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Dust Allergens within Rural Northern Rocky Mountain Residences

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Abstract

To date, few studies have characterized allergens within residences located in rural areas of the northern Rocky Mountain region. In this study, we collected dust samples from 57 homes located throughout western Montana and northern Idaho. Dust samples were collected and later analyzed for dust mite allergens *Der f 1* and *Der p 1*, Group 2 mite allergens (*Der p 2* and *Der f 2*), domestic feline (*Fel d 1*), and canine (*Can f 1*). Indoor temperature and humidity levels were also measured during the sampling program, as were basic characteristics of each home. Dog (96%) and cat (82%) allergens were the most prevalent allergens found in these homes (even when a feline or canine did not reside in the home). Results also revealed the presence of dust mites. Seven percent (7%) of homes tested positive for *Der p 1*, 19% of homes were positive for *Der f 1*, and 5% of homes were positive for the Group 2 mite allergens. Indoor relative humidity averaged 27.0 ± 7.6% within the homes. Overall, humidity was not significantly associated with dust mite presence, nor was any of the other measured home characteristics. This study provides a descriptive assessment of indoor allergen presence (including dust mites) in rural areas of the northern Rocky Mountains, and provides new information to assist regional patients with reducing allergen exposure using in-home intervention strategies.

Keywords: Residential; Indoor Allergens; Dust Mites; Cat Allergens; Dog Allergens

Abbreviations:

ARTIS: A Randomized Trial for Indoor Smoke

Introduction

Some of the most common indoor allergens include dust mites, cockroach, and pet dander. Characterizing the presence of these allergens inside residential environments is important, as exposure to these antigenic/allergenic substances can contribute to sensitization and increased rates of exacerbation among exposed asthmatics [1]. Today, between 10% and 30% of the worldwide population experiences allergic rhinitis, with 10% of US children ages 17 and under suffering from hay fever in the last 12 months [2]. In addition, 8% of the US population is asthmatic (18.7 million people), with 6.8 million children (9.3%) currently diagnosed with asthma [3].

As an evolving field of study, indoor residential interventions can be used to reduce the impact that these allergens have in exacerbating perennial allergic rhinitis and asthma. To date, multiple in-home intervention strategies targeting dust mites, domestic animal allergens, and cockroach allergens have been evaluated, with each intervention showing variable success [4-8]. Importantly, prior to the implementation of such interventions, the presence of allergens within the residence needs to be fully characterized.

Several studies have reported on levels of indoor allergens [9,10]. Most of these studies have focused on highly urban and populated areas. However, there is currently little information on the dust-related allergens found in residences throughout rural and frontier areas of the northern Rocky Mountains. As part of this study, we collected floor dust samples from 57 residences across western Montana and eastern Idaho. Samples were analyzed for the presence of feline, canine, and dust mite allergens. Humidity data and socio-economic factors were also ascertained from each of the homes to investigate their influence on allergen concentrations across our geographical study areas. In this manuscript, we present the results of this study.

Materials and Methods

Study areas included communities within a ~320 km radius surrounding Missoula in western Montana (note that Missoula is 70 km from the neighboring Idaho state line). At an elevation of ~980 meters above sea level, Missoula and the surrounding area have a population of over 120,000 people. The region is characterized by mountainous terrain, and has a semi-arid climate. The winters are typically cold with moderate snow/precipitation, and the summers hot and dry. The annual precipitation is ~35 cm with average monthly ambient relative humidity ranging from 23% to 94% depending on time of year [11]. Higher humidity is typically measured during the winter months, with lower humidity during the summer months.

Dust samples were collected as part of the ARTIS study (A Randomized Trial of Indoor Smoke), an in-home intervention study focused on asthmatic children exposed to residential wood smoke [12]. Eligibility for the program consisted of having a child (ages 7 to 17) with persistent asthma living in a home heated with an older model wood stove.

Dust Sampling

Dust samples (one composite sample per home) were collected from 57 homes in western Montana / northern Idaho during a single sampling visit. From each of the participating homes, samples of dust were collected using a Dirt Devil Breeze Vision canister vacuum and a Dustream Collector (Indoor Biotechnologies). Samples of dust (~35 mg) were collected from the floors of the common rooms of the residences (i.e. living rooms) over an area of approximately one square meter. Dust samples were collected from both carpeted and hard wood floors in this study, with the majority of the samples collected during the months of February and March.

Dust Analyses

Dust samples were initially extracted in 0.05% PBS-tween, with the extracts frozen at -20°C prior to the analyses. Dust extracts were analyzed for allergens using a Luminex 200 via MARIA 5-plex assay (Indoor Biotechnologies). Allergens that were analyzed included dust mites (*Der f 1*, *Der p 1*, and Group 2 *Der p 2* and *Der f 2*), domestic feline (*Fel d 1*), and canine (*Can f 1*).

Indoor Temperature and Humidity

Indoor temperature (°C) and relative humidity (%) were measured within the common areas (in proximity to where dust samples were collected) within each of the homes. During the winter months, a Q-Trak (TSI, Inc.) was used to measure temperature and humidity over two, 48-hour sampling periods (60 second sampling intervals). One 48-hour event was typically conducted in the first half of the winter (November/December), while the second 48-hour sampling event was carried out in the second half of winter (January/February). Dust collection did not always occur during the sampling periods when temperature/humidity was measured.

Home Questionnaire

Prior to sample collection, a questionnaire on home characteristics was completed by an adult resident. Specifically, information on type of home (house, mobile home, duplex/apartment, or other), age of home, area (m^2) within home, number of bedrooms, number of children within the home, household income, education level, and presence of pets (dog, cat, bird, or other furry pet) was obtained for each of the participating residences.

Statistical Analyses

Statistical analyses were conducted using SAS v9.2 (Cary, NC). The relationship between indoor relative humidity and indoor temperature and the presence of dust mite allergen was evaluated using analysis of variance. Comparison of categorical home characteristics and the presence of dust mite allergen were evaluated using chi-square analysis.

Results

Home characteristics

Of the 57 residences included in the present analysis, the majority were located in rural locations located throughout western Montana/northern Idaho. Participating residences included single-family homes (81%), mobile homes (15%), and duplex/apartments (4%). On average the residential structures were 46 years old, had 165 ± 83 m^2 of living space, and three bedrooms. All of the residences had at least one child, with 80% having more than one child. When considering household income, nearly 50% had annual salaries over $50,000/year. Seventy four percent (74%) of the homeowners reported having some college or a college degree. Twenty-one residences (37%) reported having a dog, 13 homes (23%) reported having a cat, one had a bird, and three reported having a "furry pet" other than dog or cat. Ten homes (18%) had both a cat and dog, while the remaining homes did not have any pets.

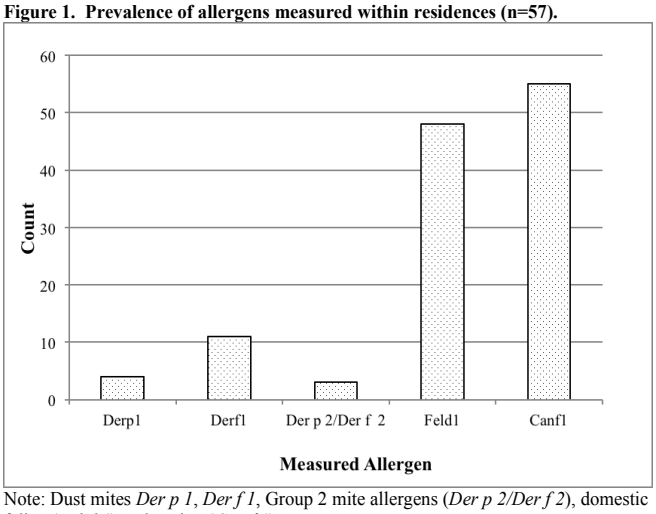
Temperature and Humidity

Indoor temperatures averaged 22.3 ± 2.8°C, with indoor relative humidity averaging 27.0 ± 7.6% during the late winter/early spring sampling periods. The maximum indoor temperature and humidity measured were 28.5°C and 50.1%, respectively. The lowest average temperature and humidity were 15.8°C and 14.7%, respectively. Eighty two percent (82%) of homes measured humidity <35%, 11% of homes had indoor humidity measuring 35-45%, while 4% of homes measured humidity >45%. Temperature/humidity were not measured in two homes due to instrument malfunctions.

Allergens

Figure 1 presents the prevalence of allergens measured in the participating western Montana / northern Idaho residences. Out of all the dust samples that were collected, the most common allergen found was canine (*Can f 1*), with all but two of the homes showing presence of this allergen. Levels were so high in many of the samples (n=41) that an accurate measurement could not be determined as concentrations fell outside the range of our standard curve. Due to analytical expenses, samples were not diluted for repeat analyses using the multiplex kit. However, for the samples that fell within the standard curve (n=13), a concentration of 5,357.8 ± 13,714.6 ng/g dust was measured. When considering all the values (including those above the standard curve), the average concentration was 18,133.8 ± 24,485.2 ng/g dust. The second most common allergen was feline (*Fel d 1*), which was found in 47 of the 57 homes investigated. Similar to the dog allergen, many of the samples had concentrations above the maximum concentration of our standard curve (n=19). For those samples for which an accurate concentration could be calculated (n=28), averages were determined to be 730.2 ± 724.4 ng/g dust. When considering each of the 47 samples, the average concentration was 1,712.6 ± 1,687.5 ng/g dust.

Figure 1. Prevalence of allergens measured within residences (n=57).



Note: Dust mites *Der p 1*, *Der f 1*, Group 2 mite allergens (*Der p 2/Der f 2*), domestic feline (*Fel d 1*) and canine (*Can f 1*).

Regarding dust mites, *Der f 1* was found to be present in 11 (19%) of the residences, while *Der p 1* was detected in four of the residences. Concentrations for these samples were 76.9 ± 69.5 ng/g dust and 1,875.2 ± 1953.7 ng/g dust, respectively. Group 2 mite allergens (*Der p 2/ Der f 2*) were also identified in three residences (average 1,602.5 ± 1,737.2 ng/g dust).

Home Characteristics

Table 1 presents the presence of dust mite allergen by home characteristics. Most of the captured categorical home characteristics were not associated with the presence of dust mite allergen. These included number of children within home, household income, education of adult residents (p=0.09), presence of furry pets, and presence of cat or dog allergen. Unfortunately, variables specific to presence of dust mites including quantifying the area of wall-to-wall carpeting (per residence) and date moved into residence were not recorded. This latter point could be important if homeowners had recently moved into the residence from more humid locations known to have dust mites.

Table 1. Presence of dust mite allergen by home characteristics.

	Distribution of Home Characteristics; n (% of total)	Presence of Dust Mite Allergen [a]; n (% of homes with given characteristic)
Number of children in home		
1-2	31 (55.4)	7 (22.6)
3+	25 (44.6)	6 (24.0)
Annual household income		
<$29;999	15 (27.3)	5 (33.3)
>= $30;000	40 (72.7)	8 (20.0)
Highest household education[b]		
High school or less	14 (25.9)	1 (7.1)
Some college / college degree	40 (70.0)	12 (30.0)
Presence of furry pets		
Yes	23 (40.4)	9 (26.5)
No	34 (59.6)	4 (17.4)

[a] positive for Der p 1, Der f 1, and/or Group 2 dust mite allergens, [b] p = 0.09.

Discussion

Domestic feline (82%) and canine (96%) were the most abundant type of allergens measured in this study. At first glance, this is somewhat surprising, as only 21 residences reported having a dog while only 13 homes reported having a cat (10 homes, or 18% had both). One possible explanation involves passive transport mechanisms. Studies have shown that schools can contain levels of indoor allergens comparable to home environments [9,10,13], especially for the feline allergen *Fel d 1* [14-16]. Krop et al. [17] found that pet allergen levels were 13 times higher in schools compared to homes without pets. One explanation for the presence of pet allergens in homes without pets is that children passively transport the allergens to their homes from schools or other locations.

Presence of Dust Mites

Few studies have examined the presence of indoor residential allergens (particularly dust mites) in the rural northern Rocky Mountain region, even though they are a common trigger of allergy and asthma symptoms. Results from this study showed that 7% of homes tested positive for *Der p 1* (n=4), 19% of homes were positive for *Der f 1* (n=11), and 5% of homes showed evidence of the Group 2 mite allergens (n=3). These findings are consistent with a previous dust mite study (1985) conducted in residences located in the Rocky Mountains of Denver, Colorado where dust mites were found in a small number of homes [18].

The survival of dust mites is dependent on environmental conditions such as warm temperatures and high relative humidity [19,20]. Historically, dust mites are not thought to be prevalent in arid or semi-arid regions, or areas in the northern Rocky Mountain region located at higher elevation and that exhibit low humidity. In a study conducted in Colorado by Ellingson et al. [21], results showed that homes with increasing indoor relative humidity through the use of evaporative coolers led to conditions that may facilitate dust mite survival.

A relative humidity of at least 54% is typically thought to support "significant" concentrations of allergens [21]. For comparison, the average indoor relative humidity that was measured across all homes in our study was low (27.0 ± 7.6%). For the homes in which *Der p 1* dust mites were found (n=3), an average relative humidity of 36.3 ± 9.2% was measured. Homes containing *Der f 1* dust mites (n=11) had an average humidity of 29.6 ± 9.1%. Overall, the homes that tested positive for dust mite allergen in our study showed no correlation with indoor relative humidity compared to homes without dust mite.

Limitations

There were several factors that could influence the results of this study. There is some concern that using only one dust sample per home may not be representative of allergens present year round. However, Antens et al. [22] showed that dust mite and cat allergens measured in house dust are sufficiently stable to use single measurements with confidence in epidemiological studies. In addition, although several home characteristics were recorded for the participating residences, other unmeasured home features may have an impact on allergen concentrations. In addition to temperature and humidity, the technical condition of buildings, including the frequency, intensity and effectiveness of cleaning and maintenance are important factors [9]. Noting the proximity of the residences to other dwellings could also be useful when considering aeroallergens. These parameters were not measured within the homes, nor were they measured within the schools that the children attended.

Conclusion

As the average person spends 90% of their time indoors, the indoor residential environment is critically important to consider when optimizing overall health. Characterizing indoor residential allergens from simple house dust is an important step for those inhabitants suffering from allergen sensitivity or allergic asthma. If the allergen content of dust can be better characterized in the home environment, residents can implement interventions targeting the allergens in an effort to avoid or limit exposures below threshold levels.

In our 57 homes located within rural and frontier areas of the Rocky Mountains, we were able to determine some of the most common and abundant allergen types found in settled floor dust. Our results also suggest the presence of dust mites in low humidity regions of western Montana and northern Ida-

ho. Regional physicians (including allergists, pulmonologists, ENTs and primary care providers) can use this information to better educate allergy and asthma sufferers on avoidance (mitigation) techniques for these identified allergens, and to help tailor interventions focused on education, cleaning, filtration, and maintenance [8]. Finally, the presence of dust mite allergens needs to be further investigated (including analyzing dust samples microscopically) to gain a better understanding of prevalence rates in this region of the country.

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References

1. National Heart; Lung; and Blood Institute (NHLBI). National Asthma Education and Prevention Program expert panel report 3: guidelines for the diagnosis and management of asthma. Bethesda (MD): National Heart; Lung; and Blood Institute/National Institutes of Health; 2007.

2. American Academy of Allergy; Asthma; & Immunology (AAAAI); accessed June 2; 2014.

3. Centers for Disease Control and Prevention (CDC); accessed April 18; 2014.

4. Carter MC, Perzanowski MS, Raymond A, Platts-Mills TA. Home intervention in the treatment of asthma among inner-city children. J Allergy Clin Immunol. 2001, 108(5):732-737.

5. Morgan WJ, Crain EF, Gruchalla RS, O'Connor GT, Kattan M et al. Results of a home-based environmental intervention among urban children with asthma. N Engl J Med. 2004, 351(11):1068-1080.

6. Takaro TK, Krieger JW, Song L. Effect of environmental interventions to reduce exposure to asthma triggers in homes of low-income children in Seattle. J Expos Analysis Environ Epidemiol. 2004, 14 (Suppl 1):S133-143.

7. Adgate J, Ramachandran G, Cho SJ, Ryan AD, Grengs J. Allergen levels in inner city homes: baseline concentrations and evaluation of intervention effectiveness. J Expo Sci Environ Epidemiol. 2008, 18(4): 430-440.

8. Wright LS, Phipatanakul W. Environmental remediation in the treatment of allergy and asthma: latest updates. Curr Allergy Asthma Rep. 2014; 14(3): 419.

9. Cyprowski M, Buczyńska A, Szadkowska-Stańczyk I. Indoor allergens in settled dust from kindergartens in city of Lodz, Poland. Int J Occup Med Environ Health. 2013, 26(6): 890-899.

10. Fromme H, Bischof W, Dietrich S, Lahrz T, Schierl R et al. Airborne allergens; endotoxins; and particulate matter in elementary schools; results from Germany (LUPE 2). J Occup Environ Hyg. 2013, 10(10): 573-582.

11. WeatherSpark-Average Weather For Missoula, Montana, USA ; accessed November 7; 2014.

12. Noonan CW, Ward TJ. Asthma randomized trial of indoor wood smoke (ARTIS): rationale and methods. Cont Clin Trials. 2012, 33 (5):1080-1087.

13. Abramson SL, Turner-Henson A, Anderson L, Mary P. Hemstreet, Shenghui Tang et al. Allergens in school settings: results of environmental assessments in 3 city school systems. J Sch Health. 2006, 76(6): 246-249.

14. Patchett K, Lewis S, Crane J, Fitzharris P. Cat allergen (*Fel d 1*) levels on school children's clothing and in primary school classrooms in Wellington; New Zealand. J Allergy Clin Immunol. 1997, 100(6 Pt 1): 755-759.

15. Almqvist C, Larsson PH, Egmar AC, Hedrén M, Malmberg P et al. School as a risk environment for children allergic to cats and a site for transfer of cat allergen to homes. J Allergy Clin Immunol. 1999, 103(6): 1012-1017.

16. Krop E, Jacobs J, Sander I, Raulf-Heimsoth M, Heederik D. Allergens and B-Glucans in Dutch homes and schools: characterizing airborne levels. PLoS ONE. 2014, 9(2):1-9.

17. Almqvist C, Wickman M, Perfetti L, Berglind N, Renström A et al. Worsening of asthma in children allergic to cats; after indirect exposure to cat at school. Resp Crit Care Med. 2001, 163(3):694-698.

18. Moyer DB, Nelson HS, Arlian LG. House dust mites in Colorado. Ann Allergy. 1985, 55(5): 680-682.

19. Hallas TE. The biology of mites. Allergy. 1991, 46(s11): 6-9.

20. Arlian LG. Water balance and humidity requirements of house dust mites. Exp Appl Acarol 1992; 16(1-2):15-35.

21. Ellingson AR, LeDoux RA, Venanthan PK, Weber RW. The prevalence of Dermatoghagoides mite allergen in Colorado homes utilizing central evaporative coolers. J Allergy Clin Immunol. 1995, 96(4): 473-479.

22. Antens CJ, Oldenwening M, Wolse A, Gehring U, Smit HA et al. Repeated measurements of mite and pet allergen levels in house dust over a time period of 8 years. Clin Exp Allergy. 2006, 36(12): 1525-1531.