

Detection of allergen sources in the homes of sensitized children

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Abstract

Objective To identify the presence of environmental factors linked to the onset of allergies and asthma in the homes of children participating in an early detection program that were identified with sensitivity to common allergens in the region of Sonora, Mexico.

Methods A walkthrough assessment was carried out in the homes of sensitized children; the research tools were the questionnaire and environmental checklist proposed by the Lowell Healthy Homes Program of the University of Massachusetts-Lowell.

Results The results showed the presence of environmental allergen sources, to which most of the children in the study are sensitized, as well as the environmental conditions and habits that determine the quality of the indoor air of the households, were both related to triggering allergies and asthma in this population. A statistically significant

association was found between the visual observation of dust inside homes and the sensitivity of children to dust mites.

Conclusions Dust found inside the home was the most relevant environmental factor related to positive cases of IgE in children. Early detection of allergies in children in the study and the methodology used in this investigation provided a useful framework for the design of plans and intervention alternatives in these homes to prevent the development of allergies and asthma panorama. These plans should be designed with a multidisciplinary approach to impact social, environmental and economic benefits in the family, improving the living conditions of the study population and contributing to the sustainable development goals of the United Nations for 2030.

Keywords Allergy · Home · Sensitized children · Allergens · Environment

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Introduction

Studies show that about 24 % of diseases in general can be attributed to environmental causes, and that 36 % of those who suffer them are children [1]. Asthma and allergic diseases are exaggerated responses of the patient's immune system identifying certain substances in the environment that are usually tolerated by most individuals as harmful [2]. The prevalence of asthma and allergic diseases caused by dysfunction of the immune system and exposure to environmental factors is increasing and is one of the most common chronic and recurring diseases [3, 4], resulting in doctor checkups, hospitalizations, and medication, impacting health resources in many countries as well as the family economy [5, 6].

Today, people spend about 70 % of their time at home [7], where the environmental conditions and contaminant levels are the result of a mixture of external and internal agents of chemical, biological or physical nature [7, 8]. These conditions and contaminants can reach levels that promote the development of allergies [9, 10], making homes one of the most influential health environments [1, 4]. Among the agents recognized as allergy and asthma triggers inside homes are dust, pests, moisture, dust mites, pet dander, tobacco smoke, pollen, volatile chemicals and products of fossil fuel combustion, the ozone, particulate matter, etc. [11, 12].

Various studies have been conducted using tools such as questionnaires or checklists to identify the presence of sources of allergens in homes, such as mites, cockroaches, rat urine, fungi, and cat and dog dander [12, 13]. Others assessed the environment, measuring the concentration of dust in the air, the temperature, and the humidity inside these homes, and discovered that these are at levels that promote the presence of fungi and mites and produce a harmful environment for its inhabitants [14–16]. However, no publications have been identified with previous clinical studies to determine the population's sensitivity to common allergens of the region and in turn use these results to compare them with the environmental diagnoses in these people's homes. Confirmation of the presence of allergens in homes where the population is sensitized is important because it sets the tone for further studies and preventive measures aimed to propose and implement specific interventions that improve the environment for its inhabitants and their health [12, 17, 18].

In Hermosillo, an early detection program for allergies detected the beginnings of the allergic sensitization of a group of 179 children 3–6 years old [19]. Subsequently, sensitized children participated in a study of ten allergens to identify the specific sensitization to one or more allergens in the pollinic map of the Sonoran region. Both tests used fluoroimmunoassay techniques that allow the early detection of allergies by immunosorbent serological analysis, which confirms or excludes the presence of mediated sensitization by immunoglobulin E (IgE) [20]. IgE is an antibody produced by the human body in response to specific allergens and is used as an indicator of allergies [21] with certain inhaled allergens (such as mites, pollen, cat and dog dander, and fungi) accountable for over 90 % of allergic sensitivity in children [22]. This left the previously mentioned population with the potential for a study of their home environment.

The aim of this paper is to present the methodology used to diagnose the presence of allergen sources and conditions that favor their presence in homes to relate the results of a previous clinical study [19] which identified and determined children's sensitivity to common allergens in

Sonora, México. The results of the methodology provided valuable information for the development of intervention alternatives and multidisciplinary prevention focused on factors linked to the onset of allergies and asthma identified in those homes.

Methodology

Selection of the population

This research was conducted in the city of Hermosillo, Sonora, located in northwestern Mexico, in the homes of children selected for their sensitization to one or more allergens in the pollinic map of the Sonoran region. These children were participants of the program in early detection of allergies [19] that detected the beginnings of the allergic sensitization of a group of 179 children 3–6 years old [19] using the Phadiatop® test. Subsequently, 23 sensitized children participated in the study of ten allergens to identify the specific IgE using the same fluoroimmunoassay technique as Phadia ImmunoCAP™100 automatized equipment. The Phadiatop® test is a qualitative in vitro technique that allows the early detection of allergies by immunosorbent serological analysis, which confirms or excludes the presence of mediated sensitization by immunoglobulin E (IgE) with a trust level between 84 and 96 % [20].

The parents of 23 children were requested by telephone invitation to participate in a diagnosis of intradomiciliary factors linked to the onset of allergies and asthma. At their homes, the project objectives were explained to the parents, as well as the opportunity of knowing if their homes had environmental factors that could promote allergic problems. They were informed about the commitment of researchers to maintain the anonymity of families, the confidentiality of the information obtained and their freedom to leave the study at a time they considered suitable. The child's mother signed an informed consent form before the home diagnostics journey. No financial or in-kind benefits were offered.

Identification of allergen sources

The questionnaire and environmental checklist proposed by the Lowell Healthy Homes Program of the University of Massachusetts-Lowell was used as a research tool [12]. This method identifies potential asthma and allergy triggers; it was translated to Spanish and adapted to the context of households in Hermosillo, eliminating and adding reagents due to differences related to the type of structures and materials used in Unites States and Mexican households as well as the customs of the Mexican population.

For example, we eliminated items related to attic and basement areas and we added items related to the type of air conditioning equipment used in the region. This instrument had the following sections: general data and family background, dust conditions of the different rooms in the household, pets, smoking, pests, humidity and mold, use and condition of air conditioners, use and presence of chemical agents, and potential sources of pollution located near the homes. It consisted of 155 multiple-choice and open questions and collected important information about the overall home and each room that is useful to describe the conditions of households, both environmental and socioeconomic, related to decreased quality of people's health.

The information provided by the questionnaire and checklist was organized in an Excel 2013 (Microsoft) document for analysis purposes. The analysis of association between positive cases of IgE specific and visual identification of dust in households was carried out by the statistical Kappa using computational software Stata 11.1 (StataCorp LP, College Station, Texas, USA).

Indoor and outdoor environmental factors

The indoor temperature and humidity in households was measured using a thermometer and hygrometer (Mannix testing and measurement digital hygro-thermometer), which has a range of -10 to 50 °C (± 1 °C) and a humidity range of 20–99 % (± 5 %). The instrument was placed in the living room and on-screen measurements were taken in homes. The measurement was done in a second visit where families allowed access to their homes.

Results

The parents of 18 of the 23 children identified as sensitized in the program of early detection of allergies [19] agreed to participate in this study (78 % of acceptance). The home visits were conducted from January to September 2014 and lasted 45–60 min, during which the parents answered the questionnaire and a walkthrough assessment by the rooms was conducted. No financial or in-kind benefits were offered. The children's age ranged from 3 to 6 years old and consisted of 17 % girls and 83 % boys. Of the parents, 33.3 % suffer from an allergy and 61 % of the children had allergies such as rhinitis, eczema and dermatitis, while 28 % had asthma. The families were lower middle class with low monthly incomes of less than \$400 U.S. Dollars. Most homes were built of brick or concrete block.

Sources of allergens and environmental conditions inside homes

During the tour, the visual inspection revealed the presence of dust in the majority of homes, as well as objects, cleaning habits and conditions that accumulated dust. There was a strong presence of plush fabric and stuffed animals, dirty air filters and oxide in air coolers in some homes, as well as peeling paint and plaster on walls and cement floors. Cleaning habits showed that at least once a week the house dust is removed, using a vacuum in some cases, although none of them use a vacuum cleaner with high efficiency filter (HEPA). In 50 % of households, children slept with at least one other person in small rooms.

Table 1 shows family and cleaning habits, as well as the objects and conditions found that are conducive to the presence and permanence of dust in the home of sensitized children.

Table 2 presents the factors and conditions observed that favored and gave indications of the existence of biological contaminants (pests and pets) in their homes.

Table 3 shows the average and peak temperature and relative humidity in nine households of the study sample.

Table 1 Sources of allergens observed in households related to the presence of dust

Factors	Frequency in homes (%) (<i>n</i> = 18)
Visual dust	89
Sources of dust	
Curtains, cotton pillowcases and stuffed animals	100
Carpets	11
Cement floors	44
Air conditioners (<i>n</i> = 25)	
Window air conditioners or mini-split	64
Air coolers (use straw)	32
Central air conditioning	4
Peeling walls (paint and plaster)	72
Habits/factors related to dust	
Dusting (1 × per week)	61
Washing bedspreads (1 × per week)	67
Cleaning air conditioners (AC)	
Dirty filter in AC window mini-split (<i>n</i> = 16)	50
Oxide in AC/air cooler or "cooler" (<i>n</i> = 8)	100
Vacuuming	33
Without high efficiency particulate air filter (HEPA)	100
Overcrowding bedrooms (more than 2 people per room (average area bedrooms: 12.4 m ²))	50

Table 2 Sources of allergens observed in households related to the presence of pests and pets

Factors	Frequency in homes (%) (<i>n</i> = 18)
Pests	
Cockroaches	72
Rats or mice	28
Mold	40
Factors related to the presence of pests	
Leftover food in kitchen	39
Exposed garbage (no garbage containers)	100
Moisture leaks	33
Holes in walls and other surfaces	33
Pets	50

Table 3 Average temperature conditions and relative humidity in homes visited (*n* = 9)

Parameter	Value
Temperature (°C)	
Low	21
Maximum	27
Average	25
Relative humidity (%)	
Low	26
Maximum	58
Average	44

Although the temperature and relative humidity were measured in a common area, they can be considered as representative of the environmental conditions of the housing.

Sources of pollution indoors and outdoors

The sources of pollution identified in the interior and in the vicinity of households that may be contributing to the air quality inside homes are presented in Table 4.

Children's sensitivity and sources of allergens in homes

Table 5 presents and makes a comparison of the results of the specific IgE test for common allergens in Sonora conducted among 18 children in the program of early detection of allergies [19], whose homes were visited in this investigation and the proportion of households where the presence of these potential sources of allergens were identified.

Table 6 shows the results of the statistical analysis done to determine the association between allergens present in households with specific sensitivity in the participating children. It was considered that allergens to which children

Table 4 Sources of pollution observed in the interior and exterior of homes

Factors	Frequency in homes (%) (<i>n</i> = 18)
Sources of indoor pollution	
Using butane stoves	100
Ventilation in kitchen	78
Using air fresheners	
Most days	17
Once a week or less	22
Use of chemical cleaners	
Most days	39
Once a week or less	50
Smoking at home	11
External pollution sources located within a radius of 800 m of the households visited	
Dry cleaners	11
Gas stations	28
Furniture painters/carpenters	22
Restaurants	72
Bakeries	50
Car repair shops	67
Loading and unloading truck areas	22
Bus stops	94
Unpaved streets	33
Other sources of odor/irritation (sewers, landfills, etc.)	67

Table 5 Results of specific IgE tests on children of the program in early detection of allergies [19] and potential sources of these allergens in homes

Allergens	% of sensitized children (<i>n</i> = 18) [19]	% of households in which allergen sources were identified (<i>n</i> = 18)
<i>Artemisia vulgaris</i> (mugwort)	66.7	–
<i>Fraxinus americana</i> (white ash)	94.4	–
<i>Timothy grass</i> (wheat grass)	88.9	–
<i>Alternaria</i> (brown stain Mandarin)	16.7	–
<i>Betula verrucosa</i> (birch)	61.1	–
<i>Pteronyssinus</i>	50.0	–
<i>Dermatophagoides</i> (dust mite)		
Cat dander	44.4	50.0
Dog dander	55.6	50.0
<i>Periplaneta americana</i> (red cockroach)	55.6	72.2
House dust	77.8	88.8

Table 6 Association of the specific sensitivity (IgE) of children with visual identification of dust in their homes

Allergens	Kappa value	p (significance)
<i>Artemisia vulgaris</i> (mugwort)	−0.3279	0.9022
<i>Fraxinus americana</i> (white ash)	−0.0976	0.7088
<i>Timothy grass</i> (wheat grass)	0.1176	0.3060
<i>Alternaria alternata</i> (brown stain Mandarin)	−0.2162	0.9787
<i>Betula verrucosa</i> (birch)	−0.1408	0.7409
<i>Dermatophagoides pteronyssinus</i> (dust mite)	0.4444	0.0117*
Cat dander	0.1220	0.2979
Dog dander	0.1000	0.3357
<i>Periplaneta americana</i> (red cockroach)	−0.2857	0.9022

* Statistically significant

are sensitized may be present in the dust, which was the most common visual finding in homes. The only statistically significant association found was between the presence of dust and sensitivity with the allergen *Dermatophagoides pteronyssinus* (dust mite) ($p = 0.01$). The value of Kappa (0.44) indicated a moderate Association (Kappa = 0.41–0.06) [23].

Discussion

The main finding of this study was the visual identification of possible allergen sources in the interior and exterior of homes that reduced the quality of the air inside the houses and could lead to allergy onset in sensitized children and asthma attacks in the asthmatic ones. Some of the allergen sources identified correspond to the positive IgE cases in the children reported by the program of early detection of allergies (PEDA) [19]. However, we only found a statistically significant association between the visual observation of dust inside homes and the sensitivity of children to dust mites (Tables 5, 6).

Dust was visually detected in most households together with objects, cleaning habits, and conditions that accumulated it as it is described in Table 1. Ambient cooling equipment was identified, especially the type known as a “cooler” with visible dust, rust, and humidity accumulation [15, 24–26]. Paint and plaster peeling were observed in the houses’ walls, [25, 26]. Overcrowding conditions (two or more people sleep in a small sized room) was observed in half of the homes, as children sleep with another person [24, 28] in same room.

These findings are relevant because the PEDA reported that 78 % of these children are sensitized to house dust [19] that may contain mites, particles of textile fibers, plants, cellulose, plastics, food, human skin scales, construction material, chemicals, mold spores, cooking oil droplets, etc., that diminish the quality of the air and irritate the human respiratory system [1, 7, 29].

Evidence of the presence of cockroaches, rodents as well as dogs and cats (Table 2) were observed. Although the association of these factors with the positive cases of IgE was not statistically significant (Tables 5, 6), these data are important because a significant proportion of children are sensitive to red cockroach allergen, cat and dog dander (Table 5). The existence of food waste and trash containers without covers in all the kitchens, as well as observation of moisture leaks and holes are also enabling environments for pests [5, 29]. The PEDA [19] did not report the children’s sensitivity to rodent allergens; however, this is another factor that cannot be discarded. Similarly, in this study, the presence of allergens from vegetation was not specifically identified, to which some of children are sensitized (Table 5).

The average conditions of temperature and humidity in homes (Table 3) were favorable for mites and molds. These organisms grow at 16–30 °C and 40–75 % of relative moisture [7, 16, 18]. The main habitats for mites are: mattresses, carpets, clothing, upholstered furniture and stuffed animals [30] that were found in all households (Table 1). Overcrowding observed in housing also contributes to the presence of mites; a person disposes 0.5–1 g of remains of human skin peeling daily and several thousand mites can live with 250 mg of this waste [31]. Half of the children of this study are sensitized to mite dust [19] and a statistically significant association was found with the observation of dust in home and IgE positive cases (Tables 5, 6).

The air quality inside the children’s homes can be affected by butane combustion of stoves, smokers, chemical cleaners and air fresheners. The children could also be affected by outside activities, i.e., bus stops, food sellers, car repair shops, sewers and vacant lots (Table 4) that generate volatile organic compounds, sulfur dioxide, carbon dioxide, carbon monoxide, nitrogen dioxide, and particulate matter that can trigger allergies and asthma attacks [8, 27, 30–32].

The exposure of children to house dust and other particles in the indoor environment could be reduced by

improving the habits and methods of cleaning and household maintenance; this is not easy in families of low socioeconomic level where this is hampered by lack of resources. Another issue is that some of these children's homes are located in neighborhoods where the streets are unpaved and the warm and dry desert climate of the region (25–47 °C in the summer [33]) requires natural ventilation from the outside and the households need coolers in the rooms during warmer months. However, ventilation from the outside could increase particulate matter within households from the exterior [34, 35] (especially where streets are unpaved), aggravating the problem and reducing the quality of air inside homes [36].

Safe pest control methods such as gels glue traps are equally important [5, 18, 29]. Pests can also be reduced by avoiding any exposed food residue, ensuring greater hygiene with pets, eliminating leaks and holes where pests can hide, cleaning air coolers, removing carpets and stuffed animals, eliminating dust more often and using vacuums with HEPA filters to remove household dust in mattresses, furniture, carpets and other textiles [9, 37]. Beds may contain the highest concentration of mites [30, 31], and using hypoallergenic bedding and mattresses is an effective way to avoid exposure of children to mites [9].

Air moisture inside homes is affected by the humidity of the outside air (annual average in the city is 42.8 %), its inhabitants and their activities [26, 38]; natural ventilation might reduce indoor humidity, however, this option could lead to unfavorable environments for pests but would expose children to outside dust [39].

Children's families range from a medium–low to a low socioeconomic level that may show greater resistance to changing their behavior [40]. A multidisciplinary approach involving staff intended to improve the environments in homes could help this problem; nurses and social workers focused on the education of participating families, changing habits of cleanliness, and giving alternative nontoxic cleaning products and methods of pest elimination is advisable. This type of strategy has been successful [17, 29, 34] and effective in 31–94 % of cases [41].

In many households, the study confirmed that the conditions of the homes could be an important cause of exposure to children sensitized to allergens, however, these children may also be exposed in other places, for example, in schools. Therefore, the identification of sources of allergens in these places as well as the implementation and effectiveness of multidisciplinary preventive interventions will be an opportunity to study in the future.

A limitation of this study is the small sample number [18] due to a few families that participated in the PEDa not allowing researchers to visit their homes. This number was smaller in the second visit when measuring temperature

and relative conditions inside homes because some families could not be reached because of relocations or did not allow a second visit to researchers. This can be attributed to lack of interest in the study, or distrust towards people entering the privacy of their homes. These aspects should be considered in the future studies.

Literature related to clinical studies in children linked to environmental aspects in homes is scarce; therefore, this research showed that our methodology was useful in providing an overview of the problem of the onset of allergies in the northwestern region of Mexico.

It is concluded that the habits of the families, the housing conditions, the presence of pests, as well as the proximity of shops and commercial activities are factors that could be determining the indoor air quality and contribute to the presence of allergens to which children are exposed in their homes. We only found a statistically significant association between the visual observation of dust inside homes and the sensitivity of children to dust mites, this factor is related to the sensitization that some of these children showed in clinical studies of specific IgE to common allergens in Sonora conducted by the PEDa [19] and can contribute in the future to allergic conditions and development of asthma in this population.

The detection of sensitization to allergens in early childhood and the development of preventive interventions that improve the home environment may help reduce future onset allergies and asthma attacks in asthmatic children. These contingency plans based on improving household and lifestyle changes should be well designed, implemented and monitored with a multidisciplinary approach that affects social, environmental and economic benefits in the family, improving the living conditions of the study population in contribution to achieving sustainable development goals by 2030.

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Compliance with ethical standards

Funding There was no funding for this study.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All procedures performed in the studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent This study protocol was approved by the Bioethics Committee of the University of Sonora (UNISON CBI Document 07/2014). Informed consent was obtained from all individual participants included in the study.

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