children's school lunches. We believe adherence to this advice plus frequent classroom vacuuming has resulted in the virtual absence of peanut allergen exposure in our study.

Only three classrooms had detectable but low levels of the cockroach allergen Bla g 2. We previously found low levels of cockroach allergen in New Zealand childcare centres.⁶ Overseas studies, predominantly from the US, have also shown that levels of cockroach allergens are very low in classrooms compared to the domestic environment¹⁹ while high cockroach allergens have been found in low-income urban cities.²⁰

A limitation of our study is that we only studied 12 primary schools in two geographical regions in New Zealand, and only sampled dust from carpeted floors. Other school studies have sampled from other areas, such as desk tops, or utilised air sampling which may be more representative of airway exposure.

Our study has shown that house dust mite allergens are low in New Zealand classrooms as opposed to the domestic environment. Although we detected Der p 1 in nearly all classrooms studied, none of the levels were >10µg/g, a level associated with respiratory symptoms in house dust mite sensitised subjects.²¹ The cat allergen Fel d 1 was detected in all classrooms with about a quarter of classrooms having Fel d 1

levels of >8.0µg/g, levels of which can cause respiratory symptoms in those sensitised to this allergen. We were able to detect horse and cow allergens in a number of classrooms; however, the levels were low and unlikely to be problematic for those sensitised to these allergens. Similarly, only one and three classrooms respectively had detectable but low levels of peanut and cockroach allergens. We believe that the cleaning practices adopted by the schools, mainly daily vacuum cleaning, were responsible for the much lower levels of allergens in the classrooms compared to what is found in the domestic environment.

Conclusions

The main significant finding of our study was the presence of high levels of cat allergen in classrooms in primary schools, which is potentially a major exposure risk for children already sensitised to this allergen. These levels of cat allergen are most likely due to passive transfer from children's clothing who have a cat at home as there generally are no cats on school premises. However, noting the high prevalence of atopy and asthma in New Zealand, the significant morbidity these conditions impose on children and their families, along with the impact on childhood educational outcomes, pragmatic consideration should be given to minimising allergen exposure in school environments. Given the evidence that smooth floorings have significantly lower cat allergen levels compared to carpeted floorings, and as all the school classrooms in our study were carpeted, our recommendation to schools to reduce cat allergen exposure would be to replace carpets with smooth flooring at their earliest convenience. However, intervention studies are required to demonstrate the benefits of replacing carpets with smooth flooring in terms of health outcomes. Further research is needed to assess any direct causative impact of the levels of cat allergen in school classrooms on respiratory symptoms.

Competing interests:

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