

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

Abbreviation used

NSLAH: National Survey of Lead and Allergens in Housing

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

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

Allergen	Units	Day-care facilities				NSLAH geometric mean (SE)
		Lower limit of detection	Samples with detectable allergen	Log normal distribution	Geometric mean (SE)	
<i>A alternata</i>	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 m² areas and vacuumed these areas at a rate of 1 m² 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 log¹⁰-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

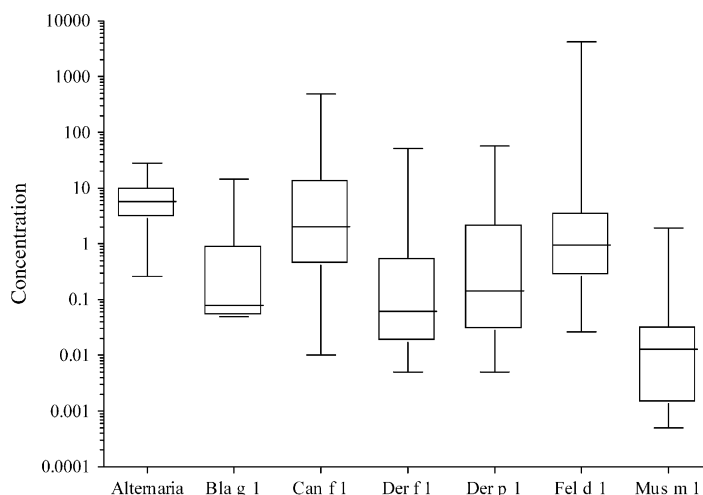


FIG 1. Distribution of allergen concentrations in day-care facilities. Box plots show the 0, 25th, 50th, 75th and 100th percentiles. All concentrations are in micrograms per gram, except for Bla g 1, which is in units per gram.

than to test hypotheses, P values were not adjusted for multiple comparisons. The issue of multiple comparisons is controversial, and strong arguments can be found on either side^{15,16}; however, this article's authors believe, as do others,¹⁷ that the quality of the results and their compatibility with other evidence are more important than the number of associations.

RESULTS

Characteristics of the day-care facilities

Of the 86 facilities with allergen data, 71% were in residences, 21% were in single-use buildings, and 8% were in multiuse buildings. Only 16% of the facilities were originally built for day care. Most day-care facilities (84%) were private, for-profit businesses. Among the family day-care homes, the median number of children enrolled was 6 (minimum, 3; maximum, 12). Among the child-care centers, the median number of children enrolled was 30 (minimum, 8; maximum, 130). The average monthly tuition was higher in child-care centers than in family day-care homes (\$517 vs \$433, $P = .056$) and in county Z than in county A (\$590 vs \$334, $P < .001$). On average, 43% of the children were minority children (Hispanic or non-white), with no significant difference by county ($P = .563$). Seventy-three percent of the facilities received government subsidies for at least one child, with no significant difference by county ($P = .809$).

Distributions of allergens

Table I provides summary statistics for concentrations of the 7 allergens. Each allergen was detected in a majority of day-care facilities (52% to 100%). The highest geometric mean concentrations were for *A alternata*, Can f 1, and Fel d 1. Geometric mean concentrations of Bla g 1, Der f 1, Der p 1, and Mus m 1 were quite low. With concentrations of Der f 1 and Der p 1 summed together, the geometric mean concentration was 0.53 μg/g (SE, 0.13 μg/g). Box plots for the distributions of the allergens are shown in Fig 1.

Comparisons with southern US homes

Comparisons of geometric mean allergen concentrations between day-care facilities and southern US homes surveyed in the NSLAH are shown in Table I. For 5 of the 7 allergens, geometric mean concentrations were not statistically different. Although the geometric mean concentration of Der f 1 was significantly higher in the NSLAH than in this survey, the concentrations were very low in each. The geometric mean concentration for Mus m 1 was also higher in the NSLAH than in this survey; however, as pointed out in the Methods section, there were differences in the Mus m 1 assays between the 2 surveys.

Correlations between allergen concentrations

Of the 21 unique pairwise comparisons between the 7 allergens, 10 had significant correlation coefficients. *A alternata* was significantly correlated with each of the other allergens: Bla g 1 ($r = .222$, $P = .040$), Can f 1 ($r = .231$, $P = .033$), Der f 1 ($r = .379$, $P < .001$), Der p 1 ($r = .280$, $P = .009$), Fel d 1 ($r = .270$, $P = .012$), and Mus m 1 ($r = .296$, $P = .006$). In addition to those correlations, Der f 1 was correlated with Bla g 1 ($r = .362$, $P < .001$) and Der p 1 ($r = .379$, $P < .001$), and Can f 1 was correlated with Der p 1 ($r = .312$, $P = .004$) and Fel d 1 ($r = .324$, $P = .002$).

Comparisons of carpeted and noncarpeted surfaces

Table II shows the results of paired t tests comparing carpet and hard-surface samples from the 20 facilities that had allergen data for both surfaces. The geometric mean concentrations of *A alternata*, Can f 1, Der f 1, Der p 1, and Fel d 1 were statistically higher on carpet than on hard surfaces; however, Der f 1 and Der p 1 levels were very low, and differences between surfaces were quite small. Bla g 1 and Mus m 1 levels were also very low and not statistically different between surfaces.

TABLE II. Comparisons of allergen concentrations between carpet and hard-surface floor samples among the 20 day-care facilities that had allergen data for both surfaces

Allergen	Units	Geometric mean (SE)		P value, paired t test
		Carpet	Hard surface	
<i>A alternata</i>	μg/g	5.60 (0.82)	2.32 (0.46)	<.001
Bla g 1	U/g	0.29 (0.10)	0.21 (0.07)	.293
Can f 1	μg/g	2.13 (1.05)	0.29 (0.13)	<.001
Der f 1	μg/g	0.04 (0.02)	0.02 (0.01)	.011
Der p 1	μg/g	0.16 (0.08)	0.02 (0.01)	<.001
Fel d 1	μg/g	2.28 (1.45)	0.39 (0.21)	<.001
Mus m 1	μg/g	0.008 (0.004)	0.004 (0.002)	.215

Associations between day-care characteristics and allergens

Table III shows the geometric mean allergen concentrations for the day-care characteristics bivariately associated with at least 1 of the 7 indoor allergens. Characteristics bivariately associated with an allergen (marked with an asterisk in Table III) were evaluated in a multivariable linear regression model by using a backward selection process. The results of these allergen-specific multivariable analyses are presented in the following.

In the final model for *A alternata*, higher concentrations were associated with carpeted floors ($P < .001$), with either a very high or a very low percentage of minority children ($P = .016$), and with lower monthly tuition ($P = .017$). For Bla g 1, levels were higher in residences or single-use buildings than in multiuse buildings ($P = .024$), in facilities where day-care staff saw cockroaches in the past year ($P = .024$), and in facilities where study staff observed open food in the sampled room ($P = .005$).

The final model for Can f 1 indicated that the allergen concentration was significantly higher in facilities where children did not sleep or nap in the sampled room ($P = .007$), in facilities that did not receive government subsidies for any child ($P = .006$), and in facilities where a dog was observed ($P = .002$). For Fel d 1, higher levels were associated with carpeted floors ($P = .004$), a cat observed in the facility ($P < .001$), and a lower percentage of minority children ($P < .001$).

In the model for Der f 1, higher concentrations were found in facilities not originally built for day care ($P = .053$), in facilities with carpet in the sampled room ($P = .043$), and in facilities with a high percentage of minority children ($P = .028$). For Der p 1, levels were higher in for-profit businesses than in nonprofit ones ($P = .009$), in older buildings ($P < .001$), and in facilities in which a dog was not observed ($P = .013$).

For Mus m 1, building type was the only variable identified as an independent predictor ($P = .016$). Levels were highest for facilities in multiuse buildings and lowest for residences.

Characteristics not bivariately associated with any of the 7 allergens were the season the facility was

sampled (June-July, $n = 31$; August-October, $n = 35$; and November-January, $n = 20$), number of days since the sampled floor was last cleaned, how the sampled room was air conditioned, how the sampled room was heated, water leaks or dampness in the past year, mildew or musty odor in the past year, whether the facility was professionally exterminated in the past year, presence of upholstered furniture in the sampled room, number of children enrolled in the past year, temperature of the sampled room, and relative humidity of the sampled room. In addition, associations with the following 5 characteristics could not be evaluated because they did not vary between facilities: children sleep or nap in the facility (yes = 85), musty or mildew odor observed (no = 83), visible mold or mildew (no = 86), live cockroaches observed by study staff (no = 86), and dead cockroaches or cockroach feces observed by study staff (no = 86).

DISCUSSION

The main finding of this study is that detectable levels of *A alternata*, Can f 1, Der f 1, Der p 1, Fel d 1, and Mus m 1 were commonly found in day-care facilities in the 2 North Carolina counties. Levels of *A alternata*, Can f 1, and Fel d 1 were high relative to the other allergens. For these allergens, with the exception of *A alternata*, thresholds of exposure have been proposed for allergic sensitization, although these thresholds are not universally accepted: 2 U/g for Bla g 1; 2 μg/g for Can f 1, Der f 1, and Der p 1; 1 μg/g for Fel d 1; and 1.6 μg/g for Mus m 1.¹⁸⁻²⁸ As can be extrapolated from Fig 1, these thresholds were exceeded in varying proportions of facilities for each of the allergens.

Can f 1 and Fel d 1 were detected in 97% and 100% of day-care facilities, respectively, even though dogs and cats were not observed in most. This finding is consistent with other studies that have reported the presence of these allergens in places where dogs and cats would not be present, such as schools.^{20,29} In the NSLAH, all US homes had detectable Can f 1, and all but one home had detectable Fel d 1.³⁰ Studies have shown that dog and cat allergens can be transported on clothing.³¹ Can f 1 and Fel d 1 were higher in facilities that did not receive government subsidies for any children and in facilities with a lower percentage of minority children. In the United States higher income and white race are associated with ownership of an indoor dog, and white race is associated with ownership of an indoor cat.³⁰ Presumably, day-care facilities with those characteristics have a higher percentage of children who own a dog or cat in their own homes and are transporting the allergen into the facility on their clothing.

An interesting finding from this study is the similarities in allergen levels between the day-care settings and homes in the southern census region, as surveyed in the NSLAH. Because 71% of day-care facilities in this study were residences, this finding was not totally unexpected. Nationwide, only 20% of children under 5 years of age

TABLE III. Day-care characteristics bivariately associated with at least one of the 7 indoor allergens

Characteristic	N	Geometric mean concentration (SE; see Table I for units)						
		<i>A alternata</i>	<i>Bla g 1</i>	<i>Can f 1</i>	<i>Der f 1</i>	<i>Der p 1</i>	<i>Fel d 1</i>	<i>Mus m 1</i>
County								
A	43	5.91 (0.74)	0.18 (0.04)	1.43 (0.58)	0.08 (0.03)	0.09 (0.03)	1.20 (0.39)	0.015 (0.005)
Z	43	4.56 (0.61)	0.23 (0.06)	2.98 (0.90)	0.12 (0.03)	0.46 (0.18)*	1.72 (0.70)	0.008 (0.003)
State license								
Family care home	57	5.51 (0.62)	0.24 (0.05)	2.42 (0.80)	0.15 (0.04)	0.21 (0.07)	2.02 (0.72)	0.009 (0.002)
Child-care center	29	4.62 (0.75)	0.15 (0.04)	1.50 (0.58)	0.05 (0.02)*	0.18 (0.09)	0.73 (0.22)	0.017 (0.007)
Business type								
For profit	72	5.46 (0.56)	0.21 (0.04)	2.24 (0.67)	0.11 (0.03)	0.27 (0.09)	1.62 (0.49)	0.010 (0.002)
Nonprofit	14	4.03 (0.87)	0.19 (0.09)	1.33 (0.47)	0.06 (0.03)	0.04 (0.02)*	0.76 (0.26)	0.018 (0.012)
Year building constructed								
1850-1969	24	6.02 (0.92)	0.22 (0.07)	3.24 (1.22)	0.15 (0.06)	0.67 (0.35)	1.53 (0.79)	0.012 (0.005)
1970-1989	24	4.97 (0.83)	0.24 (0.08)	2.59 (1.62)	0.16 (0.08)	0.69 (0.35)	2.01 (1.01)	0.011 (0.005)
1990-1995	17	6.26 (1.10)	0.32 (0.15)	2.06 (1.22)	0.10 (0.06)	0.05 (0.03)	3.52 (2.23)	0.016 (0.010)
1996-2000	18	3.58 (0.91)	0.09 (0.03)	1.16 (0.44)	0.03 (0.01)	0.03 (0.01)*	0.47 (0.17)	0.006 (0.003)
Originally built for day care								
Yes	14	3.50 (0.88)	0.08 (0.02)	1.21 (0.57)	0.02 (0.01)	0.03 (0.01)	1.03 (0.55)	0.017 (0.013)
No	72	5.61 (0.54)	0.25 (0.05)*	2.28 (0.66)	0.13 (0.03)*	0.29 (0.09)*	1.53 (0.45)	0.010 (0.002)
Building type								
Residence	61	5.41 (0.58)	0.24 (0.05)	2.52 (0.79)	0.15 (0.04)	0.23 (0.08)	1.98 (0.67)	0.007 (0.002)
Single-use building	18	4.89 (1.07)	0.20 (0.07)	1.05 (0.53)	0.03 (0.01)	0.14 (0.08)	0.56 (0.15)	0.021 (0.011)
Multiuse building	7	4.24 (1.28)	0.05 (0.00)*	2.03 (1.39)	0.06 (0.04)*	0.13 (0.14)	0.98 (0.84)	0.062 (0.067)*
Cleaning frequency								
At least daily	74	4.91 (0.50)	0.19 (0.04)	1.92 (0.55)	0.08 (0.02)	0.16 (0.05)	1.40 (0.38)	0.010 (0.002)
At least weekly	12	7.34 (1.35)	0.32 (0.14)	3.17 (1.66)	0.34 (0.13)*	0.78 (0.55)	1.64 (1.38)	0.016 (0.013)
Dehumidifier in facility								
Yes	7	7.08 (1.28)	0.64 (0.37)	4.10 (3.86)	0.11 (0.08)	0.09 (0.07)	4.78 (4.77)	0.010 (0.007)
No	79	5.05 (0.50)	0.19 (0.03)*	1.94 (0.51)	0.10 (0.02)	0.21 (0.07)	1.29 (0.34)	0.011 (0.003)
Children sleep or nap in sample room								
Yes	70	5.27 (0.56)	0.21 (0.04)	1.44 (0.40)	0.09 (0.02)	0.18 (0.05)	1.26 (0.38)	0.010 (0.003)
No	16	4.88 (0.90)	0.21 (0.07)	9.97 (4.91)*	0.20 (0.12)	0.35 (0.25)	2.50 (1.24)	0.013 (0.009)
Cockroaches seen in past year								
Yes	25	5.52 (0.87)	0.38 (0.14)	1.48 (0.67)	0.09 (0.03)	0.18 (0.10)	1.48 (0.72)	0.007 (0.002)
No	61	5.07 (0.58)	0.16 (0.03)*	2.36 (0.73)	0.10 (0.03)	0.21 (0.07)	1.41 (0.44)	0.013 (0.004)
Staff use insecticides in past year								
Yes	12	6.80 (1.53)	0.53 (0.26)	1.28 (0.70)	0.11 (0.05)	0.10 (0.07)	1.63 (1.26)	0.018 (0.006)
No	74	4.97 (0.50)	0.18 (0.03)*	2.23 (0.63)	0.10 (0.03)	0.22 (0.07)	1.40 (0.39)	0.010 (0.003)
Receive subsidies for any child								
Yes	63	4.69 (0.55)	0.19 (0.04)	1.30 (0.35)	0.09 (0.02)	0.17 (0.05)	0.99 (0.29)	0.012 (0.003)
No	23	6.88 (0.81)	0.25 (0.09)	7.29 (3.73)*	0.14 (0.06)	0.33 (0.20)	3.93 (2.03)*	0.009 (0.004)
Floor covering in sampled room								
Carpet only or carpet and hard surface	73	6.12 (0.54)	0.22 (0.04)	2.41 (0.65)	0.12 (0.03)	0.23 (0.08)	1.84 (0.53)	0.011 (0.003)
Hard surface only	13	2.07 (0.49)*	0.13 (0.05)	0.85 (0.60)	0.03 (0.02)*	0.08 (0.04)	0.35 (0.15)*	0.009 (0.006)
Open food observed in sampled room								
Yes	5	4.73 (1.82)	1.96 (1.77)	3.42 (2.98)	0.12 (0.13)	0.15 (0.22)	0.44 (0.26)	0.017 (0.015)
No	81	5.22 (0.50)	0.18 (0.03)*	2.00 (0.53)	0.10 (0.02)	0.20 (0.06)	1.54 (0.42)	0.011 (0.003)
Cat observed in the facility								
Yes	9	6.20 (1.50)	0.38 (0.19)	2.01 (1.96)	0.15 (0.13)	0.06 (0.05)	75.7 (39.7)	0.011 (0.009)
No	77	5.09 (0.51)	0.19 (0.04)	2.07 (0.54)	0.10 (0.02)	0.23 (0.07)	0.9 (0.21)*	0.011 (0.003)
Dog observed in the facility								
Yes	11	4.83 (1.19)	0.18 (0.09)	17.3 (15.6)	0.05 (0.03)	0.04 (0.03)	12.8 (11.9)	0.008 (0.004)
No	75	5.25 (0.53)	0.21 (0.04)	1.51 (0.36)*	0.11 (0.03)	0.25 (0.08)*	1.0 (0.26)*	0.011 (0.003)
Percentage of minority children								
0-5	22	6.24 (0.95)	0.18 (0.06)	7.75 (4.25)	0.12 (0.07)	0.19 (0.12)	9.81 (5.72)	0.022 (0.010)
6-35	21	4.82 (0.93)	0.12 (0.03)	1.81 (0.71)	0.05 (0.02)	0.17 (0.10)	1.00 (0.29)	0.004 (0.002)
36-75	22	3.54 (0.61)	0.24 (0.09)	1.70 (0.76)	0.05 (0.02)	0.15 (0.08)	0.77 (0.32)	0.008 (0.004)
76-100	21	6.90 (1.31)*	0.34 (0.14)	0.71 (0.36)*	0.29 (0.14)*	0.32 (0.18)	0.53 (0.25)*	0.017 (0.008)
Monthly tuition (\$)								
220-400	43	6.36 (0.78)	0.19 (0.05)	2.23 (0.83)	0.10 (0.04)	0.09 (0.03)	1.38 (0.45)	0.013 (0.004)
401-1000	41	4.08 (0.55)*	0.19 (0.05)	1.91 (0.68)	0.10 (0.03)	0.40 (0.16)*	1.57 (0.67)	0.008 (0.003)

* $P \leq .05$ from F test in 1-way ANOVA.

attend day care in organized care settings (eg, day-care centers, schools, and nurseries), with the rest attending day care in residences.³ The similarities in allergen levels between the 2 surveys raise the possibility that some children who attend day care are being exposed to similar types and levels of allergens in day-care settings as they are in their own homes, thus providing for a prolonged exposure to those allergens. In contrast to our findings, 2 studies, one conducted in France and the other in Singapore, that compared dog, cat, dust mite, and cockroach allergens between homes and child-care facilities found that levels were much higher in homes.^{4,7}

Another interesting yet not unexpected finding is the differences between carpeted and noncarpeted surfaces. Twenty day-care facilities had allergen data for both surfaces, which allowed for side-by-side comparisons of allergen concentrations. As reported, concentrations for 5 of the 7 allergens were significantly lower on the non-carpeted surfaces. For Can f 1 and Fel d 1, the differences were not only statistically significant but clinically significant, with mean levels on noncarpeted surfaces being well below the proposed thresholds for allergic sensitization. The mean level of *A alternata* on carpet was more than twice the level on a hard surface (5.6 µg/g vs 2.3 µg/g). Presumably, carpeting provides a reservoir for these allergens.

Fourteen of the 18 housing characteristics listed in Table III were independent predictors of at least one allergen. No one characteristic was associated with all 7 allergens, and some characteristics, such as a high percentage of minority children, dog observed in the facility, and building type, predicted higher levels of one allergen but lower levels of another. In addition, some characteristics, such as business type and tuition, might be valuable only for their ability to predict allergen levels; however, several characteristics are more closely linked to the cause of the allergen level and are modifiable, such as open food in the day-care facility, cockroaches seen during the past year, presence of an indoor dog or cat in the day care, and the type of floor covering. Whether the facility was licensed as a family day-care home or a child-care center did not significantly affect any of the allergen levels, and whether the building was a residence, a single-use building, or a multiuse building only affected the levels of Bla g 1 and Mus m 1.

The main limitation of this study is the constrained generalizability of the reported allergen levels. Because some allergens are influenced by outdoor climatic factors and all allergens are influenced by one or more day-care characteristics, day-care facilities in other regions of the country or with different characteristics would likely have different distributions of allergens. However, with regard to the predictors of allergen levels identified in this study, the relationships between predictors and allergen levels should be much more consistent over a larger population of day-care facilities than the allergen levels would be. Another limitation to the study is that allergens were assessed in one room of the facility (although it was the room that most of the children spent most of their time) at

one point in time. There would certainly be between-room variation within a day-care facility at a given point in time and within-room variation over time. The main strength of this study is the comprehensive panel of indoor allergens and the large number of day-care characteristics studied.

In conclusion, this study provides evidence that day-care settings are an important source of exposure to indoor allergens, perhaps as important as the home. Further study of day-care facilities should be conducted to characterize allergen exposures in other regions of the country, to identify modifiable predictors of allergen levels, and to examine relationships between allergen exposures in day-care facilities and health outcomes in children and day-care workers.

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