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To cite this article: James D. Johnston, Taylor P. Barney, Justin H. Crandall, Marinn A. Brown, Tarah R. Westover, Sterling M. Paulson, Madeleine S. Smith & K. Scott Weber (2018) Prevalence of house dust mite allergens in low-income homes with evaporative coolers in a semiarid climate, Archives of Environmental & Occupational Health, 73:1, 38-41, DOI: [10.1080/19338244.2017.1282846](https://doi.org/10.1080/19338244.2017.1282846)

To link to this article: <https://doi.org/10.1080/19338244.2017.1282846>



Accepted author version posted online: 18 Jan 2017.
Published online: 10 Feb 2017.



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Prevalence of house dust mite allergens in low-income homes with evaporative coolers in a semiarid climate

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ABSTRACT

House dust mites are typically absent in homes in arid and semiarid climates due to low humidity. Evaporative “swamp” cooling significantly increases indoor humidity in dry climates and is suspected of promoting dust mite survival in these regions. We investigated the prevalence and concentration of mite allergens in dust from low-income homes ($N = 22$) with evaporative coolers in Utah County, Utah. Overall, 15 homes (68.2%) were positive for either Der p 1 or Der f 1 in at least 1 location. Geometric mean allergen levels in mattresses were 0.107 and 0.087 $\mu\text{g/g}$ dust for Der p 1 and Der f 1, respectively. In furniture, levels were 0.143 and 0.165 $\mu\text{g/g}$ dust for Der p1 and Der f 1, respectively. The percentage of positive homes in this study was much higher than previously reported in larger homes with swamp coolers in the same community. These results suggest socioeconomic factors may play a role in dust mite allergen prevalence in homes with evaporative coolers in dry climates.

ARTICLE HISTORY

Received 21 July 2016
Accepted 12 January 2017

KEYWORDS

Allergens; asthma; evaporative cooler; house dust mites; indoor environmental quality

House dust mite allergens are among the most clinically significant antigen exposures affecting humans, with medical outcomes including the development and exacerbation of asthma, allergic rhinitis, and atopic dermatitis.^{1–5} House dust mites acquire water primarily by absorbing it from humid air.^{6,7} The critical equilibrium humidity for dust mites to maintain water balance ranges from 55.0% to 75.0% RH at 15.0°C–35.0°C.^{6,8} Thus, mites are typically absent in arid and semiarid climates unless moisture is added to indoor air.

Evaporative “swamp” cooling, a common form of low-cost air conditioning used in dry climates, is suspected of contributing to mite allergen exposures in regions where mites are usually absent. Evaporative cooling works by pulling hot, dry outdoor air into the home across wet natural or synthetic fiber pads,⁹ thus lowering indoor air temperature while increasing indoor relative humidity (RH).¹⁰ Two prior studies in the Rocky Mountain States (USA) and one study in Australia found associations between evaporative cooler use and mite allergens in homes^{10,11} or mite allergen sensitivity.¹² However, another study from Australia and a prior study by our group in 2014 found no association between evaporative cooler use and the presence of mite allergens.^{13,14}

Socioeconomic and housing factors may partially explain these contradictory findings. Factors such as home age, family income, home size, and occupant density may play important contributing roles in conjunction with type of air conditioning; however, comparing prior studies on the prevalence of mite allergens in dry climates is difficult because housing characteristics are not always reported. Our previous study in Utah found no association between evaporative cooler use and mite allergen prevalence in middle-income, relatively larger homes recruited from among university faculty and staff.¹⁴ Here we report findings from a pilot project to determine whether mite allergens are more prevalent in the same community in smaller, lower-income homes with evaporative coolers. To test this, we recruited low-income homes with evaporative coolers in Utah County, Utah, and conducted allergen testing from two locations in each home.

Methods

Homes ($N = 24$) were recruited among individuals exiting the Women, Infants, and Children (WIC) office at the Utah County Health Department (UCHD). All homes were in Utah County and used evaporative cooling during summer months. Exclusion criteria were (1) use of humidifiers or vaporizers, (2) previous water

damage covering more than 9.29 m² (100 ft²), and (3) household income $\geq$ 200% of the 2015 federal poverty guidelines.¹⁵ The US federal poverty guidelines use a sliding scale based on family size. For a family of four in 2015, 200% of the guidelines was 48,500 USD. Dust samples were collected from August to September 2015 near the end of peak air-conditioning use. We administered a survey including home age, square footage, number of residents, household income, and ages of mattresses and furniture. Brigham Young University's Institutional Review Board (IRB) approved this study.

Dust samples were collected from the homeowner's mattress and a piece of upholstered furniture in a main living area. Mattress and furniture samples had the highest prevalence of mite allergens in the 2014 Utah study and were thus used in this study. Dust was collected using a Eureka (Bloomington, IL, USA) "Mighty Mite" vacuum (model 3684F) with a Duststream dust collector and 40 μ m nylon filter (Indoor Biotechnologies, Charlottesville, VA, USA). Each surface was vacuumed within a taped 1 m² area for 3 minutes, and dust was transferred to 15 mL polypropylene conical tubes and stored at -20°C until analyzed.

Der p 1 (*D. pteronyssinus*) and Der f 1 (*D. farinae*) allergens were extracted by suspending 100 mg of dust in 2 mL of phosphate-buffered saline with 0.05% Tween-20 (PBS-T). Samples were agitated for 2 hours at room temperature then centrifuged for 20 minutes at 2,500 RPM and 4°C. Allergen levels were detected using a two-site monoclonal antibody-based enzyme-linked immunosorbent assay (ELISA) kit (Indoor Biotechnologies, Charlottesville, VA, USA). Sample extracts (200 μ L) were added in triplicate to each plate, and a 10-point curve was made using sequential 2-fold dilutions of a known standard in PBS-T with 1% BSA. Samples were read with an optical density plate reader at wavelength 405 nm. Prism 6 software was used to extrapolate allergen concentrations from the standard curve for each plate. The limit of detection (LOD) for both Der p 1 and Der f 1 assays was 0.04 $\mu\text{g/g}$ of dust.

Means, standard deviations, and percentages were calculated using SPSS version 23 (IBM SPSS Statistics,

Table 1. Characteristics of low-income homes in Utah County, Utah.

	N	Mean	SD	Min	Max
Home age (years)	22	48.14	20.56	20.00	89.00
Home size (m ²)	21	122.30	47.33	55.74	222.97
Number of residents	22	4.41	1.26	3.00	7.00
Occupant density (people/100 m ²)	21	3.83	1.21	1.79	6.62
Mattress age (years)	22	7.36	4.49	1.00	20.00
Furniture age (years)	22	6.77	2.78	1.00	11.00

Note. SD = standard deviation; Min = minimum; Max = maximum.

Armonk, NY, USA). Due to allergen levels being positively skewed, we log transformed the data. Results were back transformed using the antilog to report geometric means and ranges. To evaluate the influence of housing factors on mite allergen concentrations, we performed stepwise multiple regression using a probability level for entry of 0.15.

Results

We evaluated levels of Der p 1 and Der f 1 from 2 locations in 24 low-income homes in Utah County, Utah. One home was dropped because household income exceeded 200% of the poverty level, and one home was dropped due to insufficient survey data, leaving 22 homes in the final sample. Homes were 64% ($n = 14$) single-family dwellings and 36% ($n = 8$) multifamily dwellings. Home characteristics are shown in Table 1.

Overall, 15 (68.2%) homes were positive for either Der p 1 or Der f 1 in at least 1 location, and 3 homes (13.6%) were positive for both allergens. For Der p 1, 10 (45.5%) of the furniture samples were positive and 7 (31.8%) of the mattress samples were positive. For Der f 1, 2 (9.1%) of the furniture samples were positive and 2 (9.1%) of the mattress samples were positive. Only 1 home was found with allergen levels (Der p 1) that would be considered clinically significant at the 2 $\mu\text{g/g}$ dust level.^{16,17} This sample was from upholstered furniture (4.690 $\mu\text{g/g}$ dust). Table 2 shows geometric means and ranges for Der p 1 and Der f 1 allergens by location in the home.

Table 2. Reservoir dust levels of Der p 1 and Der f 1 in low-income homes in Utah.

Sample location	Der p 1				Der f 1			
	Positive samples		Mean	Range	Positive samples		Mean	Range
	n	%			n	%		
Mattress	7	31.8	0.107	0.041–0.389	2	9.1	0.087	0.071–0.107
Furniture	10	45.5	0.143	0.041–4.677	2	9.1	0.165	0.041–0.661

Note. Der p 1 = *D. pteronyssinus*; Der f 1 = *D. farinae*; Mean = geometric mean expressed in μg Der p 1/Der f 1 per gram of dust.

Stepwise regression for Der p 1 in mattresses brought in age of home and age of mattress; however, neither variable was significant ($p = .09$, $p = .16$, respectively) in the final model. For Der p 1 in furniture, age of furniture was brought into the model but was not significant ($p = .08$). Der f 1 levels in mattresses and furniture did not show any relationship with housing characteristics.

Comment

Overall, almost 70% of homes in this study had detectable levels of Der p 1 or Der f 1 allergens. By contrast, a prior study of larger, middle-income homes in Utah County, Utah, in 2014¹⁴ found mite allergens in only 28% of evaporative cooler homes.¹⁴ The homes in this study were markedly smaller (122.3 m²) and had higher occupant densities (3.83 people/100 m²) on average than evaporative cooler homes in the 2014 study (211.5 m²; 1.37 people/100 m²). There are several noteworthy similarities between the current study and the 2014 study. All homes in both studies were located in Utah County, Utah. In both studies, sample collection occurred during August–September near the end of peak air-conditioner use. Consistent with these findings, Der p 1 was detected more often than Der f 1 in mattress and furniture samples in the 2014 study, indicating that *D. pteronyssinus* is more prevalent than *D. farinae* in Utah County homes. It is interesting to note that it was recently reported that Der f 1 was more prevalent in rural homes in northern Idaho and western Montana,¹⁸ suggesting intraregional differences in mite prevalence by species. We suggest the high prevalence of mite allergens in low-income homes may be explained by the combined influence of evaporative cooler use and humidity associated with increased occupant density. Together, these moisture sources may increase indoor RH enough in smaller, crowded housing to exceed the critical equilibrium humidity necessary for house dust mites to survive in an otherwise inhospitable climate.

In the Rocky Mountain States, dust mites are not typically viewed as a major source of allergen exposure due to low humidity. However, our findings agree closely with those of a previous study in Colorado, where 63% of evaporative cooler homes tested positive for group 1 mite allergens during summer months.¹⁰ However, allergen levels in our study were much lower than those reported in the Colorado study, with only 1 home exceeding the 2 µg/g threshold for clinical significance. We used 200% of the federal poverty guideline as our cutoff for study inclusion. A more constricted sampling strategy at or below 100% of the poverty level may reveal higher allergen prevalence or concentrations. Our stepwise

multiple regression analysis did not show any significant relationships between housing characteristics and mite allergen levels, most likely due to the small sample size and large variability in the data.

This study provides evidence for including socioeconomic and housing factors in future studies. However, our findings are limited to a small number of low-income homes with evaporative coolers in one US county and therefore may not be generalizable to other communities in arid and semiarid regions. Future large-scale studies addressing these points are needed.

Funding

Our special thanks to the Ira and Mary Lou Fulton Foundation, which funded this project.

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