Exposure to indoor allergens in day-care facilities: Results from 2 North Carolina counties

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Background: With 63% of US children under 5 years of age in regular child care, day-care facilities could be an important source of exposure to indoor allergens.
Objective: This study examined levels of 7 indoor allergens in 89 day-care facilities in 2 North Carolina counties.
Methods: At each facility, a questionnaire was administered, observations were made, and vacuumed dust samples were collected from carpeted and noncarpeted areas of one room. Allergen concentrations were measured with antibody-based ELISAs.
Results: Each allergen was detected in a majority of facilities (52% to 100%). Geometric mean concentrations were 5.19 μg/g for *Alternaria alternata*, 2.06 μg/g for Can f 1, 1.43 μg/g for Fel d 1, 0.21 U/g for Bla g 1, 0.20 μg/g for Der p 1, 0.10 μg/g for Der f 1, and 0.01 μg/g for Mus m 1. Concentrations for 5 of the 7 allergens were not statistically different from concentrations found in southern US homes sampled in the National Survey of Lead and Allergens in Housing. In rooms with carpet and hard-surfaced flooring, levels of *A alternata*, Can f 1, Der f 1, Der p 1, and Fel d 1 were statistically higher on carpet.
Conclusions: In this survey of day-care facilities in North Carolina, detectable levels of indoor allergens were commonly found. For many young children and day-care staff, day-care facilities might be a source of clinically relevant exposures to indoor allergens. (J Allergy Clin Immunol 2005;116:133-9.)

Key words: *Alternaria species, Alt a 1, Bla g 1, Can f 1, cat allergen, child day-care centers, cockroach allergen, day care, Der f 1, Der p 1, dog allergen, dust mite allergen, Fel d 1, indoor allergens, mouse allergen, Mus m 1*

Exposure to indoor allergens has been associated with an increased risk of development of allergic sensitization and asthma symptoms among susceptible children.[1,2] Most studies that have examined these relationships have used allergen levels in the child's home as the relevant measure of exposure because young children typically spend most of their time at home. However, many children in the United States spend significant proportions of their time in day care. In 1997, 63% of the country's 19.6 million children under 5 years of age were in some form of regular child care during a typical week.[3] These children were cared for in organized child-care centers and in residences. On average, they spent 37 hours per week in child care.[3]

Abbreviation used
NSLAH: National Survey of Lead and Allergens in Housing

Although there have been reports on allergen levels in day-care facilities in other countries, such as Brazil, France, Germany, Singapore, and Sweden,[4-9] little information has been reported from the United States. The only published study we are aware of examined dust mite, cat, and cockroach allergen in 20 day-care centers in Tampa, Florida.[10] That study found dust mite allergen (Der f 1 or Der p 1) in floor dust samples from 10 centers and in air samples from 18 centers. Eight of the floor dust samples had dust mite allergen levels high enough to cause allergic sensitization. Cockroach allergen (Per a 1) and cat allergen (Fel d 1) were detected in all 20 centers.

This study evaluated allergen levels and their predictors in day-care facilities in 2 North Carolina counties. The purpose was to determine whether further study of day-care facilities on a regional or national basis is warranted and to identify associations that might be important to evaluate in larger studies.

METHODS

Selection of day-care facilities

A random sample of child day-care facilities in 2 North Carolina counties was surveyed. Child day-care facilities in North Carolina are regulated by the state's Division of Child Development and licensed as either a family day-care home or a child-care center. Family day-care homes provide care for as many as 5 preschool and 3 school-aged children (the provider's own school-aged children are not counted). Child-care centers provide care for more than 3 children but not in a residential setting. The 2 counties, which for confidentiality reasons are identified in this article as counties A and Z, were selected for their proximity to each other, their similarities in numbers of family day-care homes and child-care centers, and their difference in the percentage of children living below the poverty level. At the start of the study, each of the 2 counties had approximately 100 licensed facilities, with roughly twice as many day-care homes as centers. County Z had a low percentage of persons less than 18 years of age

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TABLE I. Summary statistics for allergen concentrations in the day-care facilities, along with allergen concentrations from living room floors of southern US homes surveyed in the NSLAH

		Day-care facilities				
Allergen	**Units**	**Lower limit of detection**	**Samples with detectable allergen**	**Log normal distribution**	**Geometric mean (SE)**	**NSLAH geometric mean (SE)**
A alternata	μg/g	0.140	86/86 (100%)	Yes	5.19 (0.48)	6.30 (0.29)
Bla g 1	U/g	0.100	45/86 (52%)	No	0.21 (0.04)	0.20 (0.02)
Can f 1	μg/g	0.020	83/86 (97%)	Yes	2.06 (0.53)	3.44 (0.56)
Der f 1	μg/g	0.010	75/86 (87%)	Yes	0.10 (0.02)	0.29 (0.05)*
Der p 1	μg/g	0.010	73/86 (85%)	Yes	0.20 (0.06)	0.25 (0.04)
Fel d 1	μg/g	0.003	86/86 (100%)	Yes	1.43 (0.37)	1.16 (0.22)
Mus m 1†	μg/g	0.001	71/86 (83%)	Yes	0.01 (0.003)	0.33 (0.03)*

*$P \leq .050$ for t test comparing means of log-transformed data between the 2 surveys.
†There were analytic differences between surveys in the measuring of Mus m 1 (see the Methods section).

in poverty, in the lowest 10% of counties, whereas county A ranked above half of the counties in the percentage of children in poverty.[11] Both counties were located in central North Carolina.

Names and addresses of licensed facilities serving children aged 6 years and less were obtained from the North Carolina Division of Child Development's online listing. Within each county, the lists of family day-care homes and child-care centers were randomized. The recruitment goal was 15 centers and 30 homes per county. Administrators were contacted first by letter and then by telephone. In county A 17 eligible centers and 49 eligible homes were contacted to enroll 15 centers and 29 homes. A 30th home could not be recruited before the list was exhausted. In county Z 20 eligible centers and 40 eligible homes were contacted to reach the recruitment goal. The study was approved by the Institutional Review Board of the National Institute of Environmental Health Sciences.

Data collection

At each facility, a questionnaire was administered to the manager or administrator, observations were made of the sampled room (the room where most of the children spend most of their time), and vacuumed dust samples were collected. A technician recorded observations of the sampled room and collected either a carpet sample, a hard-surface sample, or one of each if both surfaces were present. For a given sample, the technician marked off as many as four 1 m^2 areas and vacuumed these areas at a rate of 1 m^2 per 2.5 minutes. Vacuuming was performed with a Eureka Mighty-Mite 10-ampere vacuum cleaner (Eureka Co, Bloomington, Ill). The dust-collection device, which was also used in the National Survey of Lead and Allergens in Housing,[12] was a 19 mm × 90 mm cellulose extraction thimble (Whatman International, Ltd, Middlesex, England) fitted into the distal end of the vacuum's extension tube, sealed with a rubber O-ring placed around the circumference of the thimble, and covered with a crevice tool.

At the laboratory, dust samples were sieved through 425-μm pore grating and weighed. Sieved dust was extracted in PBS and clarified by means of centrifugation. Supernatants were decanted and stored at −20°C. Allergen concentrations were measured with ELISAs. Bla g 1, Can f 1, Der f 1, Der p 1, and Fel d 1 were measured with mAb-based ELISAs from Indoor Biotechnologies, Inc (Charlottesville, Va); Mus m 1 was measured with a polyclonal antibody–based ELISA from Indoor Biotechnologies, Inc; and *Alternaria alternata* was measured with a polyclonal antibody–based ELISA from Greer Laboratories, Inc (Lenoir, NC). Because the *A alternata* assay is based on a polyclonal antibody raised to an *A alternata* extract, it reacts to a variety of *A alternata* proteins, which could result in a higher concentration than if the assay had been to a specific protein, such as Alt a 1. The other assays were based on antibodies raised to a specific protein. These differences should be considered when the allergen concentrations are compared with one another.

Statistical analyses

For facilities with a carpet and hard-surface sample, the higher allergen concentration of the 2 samples was used in statistical analyses. Among the 89 day-care facilities, 49 had only a carpet sample collected, 16 had only a hard-surface sample collected, and 24 had both samples collected. Because 7 hard-surface floor samples had insufficient dust for all laboratory analyses and 3 of those samples came from facilities without a carpet sample, 3 of the 89 facilities did not have allergen data for statistical analyses. Allergen concentrations below the lower limit of detection (Table I) were imputed as 0.5 times the lower limit of detection.

All statistical analyses were conducted on the $\log^{10}$-transformed values of allergen concentrations by using SAS statistical software (Release 8.02; SAS Institute, Cary, NC) or SUDAAN software (Release 9; RTI International, Research Triangle Park, NC). Correlations were assessed with Pearson correlation coefficients, bivariate associations were assessed with the F test in 1-way ANOVA, and multivariate associations were assessed with linear regression. Among the facilities that had both a carpet and hard-surface sample, side-by-side comparisons of allergen concentrations were evaluated with paired t tests.

Allergen concentrations were compared between this survey and the National Survey of Lead and Allergens in Housing (NSLAH) by using 2-sample t tests. The NSLAH, conducted from 1998 through 1999, surveyed 831 homes that were representative of the US population of permanently occupied, noninstitutional housing units that permitted resident children.[12] For these comparisons, allergen concentrations from living room floor samples of the 277 homes in the south census region were used (unpublished data). The NSLAH and day-care samples were assayed by 2 different laboratories; however, each laboratory used ELISA kits purchased from the same sources, with the exception of the kit for Mus m 1. For Mus m 1, the NSLAH samples were analyzed by using ELISA kits from Greer Laboratories, Inc, whereas the day-care samples were analyzed by using ELISA kits from Indoor Biotechnologies, Inc. The ELISA kit from Indoor Biotechnologies, Inc, was developed from rabbit polyclonal antibodies to recombinant Mus m 1, whereas the one from Greer Laboratories, Inc, was developed from rabbit polyclonal antibodies to Mus m 1 purified from mouse urine.[13,14]

In all analyses the level of significance was set at a P value of .05. Because the purpose of this study was to explore associations rather