Original Article

School indoor air quality and allergen exposure

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Abstract

There is growing concern about the association of school indoor air quality (SIAQ) with asthma, rhinitis and rhinoconjunctivitis. The most commonly studied allergens are cat (Fel d 1), dog (Can f 1) and dust mite (Der f 1, Der p 1). Very few studies have analysed the significance of cockroach (Bla g 1 and 2) and mould allergens in schools and not much is known about SIAQ in island nations such as Malta. Schools with high allergen levels have an increased incidence of atopic disease resulting in a negative impact on the childrens' health and performance. An acceptable SIAQ can be achieved by adopting published recommendations regarding the control and prevention of indoor allergens. The absence of a European SIAQ monitoring programme highlights the urgent need for more research in this field so as to issue the necessary evidence based recommendations specific to the individual countries.

Key words

Allergens, Air, Asthma, Indoor, School.

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Introduction

The importance of school indoor air quality (SIAQ) has been increasingly recognised since children spend most of their time outside home within the school environment. Although several studies of school indoor air quality and health complications in schools exist, there is no comprehensive analysis of existing literature and data with special reference to European schools.

Background

In Europe more than 71 million kindergarten, primary and secondary students attend school on a daily basis. Poor SIAQ will therefore have a negative impact on the children's health, growth and performance both at school and within society in general.

SIAQ has negative effects on asthma, rhinitis, rhinoconjunctivitis and allergies. Various indoor pollutants such as moulds, bacteria and airborne dust have been found within the school indoor environment.[1-3]

Aim of review

The primary aim of this review is to describe the current evidence indoor air allergens in primary schools. Another aim is to study the effect these indoor air allergens have on the respiratory health of the children. We will also look at what data exists about SIAQ and allergens in island nations such as Malta due to their unique geographical and environmental characteristics and to determine the need and significance of new research within this field.

Method

This review was conducted by looking at online bibliographic databases, web reports and expert opinions and finally a manual search of reference lists. The concept words used in our search were indoor, allergens, school, asthma, allergic rhinitis and atopic eczema. A search was initially performed using the individual concept words and completed using all concept words with the word 'AND' between them.
The bibliographic databases used where PubMed, Embase, Medline and Web of Science. Both the World

Health Organisation and American Thoracic Society websites where searched for relevant studies.
The practical screening criteria used in our search included looking at studies on SIAQ due to allergens published between 1987 and 2012, studies performed in primary schools and manuscripts written in English and Italian were reviewed. Studies dealing specifically with food allergen contamination were eliminated from the review. Methodological screening criteria were utilised so as to include studies that had reliable and valid data sources, appropriate analytical methods and robust and significant statistical analysis. Any studies which did not conform with these practical and methodological criteria were excluded.

Allergen exposure in schools and its impact on asthma and atopic disease

Asthma is one of the most common conditions diagnosed in children and recent studies have shown that allergens produced by dust mite, cockroach, cats, dogs and fungi all contribute to the development or progression of the disease. [4] The prevalence of wheezing and rhinitis in Maltese 5 to 8 year old school children in 2001 surpassed the global mean with an upward trend seen when compared to the ISAAC Phase 1 data in 1994.[5] A negative correlation exists between acute asthma admissions in Malta and mean monthly ambient temperatures which might suggest that temperature is a proxy for the time spent indoors. [6]

School environments with high levels of cat, dog, mould and dust allergens have an increased incidence of asthma diagnosis among the pupils.[7-9] This trend has been confirmed by an increase in eosinophil peroxidase (EPO) and myeloperoxidase (MPO) in sputum of exposed children.[10] Adult school personnel exposed to high amounts of dust allergens had an increased incidence of nasal obstruction confirmed by acoustic rhinometry.[11]
Classes with more than 18% of the pupils owning cats at home where found to have a significant decrease in peak expiratory flow rates and increased asthma symptoms and use of asthma medications in those children who did not report direct contacts with pets.[12]

Asthma prevalence rates correlated positively with the mean levels of Bla g 1/2 in the schools (*p=0.001*). Furthermore cockroach allergen in schools was positively correlated with an increase in asthma symptoms.[35] Viable mould in the school environment is associated with increased asthma symptoms [13] with Swedish schools showing that viable mould in classrooms is positively correlated with asthma when compared to schools with better indoor air quality.[1] *Aspergillus* sp was found to result in a decrease in nasal patency while ECP and lysozyme levels in NAL where increased.[14] The HESE Study showed that Aspergillus/Penicillium DNA was significantly positively associated with wheeze, while Aspergillus versicolor DNA correlated positively with wheeze, rhinitis, and cough.[15]

Allergens in the school indoor environment.

The most commonly studied allergens within the school indoor environment are Cat (Fel d 1), dog (Can f 1) and the dust mite (Der f 1, Der p 1).[16] Studies have also looked at the presence of cockroach (Bla g 1 and 2) and mould allergens in schools.
Dust mite allergens

The concentration of dust mite Der f 1, Der p 1 allergens in daycare facilities and schools is usually similar or minimally reduced when compared to other indoor environments especially homes.[16] In 60 primary schools in the United States only 2.5% of the classrooms had dust mite levels exceeding recommended levels. [17] Classrooms in both the US and Europe having carpeting and furnishings especially mattresses, pillows and stuffed animals are characterised by significantly high dust mite levels while non carpeted rooms have low levels of Der f1 and Der p 1.[18-23]
Low levels of dust mite allergens have also been found in Norwegian classrooms with detectable levels in less than 1 % of rooms.[24-25] Dust mite allergen levels in four primary schools in Western Australia were found to be much lower than the recommended sensitizing thresholds. There was no difference in levels between the standard schools and 'low allergen' schools. [26-27]
Cat and dog allergens

Cat and dog allergen levels have been found to be higher in school classrooms when compared to homes with no pets. [20] The two most common isolated allergens are cat (Fel d 1) and dog (Can f 1).[16] Allergen levels in classroom dust samples have been found to be as high as 1300ng/g and 1650ng/g for cat and dog allergens respectively. [28] Floor levels and pupil cat ownership rates were positively correlated *(r2=0.93, p=0.0003*) while children from homes with cats carried allergen on their clothes (mean Fel d 1, 6.10microg per garment compared with non-cat owners (0.72microg per garment).[29-31] Children who are in daily contact with cats and dogs in the home environment have been shown to carry cat and dog allergens to school via their shoes and bags [20] and human hair.[32]

Furnishings and textiles are associated with higher levels of cat and dog allergens. The presence of open shelves and curtains resulted in higher levels of pet allergens although these were lower in classrooms which were cleaned more often.[33] In rooms with carpet and hard-surfaced flooring, levels of Can f

1, Fel d 1 were statistically higher on the carpets.[34]

Cockroach allergens

Cockroach allergen correlated positively with the presence of carpets and soft furnishings[23] and allergen levels were detected (>0.003microg/g) in 71% of the dust samples and 22% of airborne samples from the schools.[35-36] Inner city schools serving low income populations have been shown to have higher levels of allergen with particular reference to food related areas which had significantly higher levels of cockroach allergen when compared to classrooms (*p=0.048*).[37]

Fungal allergens

Fungal exposure has been assessed by indirect methods utilising spores as a marker of allergen presence and little data exists regarding the presence of fungal allergens in schools with most studies carried out in the US. Mould spores for *Aspergillus* and *Alternaria* had a high prevalence in school classrooms. [38-39] A study carried out in Texan schools showed that more than half of the tested classrooms had fungal spore counts of > 10,000col/g (median 14,400col/g). [17]

In summary, although the majority of schools have house dust mite levels which are comparable to the home environment,[17] the presence of indoor soft furnishing and carpets favours the presence of Der f 1, Der p 1 allergens in schools.[18-19] Cat (Fel d 1) and dog (Can f 1)[16] allergens have been isolated in schools and those children who are in daily contact with cats and dogs within the home environment carry these allergens to school via clothes, shoes, bags and hair.

As with house dust mite there is a positive correlation between cat and dog allergens and the presence of carpets and soft furnishings within the school environment. Interestingly cockroach allergen was detected in 71% of dust samples and 22% of airborne samples from the schools. *Aspergillus* and *Alternaria* moulds had a high prevalence in school classrooms with higher levels seen in carpeted floors . School children spend a large part of their time within a school environment thus putting them at risk for exposure to these allergens. This is of importance since during the first few years of life children develop IgE mediated sensitivity to specific allergens thus increasing the prevalence of future atopic disease.[36]

Prevention strategies

The evidence shows that sensitization to indoor allergens in schools is associated with increased eNO levels [40] and therefore strategies favouring better SIAQ should be developed. Both the American Thoracic Society (ATS) Workshop on indoor air pollution [41] and the WHO air quality guidelines [42] have recommendations regarding the control of allergens within the indoor environment.

When analysing of the data available we have concluded that prevention strategies in schools for indoor allergens should be divided into a preventive phase and an interventional phase. The preventive phase should target those allergens that are commonly found within the school environment. A standardised regular cost effective maintenance schedule in schools should be implemented thus decreasing the levels of allergens in classrooms. This will prevent accumulation of dust, entry of pets and pests especially cockroach and finally avoid the establishment of mould by regular maintenance of both the external structures and plumbing systems. Staff should be specially trained to target these pollutants specifically and regular assessment of the indoor environment should be carried out. Both children and their parents should be educated in how to avoid exposure to pet allergens with emphasis on clothing, shoes and hair transfer of allergens.

The interventional phase should include the use of high efficiency particulate air (HEPA) with negative ions, filtration and electrostatic precipitation. [43] A regular pest eradication programme has to be implemented and should reflect the geographical and environmental characteristics of the area.[44] Any established mould should be immediately treated on a regular basis using environmentally friendly products.

Limitations of review

One of the major limitations of our review is that most studies involve relatively small numbers of children thus limiting the significance of results. Studies are mostly non standardised using different protocols and criteria.

Conclusions

Although the prevalence of respiratory disease has increased in Europe, not enough information is available about the quality of school air and indeed its impact on the pupils' health.

Future research needs.

The absence of a European SIAQ monitoring programme for indoor air allergens highlights the urgent need for more research in this field so as to issue the necessary evidence based recommendations specific to the particular country. To date all studies in Europe have not been standardised and mostly analysed small numbers of children in a limited number of northern countries. Although the subject has been discussed in previous publications, to our knowledge this is the first review of SIAQ which highlights the need of new data from European schools so as to enable policy makers issue the necessary recommendations. Due to the heterogenous characteristics making up European countries it is very difficult to issue recommendations based on the

evidence currently available. No standardised studies have been carried out looking at school allergens in island nations such as Sicily Malta and Cyprus. These countries have unique environmental and air quality characteristics which differ from mainland Europe and US schools. Local studies have shown that the prevalence of asthma in school children is increasing and therefore it is important to obtain data with regards to what school indoor allergens exit locally. This will influence what preventive recommendations are needed both at school level and politically. Two European Union funded studies (SINPHONIE[45] and RESPIRA)[46] are currently assessing SIAQ in Maltese schools using standardised methodology and these should provide us with some urgently needed local data.

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