

A nationwide study of indoor and outdoor environments in allergen avoidance and conventional daycare centers in Sweden

Abstract Sweden has had specialized ‘allergen avoidance daycare centers’ (AADC) since 1979. The aim was to compare AADC with ordinary daycare centers (ODC). Through contacts with municipalities and hospitals, 72 AADC were identified. For each AADC, the two nearest ODCs served as controls. A questionnaire was sent to the local directors of the 216 daycare centers (531 sections), 83% responded. A total of 39% of the ODCs had ever had dampness/molds, 12% were near (< 500 m) stables/farms, 23% were closer than 50 m to a heavily trafficked road, and 13% were exposed to wood smoke in winter. Only 11% of the AADCs had any child with furred pets at home, while 97% of the ODCs had children with furred pets. Bans on smoking at home and on perfumes were more common at the AADCs ($P = 0.001$). Fewer AADCs had PVC floors (OR = 0.53; $P = 0.01$), dampness/molds (OR = 0.55; $P = 0.04$), shelves (OR 3.03; $P = 0.001$), curtains (OR = 1.67; $P = 0.047$), and flowers (OR = 0.03; $P < 0.001$), while more had daily floor cleaning (OR = 19.9; $P = 0.004$), weekly wiping of furniture (OR = 11.0; $P = 0.001$), and washing of pillows/mattresses (OR = 2.74; $P = 0.005$) and curtains (OR = 9.07; $P = 0.001$). In conclusion, allergy avoidance daycare centers differ from other daycare centers, and may have better indoor environments.

**K. Bröms^{1,2}, K. Svärdsudd¹,
C. Sundelin³, D. Norbäck⁴**

¹Department of Public Health and Caring Sciences, Family Medicine and Clinical Epidemiology, Uppsala University, Uppsala, ²Centre for Clinical Research, Uppsala University/County Council of Gävleborg, Uppsala, Departments of ³Women's and Children's Health, Pediatrics and ⁴Medical Sciences, Occupational and Environmental Medicine, Uppsala University, Uppsala, Sweden

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Dr Kristina Bröms
Family Medicine and Clinical Epidemiology Section
Department of Public Health and Caring Sciences
University Hospital
751 85 Uppsala
Sweden
Tel.: +46 18 611 34 20
Fax: +46 18 51 16 57
e-mail: kristina.broms@pubcare.uu.se

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Practical Implications

There is a need to improve the indoor environments of daycare centers, including reduction of building dampness and molds. Allergen avoidance daycare centers (AADC) in Sweden differ from ordinary daycare centers in many respects, with fewer indoor and building factors related to dust, allergens and irritants. This shows that the indoor environments of daycare centers can be improved. Data suggest that AADC may have lower levels of pet allergens, and this is beneficial for children with pet allergy. The effects of these improvements on indoor exposures and health of the children need to be further evaluated.

Introduction

In recent decades, the prevalence of asthma and allergies has increased in the Western world, particularly among children (Åberg et al., 1995; Maziak et al., 2003; Newman-Taylor, 1995). Apart from the home environment, daycare centers is an important indoor environment for pre-school children. The proportion of children attending daycare centers is increasing in Europe, and has been large for many years in Sweden. In 2000, 71% of all pre-school children in Sweden attended a daycare center, and the

proportion increased to 76% in 2004 (Swedish Association of Local Authorities and Regions, 2005). Several studies indicate that children attending daycare centers are more prone to infection, including otitis media (Nafstad et al., 1999), and airway infections (Celedon et al., 1999; Koopman et al., 2001; Nafstad et al., 1999). Some epidemiological studies found daycare attendance to be a risk factor for asthma or respiratory symptoms (Nafstad et al., 1999; Nystad, 2000; Salam et al., 2004; Smedje et al., 1997), while most other studies indicate that early attendance at daycare centers may have preventive effects on allergy

development and atopic asthma (Ball et al., 2000; Haby et al., 2000; Kramer et al., 1999; de Meer et al., 2005; von Mutius, 2002).

There is little information available about the indoor environments of daycare centers. Two studies from the USA and Canada measured CO₂ in daycare centers, and concluded that the ventilation is often inadequate, with CO₂-levels exceeding 1000 ppm (Daneault et al., 1992; Ferng and Lee, 2002). In one older Swedish study, CO₂ levels were lower (458–822 ppm) (Cars et al., 1992). One Danish study from the 1980s related formaldehyde levels at daycare centers (80–430 µg/m³) to symptoms among daycare staff (Olsen and Døssing, 1982). Recently, exposure to organic pesticides and other persistent organic pollutants at daycare centers in North Carolina, USA was measured (Morgan et al., 2005; Wilson et al., 2001). Lead contamination at daycare centers has been studied in the USA (Weissmann et al., 1995) and Venezuela (Fernández et al., 2003). Two studies from Finland have measured indoor exposure to outdoor air pollutants [NO, NO₂; TSP (total suspended particulates) and PM₁₀] at daycare centers (Alm et al., 1998; Partti-Pellinen et al., 2000). In addition, building dampness and mold growth have also been shown to be common at daycare centers in Taiwan (Li et al., 1997), Norway (Nafstad et al., 2004) and Finland (Koskinen et al., 1997; Ruotsalainen et al., 1995). Microbial components, such as endotoxin (Andersson et al., 1999; Instanes et al., 2005; Rullo et al., 2002), beta-D-glucan (Andersson et al., 1999), and different species of molds (Li et al., 1997), and bacteria (Andersson et al., 1999) have been measured in settled dust or air samples from daycare centers in Finland, Taiwan, and Brazil. Exposure to traffic air pollution and other outdoor sources of pollution at daycare centers have rarely been addressed (Mukala et al., 2000; Söderström et al., 2004).

Daycare centers may be contaminated with cat allergens (Fel d 1) (Arbes et al., 2005; Fernández-Caldas et al., 2001; Instanes et al., 2005; Munir et al., 1995; Wickman et al., 1999), dog allergens (Can f 1) (Arbes et al., 2005; Instanes et al., 2005; Munir et al., 1995; Wickman et al., 1999), house dust-mite allergens (Der p 1, Der f 1) (Arbes et al., 2005; Engelhart et al., 2002; Fernández-Caldas et al., 2001; Li et al., 1997; Munir et al., 1995) and cockroach allergens (Per a 1; Bla g 1) (Arbes et al., 2005; Fernández-Caldas et al., 2001), and mice allergen (Mus m 1) (Arbes et al., 2005).

There are few studies in children on the health significance of the indoor environment at daycare centers (Koskinen et al., 1997), but some studies have been made on respiratory effects or sick building syndrome (SBS) in daycare center staff, in relation to molds and dampness (Li et al., 1997; Nafstad et al., 2004; Ruotsalainen et al., 1995). We have not found any studies on health effects of allergen exposure at daycare centers, but studies from schools indicate that

cat allergen exposure at school may increase new onset of asthma (Smedje and Norbäck, 2001a). Asthmatic schoolchildren with cat allergy but no cats at home had an increased risk of exacerbated asthma when starting at school after the summer holidays. The risk was increased only in school classes with a high proportion (> 18%) of cat owners (Almqvist et al., 2001). Moreover, children with asthma and a positive skin prick test to cat or dog allergens, had increased bronchial hyperresponsiveness after exposure to cat and dog allergens at school (Lönnkvist et al., 1999).

In Sweden, public daycare for pre-school children is a legislated right. The responsibility for providing daycare lies with the municipalities, although there are also some private daycare centers. During the 1990s there has been a focus on the health significance of the indoor environment at schools and daycare centers. The official report from the government allergy commission (SOU 1989:78, 1989), the Swedish national action plan designed to reduce environmental risks (SOU 1996:124, 1996), and the Environmental and Natural Resources Act (SFS 1998:808, 1998) have focused on the need for improvements of the indoor environments in Sweden. One national goal has been that no one should become ill owing to indoor exposures. The Swedish Asthma and Allergy Association (1998) has written detailed advice on how to improve the indoor environments at schools and daycare centers (Astma och allergiförbundets råd). In addition, The National Board of Health and Welfare has published recommendations on cleaning procedures for schools and daycare centers (The National Board of Health and Welfare, 1996: SOSFS 1996:33). The national campaigns for allergy prevention and better indoor environments resulted in the creation of special daycare centers, called 'allergen avoidance daycare centers', or 'allergy adapted daycare centers' (AADC). They exist in all areas of Sweden, and are financed within existing municipal budgets. The first AADC was opened in 1979, in Härnösand, in northern Sweden.

In the Swedish Daycare Centre Study, we are performing nationwide research on asthma and allergies among pre-school children, in relation to the daycare environment and other risk factors. In this paper, we present environmental data on different types of daycare centers in Sweden. The main aim was to compare AADC with ordinary daycare centers (ODC), with respect to different risk factors for allergen and irritant exposure in the daycare environment. In addition, we describe building characteristics and indoor environmental factors at the ODC, as the sample was quite large.

Building characteristics and indoor factors that could serve as proxy-variables for different types of indoor exposures were evaluated. As examples, it has been shown that the amounts of textiles in schools is

related to the amounts of settled dust and indoor concentrations of formaldehyde, and the extent of open shelves is related to formaldehyde in air and pet allergens in settled dust (Smedje and Norbäck, 2001b). Moreover, wet mopping was related to more bacteria in the air, but less settled dust, when compared with dry cleaning methods. Finally, a high frequency of cleaning of desks and curtains was associated with lower levels of cat and dog allergens in settled dust (Smedje and Norbäck, 2001b), and fewer signs of nasal inflammation in the teachers (Wålinder et al., 1999). A flat roof is a well-known risk factor for water leakage, and can be related to nasal obstruction and inflammation (Wålinder et al., 2001), and PVC floor coatings are one indoor factor related to higher levels of phthalates in indoor dust (Bornehag et al., 2005).

Study population and methods

Sampling

The first step was to identify AADCs nationwide. A standardized inventory questionnaire was constructed and sent to the technical and environmental sections of all 288 municipalities in Sweden, and to all inpatient and outpatient pediatric clinics in late 1998. Those who did not respond by mail were contacted by telephone. In this way, 72 AADCs were identified, and 68 participated in the investigation. In order to identify control daycare centers, the local director of each AADC was asked, in 1999, to specify the two geographically closest ODC. Thus, we obtained 72 AADCs with 91 sections and 144 ODCs with 440 sections (a total of 531 sections). As about one-third of the AADCs were situated in an ODC building, all analyses were performed at section level. In 2000, a questionnaire was mailed to the local director of each section. After two reminders and additional phone calls, a total of 84 AADC sections (92%) and 355 ODC sections participated (81%), and the total response rate was 83%.

Questionnaire

The questionnaire aimed to gather information related to the particular daycare section. It included questions on numbers of children and staff, age distribution of the children, education on allergy issues among staff, and different aspects of the indoor and outdoor environments. They included building age and design, redecoration, visible mold growth and building dampness, proximity of major roads, and questions on cleaning routines, open shelves, and fixtures. There were also some questions on allergy policies concerning use of perfumes, restrictions concerning serving high-risk allergenic food (fish, soybeans, nuts, peanuts, and eggs), and furry pets and smoking in the dwellings of

children and staff. The study was approved by the Ethics Committee at Uppsala University.

Statistical methods

The statistical analyses were performed with the SAS and JMP programme packages. Summary statistics, such as mean values, measures of dispersion and 95% confidence intervals (95% CI) were computed using standard parametric methods. Chi-square statistics were used. Mann–Whitney *U*-test was used to compare differences in data with ordinal scales or data which were not normally distributed, e.g. cleaning frequency and year of construction. Adjusted odds ratios (OR) with a 95% CI were calculated by logistic regression, adjusting for building age as a continuous variable. AADC was coded 1 and ODC was coded 0. All tests were two tailed, and a two-tailed *P*-value below 0.05 was used to indicate statistical significance.

Results

The AADC had an average of three fewer children per section, and one less child per staff member. Most of the staff at the AADCs had education on allergy issues, but such education was very rare in ODC. In addition, almost all AADCs had restrictions on keeping furry pets at home, both among the children and among the staff, while such restrictions were very rare in ODCs. The same pattern was found for restrictions on indoor smoking at home, and restrictions on use of perfume (Table 1).

Building characteristics

The median building construction year was 1987 for AADCs (interquartile range 1975–1990), and 1977 for ODCs (interquartile range 1972–1986), a significant difference. The oldest daycare center was built in 1864.

Table 1 Staffing and rules among allergen avoidance daycare centers and ordinary daycare centers

	Allergy section (<i>n</i> = 84)		Ordinary section (<i>n</i> = 355)		<i>P</i> -value ^a
	Mean	95% CI	Mean	95% CI	
No. of children	14.9	14.0–15.7	17.6	17.2–18.0	<0.001
No. of staff	3.0	2.8–3.1	3.0	2.9–3.0	0.87
Children per staff	5.2	4.8–5.5	6.1	5.9–6.2	<0.001
Allergy education (%)	86.9	79.7–94.1	24.5	20.0–29.0	0.001
Restrictions on parents (%)					
No furred pets	98.8	96.5–100.0	1.4	0.2–2.6	0.001
No smoking	83.3	75.4–91.3	0.6	0–1.3	0.001
Restrictions on staff (%)					
No furred pets	92.9	87.4–98.4	1.4	0.2–2.6	0.001
No smoking	89.3	82.7–96.0	3.1	1.3–4.9	0.001
Ban on perfume use (%)	100.0	–	24.5	20.0–29.0	0.001

^aCalculated using 2 × 2 chi-square contingency table.

The majority of the AADCs were built after 1983, while the majority of the ODCs were built before 1984. The majority of both types of daycare centers were in special daycare buildings, a minority were situated in the same building as a primary school, or in residential buildings. The distribution of building type differed between AADCs and ODCs, with more AADCs in residential buildings. Vinyl/PVC floor covering was less common, and wooden floors more common in AADCs, otherwise there were no significant differences in type of floor material. None of the AADCs and one (0.3%) of the ODCs had wall-to-wall carpets. There were no differences in frequency of remodeling, such as change of floor material or indoor painting during the last 12 months. (Table 2).

Building dampness was common both in AADCs and ODCs. A total of 25.3% of the AADCs and 39.1% of the ODCs had either past or present signs of building dampness or indoor mold growth ($P = 0.02$). Dampness or molds previous to the last year, was less common in AADCs (20.5%) than in ODCs (31.9%). Moreover, reports of odors, other than a moldy odor, were less common at AADCs. Condensation on window frames in winter was uncommon both in AADCs (1.2%) and ODCs (4.6%), a non-significant difference (Table 3).

As a next step, predictors of dampness and indoor mold growth were evaluated by comparing building characteristics of buildings with and without damp-

Table 2 Selected building characteristics of the daycare center buildings

	Allergy section (<i>n</i> = 84)		Ordinary section (<i>n</i> = 355)		<i>P</i> value
	%	95% CI	%	95% CI	
Year of construction					
1870–1974	20.0	11.2–28.8	31.9	27.0–36.8	0.001 ^a
1975–1983	20.0	11.2–28.8	39.9	34.8–45.1	
1984–1990	30.0	20.0–40.0	16.5	12.5–20.3	
1990–1998	30.0	20.0–40.0	11.7	8.4–15.2	
Location of the day care section					
In separate daycare center building	63.1	52.8–73.4	83.9	80.1–87.8	0.001 ^b
In same building as a primary school	3.6	0–7.5	3.1	1.3–4.9	
Situated in a single-family house	11.9	5.0–18.8	2.3	0.9–4.1	
Situated in a multi-family house	15.5	7.7–23.2	4.8	2.6–7.0	
Situated in other type of building	5.6	0.1–11.0	5.9	3.5–8.4	
Building characteristics					
Wooden building	67.5	57.4–77.5	70.2	65.4–75.0	0.63 ^c
Basement	16.7	8.7–24.6	17.2	13.3–21.2	0.90 ^c
Flat roof	17.9	9.7–26.1	23.5	19.0–27.9	0.27 ^c
Type of floor and wall material					
Linoleum floor	56.8	46.0–67.6	51.2	45.9–56.7	0.36 ^c
Vinyl (PVC) floor	53.1	42.2–64.0	68.1	63.2–73.0	0.01 ^c
Wooden floor	7.4	1.7–13.1	1.7	0.4–3.1	0.005 ^c
Wall-to-wall carpet	0	–	0.3	0–0.9	0.63 ^c
Textile wall covering	10.7	4.1–17.3	23.1	18.7–27.5	0.01 ^c
Recent redecoration					
New floor last year	9.5	3.2–15.8	6.5	3.9–9.1	0.34 ^c
Re-painted last year	14.3	6.8–21.8	14.9	11.2–18.6	0.88 ^c

Calculated using ^a2 × 4, ^b2 × 5, and ^c2 × 2 chi-square contingency table.

Table 3 Reports on dampness, odor and indoor molds in the daycare center buildings

	Allergy section (<i>n</i> = 84)		Ordinary section (<i>n</i> = 355)		<i>P</i> value ^a
	%	95% CI	%	95% CI	
Current dampness					
Water leakage/flooding last year	6.0	0.9–11.0	9.5	6.4–12.6	0.30
Dampness in the floor construction last year	3.6	0–7.5	6.6	4.0–9.2	0.29
Visible indoor mold growth last year	0	0	0.6	0–1.4	0.49
Mouldy odor last year	0	0	3.5	1.5–5.4	0.08
Any type of current dampness ^b	9.5	3.2–15.8	18.3	14.0–22.0	0.06
Previous dampness					
History of dampness/molds before last year	20.5	11.8–29.2	31.9	27.0–36.8	0.04
Current or previous dampness (combinations)					
Neither current nor previous dampness/molds	74.7	65.3–84.1	60.9	55.8–66.1	0.02
Previous but not current dampness/molds	15.7	7.8–23.5	20.4	16.1–24.7	0.33
Current but not previous dampness/molds	4.8	0.2–9.4	7.0	4.3–9.7	0.47
Both current and previous dampness/molds	4.8	0.2–9.4	11.7	8.3–15.1	0.07
Other indoor factors					
Window condensation during winter time	1.2	0–3.5	4.6	2.4–6.8	0.15
Other type of odor (not moldy) last year	8.3	2.4–14.2	20.2	15.9–24.4	0.01

^aCalculated using 2 × 2 chi-square contingency table.

^bLeakage/flooding, dampness in the floor construction, visible indoor molds or moldy odor in the last 12 months.

ness/molds in the total material of the daycare section ($N = 439$). The main difference was in building age. Sections that had dampness currently or ever were more often located in older buildings built before 1975. For sections located in buildings built during 1975–1983, there was a borderline significance for current dampness problems ($P = 0.05$). Sections located in buildings built from 1984 to 1990 had less often current dampness or ever dampness. Finally, the newest buildings had less often ever dampness.

The second predictor of dampness/molds was a flat roof, which was more common in buildings ever having dampness. In fact, 31.6% of all daycare centers with a history of dampness problems had a flat roof. Type of external building material (wood/concrete), presence/absence of basement, wet mopping, or type of floor material was not related to current or previous building dampness/indoor molds. Moreover, there were no regional differences in dampness/molds (Table 4).

Outdoor environment

Most buildings were situated in urban areas: 25% in larger cities (>100,000 inhabitants), 41% in larger towns (50–100,000 inhabitants), 25% in middle-size towns (10–50,000 inhabitants), and 9% in smaller towns/villages (<10,000 inhabitants). A total of 7.2% of the AADCs and 11.6% of the ODCs were situated closer than 500 m from a stable, horse enclosure, or an animal farm. A total of 21.4% of the AADCs and 22.9% of the ODCs were situated closer than 50 m

Table 4 Characteristics among all 439 daycare center sections, in relation to building dampness/molds

	Current dampness (%)			Never dampness (%)	Ever dampness (%)	<i>P</i> -value ^a
	No	Yes	<i>P</i> -value ^a			
Building characteristics						
Wooden building	69.6	69.6	0.99	67.2	75.2	0.09
Basement	17.6	16.7	0.86	18.5	15.4	0.42
Flat roof	21.0	29.2	0.13	16.6	31.6	0.001
Wet mopping	64.0	70.8	0.27	61.6	70.5	0.06
Linoleum floor	52.7	52.2	0.94	53.6	51.0	0.61
PVC floor	64.6	68.1	0.57	63.0	69.3	0.20
Wooden floor	2.8	2.9	0.98	3.4	2.0	0.40
Year of construction						
1870–1974	29.1	33.3	0.048	21.9	42.4	0.001
1975–1983	34.2	46.4	0.054	33.6	41.4	0.13
1984–1990	21.1	8.7	0.02	25.7	8.0	0.001
1990–1998	15.7	11.6	0.39	18.9	8.6	0.005
Region						
Southern Sweden (Götaland)	41.0	44.4	0.58	43.9	37.4	0.19
Mid-Sweden (Svealand)	48.2	47.2	0.88	45.0	52.9	0.12
Northern Sweden (Norrländ)	10.9	8.3	0.52	11.1	9.7	0.65

^aCalculated using 2 × 2 chi-square contingency table.

from a heavily trafficked road, and 16.7% of the AADCs and 17.5% of the ODCs were situated closer than 1000 m from an industry or other occupational activity emitting air pollution. As wood heating is common in Sweden, there was a question on perception of smoke from wood combustion outdoors during winter time. A total of 11.9% of the AADCs and 12.6% of the ODCs reported weekly smell from wood heating in winter. None of these differences in outdoor factors were significant, except being situated near an industry with air pollution, a risk factor less common for the AADCs (Table 5).

Furnishing, fixtures and cleaning routines

The AADCs had cupboards reaching up to the ceiling (no interspaces) significantly more often, fewer open shelves with books, fewer long curtains, and fewer flowers and pot plants. The vast majority of the sections, regardless of type, had written cleaning instructions, but such instructions were more common at the AADCs. Most had daytime cleaning and daily floor cleaning, regardless of type. Daytime cleaning was, however, less common in the AADCs, and frequent (daily) floor cleaning was more common. The most common methods of floor cleaning were dry electrostatic mopping and wet mopping. Wet mopping was less common and use of central vacuum cleaner was more common at the AADCs. In addition, wiping of furniture, and washing of pillows/mattresses and curtains was more common at the AADCs (Table 6).

Table 5 Selected outdoor exposure factors for the daycare center buildings

	Allergy section (n = 84)		Ordinary section (n = 355)		P-value ^a
	%	95% CI	%	95% CI	
Distance to stable, horses, or animal farm (m)					
<50	0	—	0.9	0–1.8	0.24
50–200	2.4	0–5.6	3.4	1.5–5.3	
200–500	4.8	0.2–9.3	7.3	4.6–10.0	
>500	92.9	87.4–98.4	88.5	85.1–91.8	
Distance to heavy trafficked road (m)					
<25	10.7	4.1–17.3	14.7	11.0–18.3	0.98
25–50	10.7	4.1–17.3	8.2	5.3–11.0	
50–200	29.8	20.0–39.5	26.8	22.2–31.4	
>200	48.8	38.1–59.5	50.4	45.2–55.6	
Distance to industry with air pollution (m)					
<1000	16.7	8.7–24.6	17.5	13.6–21.5	0.048
1000–5000	10.7	4.1–17.3	24.0	19.6–28.5	
>5000	72.6	63.1–82.2	58.5	53.3–63.6	
Smell from wood heating in winter					
Never	61.9	51.5–72.3	66.4	61.4–71.3	0.55
<Once/week	26.2	16.8–35.6	21.1	16.8–25.3	
1–4 times/week	9.5	3.2–15.8	8.6	5.6–11.5	
Every day	2.4	0–5.6	4.0	1.9–6.0	

^aCalculated using Mann–Whitney U-test.

Table 6 Furnishing, fixtures and cleaning procedures in the daycare center sections

	Allergy section (n = 84)		Ordinary section (n = 355)		P-value
	%	95% CI	%	95% CI	
Furnishing and fixtures					
Cupboard reaching up to the ceiling	66.3	56.1–76.4	19.2	15.1–23.2	0.001 ^a
Total shelves length <1 m	56.1	45.4–66.8	32.7	27.8–37.6	0.001 ^a
Short or no window curtains	44.1	33.4–54.7	29.3	24.6–34.0	0.009 ^a
Presence of any flowers or pot plants	20.2	11.6–28.8	90.4	87.4–93.5	0.001 ^a
No. of flowers or pot plant per section (mean)	1.5	0.8–2.3	11.9	10.9–12.9	<0.001 ^a
General cleaning procedures					
Written cleaning instructions available	84.0	76.0–91.9	70.5	65.6–75.4	0.014 ^a
Daytime cleaning (6.30 AM to 6 PM)	73.4	63.7–83.2	86.1	82.5–89.8	0.006 ^a
Daily floor cleaning	97.6	94.4–100	80.3	76.1–84.4	0.001 ^a
Floor cleaning methods					
Ordinary vacuum cleaning	32.9	22.8–43.1	35.9	30.9–40.9	0.62 ^a
Central vacuum cleaner	34.2	23.9–44.4	3.4	1.5–5.3	0.001 ^a
Dry electrostatic mopping	61.0	50.4–71.5	63.0	58.0–68.0	0.73 ^a
Wet mopping	52.4	41.6–63.2	67.5	62.6–72.4	0.010 ^a
Wiping of furniture ^b					
Less than once/month	0	—	26.9	22.3–31.5	<0.001 ^c
A few times/month	10.0	3.4–16.6	28.9	24.2–33.6	
1–3 times/week	47.5	36.6–58.4	38.8	33.7–43.9	
4–7 times/week	42.5	31.7–53.3	5.4	3.0–7.7	
Textile cleaning					
Pillows/mattress washing >twice/year	87.7	80.5–94.8	71.1	66.3–75.8	0.002
Curtain washing >twice/year	43.6	32.6–54.6	8.0	5.1–10.8	0.001

^aCalculated using 2 × 2 chi-square contingency table.

^bChairs, shelves, window ledges.

^cCalculated using Mann–Whitney U-test.

Finally, multiple logistic regression was used to calculate OR with 95% CI for significant indoor environmental characteristics, adjusting for building age as a continuous variable (Table 7). Adjusting for age did not change the results. In the bivariate analysis (Tables 2 and 3) there were no significant differences between the AADCs and the ODCs regarding water damage, floor dampness, having a basement, a flat roof, or being situated in a wooden house. Multiple regression analysis, adjusting for building age, did not change these findings (Table 7).

Characteristics of the allergy avoidance daycare centers

There were a set of questions specifically aimed to characterize different aspects of the AADCs. The AADCs had different names, the most common being 'allergy adapted daycare center' (48%), other names were 'allergy daycare center' (26%) or 'allergy sanitized daycare center' (19%). The initiative to establishing the AADCs come from many different sources, including municipal school administrations, parents, local politicians, and local daycare staff. A total of 38% were situated in the same building as an ODC. Mostly, allergic or asthmatic children with a certificate issued by a physician had priority of attendance, but only six AADCs (7%) exclusively recruited allergic children. Siblings or other non-allergic or non-asthmatic children were often recruited in order to have a sufficient

number of children. Most of the AADCs (61%) had not had any support from an allergy doctor or nurse during the last year, while 23% had regular medical support at least three times a year.

Discussion

Swedish daycare centers, like all buildings, have a number of environmental factors that could be associated with allergen and irritant exposure, e.g. furnishing and fixtures that could accumulate dust and allergens, insufficient cleaning, and outdoor factors such as proximity to stables, horses or animal farms, heavy trafficked roads, and smoke from wood heating in winter. Moreover, 39% of the ODCs had a history of mold growth or building dampness. Most of these risk factors (proxy variables for exposure) were less common in AADC.

The study is the first national study on the indoor environment in daycare centers in Sweden. In 1998, there were a total of 8953 daycare centers in Sweden, and the number was similar (8746) in 2004 (Swedish National Agency for Education, 2005: <http://www.skolverket.se>). Thus, our study included about 1.6% of all Swedish ODC. In late 1998 we could identify, on the basis of different information sources, 72 AADCs in Sweden, and of them 68 participated. This number is in agreement with another survey of allergy avoidance daycare centers performed 2 years later (Swedish National Institute of Public Health, 2001) suggesting that our study covered most of existing allergy avoidance daycare centers in Sweden. The participation rate was high and similar from both types of daycare centers. Thus, selection bias is less likely. The ODCs were recruited as controls for the AADCs and do not represent a random sample of daycare centers in Sweden. However, as the ODCs came from all parts of Sweden, and from different sizes of cities/towns/villages, we consider them to be reasonably representative of daycare centers in Sweden in general.

Another methodological problem is possible information bias (response bias) in relation to awareness of exposure. The daycare center staffs at the allergy avoidance sections were aware that the study focus of our study was on this type of daycare centers, while the ODCs were not informed that they served as controls. A general recall bias is most likely to result in general over-reporting of expected risk factors in the AADCs: building characteristic, indoor factors, and outdoor exposure. As the AADCs and ODCs were situated close to each other, the general outdoor environment would be expected to be similar. However, most of the outdoor factors did not differ, only some specific factors differed significantly, we found differences in both directions, and many building characteristic did not differ. A number of statistical tests were carried

Table 7 Selected indoor environment characteristics in allergen avoidance sections, when compared with ordinary sections, adjusted for building age^a

	OR (95% CI)	P-value
PVC floor	0.53 (0.32–0.87)	0.01
Wooden floor	5.00 (1.52–16.7)	0.008
Textile walls	0.36 (0.17–0.76)	0.008
Other odor	0.40 (0.18–0.93)	0.03
Current dampness	0.52 (0.24–1.12)	NS
Previous dampness	0.56 (0.31–1.04)	NS
Current or previous dampness	0.55 (0.31–0.96)	0.04
Cupboards reaching up to ceiling	6.25 (4.00–10.0)	0.001
Total shelf <1 m	3.03 (1.92–4.76)	0.001
Short or no window curtains	1.67 (1.01–2.77)	0.047
Presence of any flowers or pot plant	0.03 (0.02–0.06)	<0.001
Written cleaning instructions available	2.60 (1.31–5.14)	0.006
Daytime cleaning	0.43 (0.24–0.77)	0.005
Daily floor cleaning	19.9 (2.68–148)	0.004
Central vacuum cleaning	16.6 (7.74–35.5)	0.001
Wet mopping	0.51 (0.31–0.83)	0.007
Wiping of furniture at least once/week	11.0 (5.10–23.6)	0.001
Pillow/mattress washing >twice/year	2.74 (1.35–5.54)	0.005
Curtain washing >twice/year	9.07 (4.99–16.5)	0.001
Water damage	0.70 (0.26–1.89)	NS
Floor dampness	0.53 (0.16–1.82)	NS
Basement	1.09 (0.54–2.22)	NS
Flat roof	0.75 (0.41–1.39)	NS
Wooden house	0.96 (0.56–1.64)	NS

^aOR with 95% confidence interval calculated by logistic regression, adjusting for building age expressed as a continuous variable. Ordinary sections (coded 0) were compared with allergy sections (coded 1).

out, but most of them were highly significant ($P < 0.01$ or less). Thus, we do not believe that our conclusions are seriously biased by selection or information bias, or due to chance findings.

A high proportion of ODC sections (39%) had a history of building dampness and mold growth, and 18% had current dampness/mold growth in the last year. The most common problems were water leakage (10%) and dampness in the floor construction (6.6%), while visible indoor molds (0.6%), moldy odor (3.5%), and window condensation in the winter was rare (4.6%). In a study of 175 randomly selected daycare centers in Oslo, dampness problems (signs of molds, water leakage, dampness-related damage to floor/wall) were observed in 51% of all daycare centers (Nafstad et al., 2004). Even high prevalences of water damage (70%) and mold odor (17%) were found in a random sample of 30 daycare centers in Espoo, Finland (Ruotsalainen et al., 1995). Finally, a study of 28 daycare centers in Taipei, Taiwan reported dampness in 72.3% of all daycare centers, visible molds in 23.3%, water damage in 40.8% and flooding in 51.2% (Li et al., 1997). As dampness and mold growth are risk factors for asthma, allergy and SBS (Bornehag et al., 2001), there is an obvious need to take preventive measures against building dampness and molds in daycare centers, both in Sweden and other countries.

Building age and flat roof were associated with a higher prevalence of building dampness and mold growth. It is well known that flat roofs may increase the risk of water leakage from the roof, and one previous study has demonstrated that teachers in a school with flat roof and water leakage had an increase of biomarkers for inflammation in the nasal mucosa (Wålinder et al., 2001). Older daycare centers, constructed before 1975, had more dampness problems and newer buildings built after 1983 had fewer dampness problems. We have no detailed data of the type of previous dampness in the buildings, but the risk of water leakage may increase with age. Older building may have poor ventilation, causing condensation dampness, but window condensation was rare. One-third of the daycare centers were built in the period 1975–83, and there was borderline significance for current dampness in this group. During this period, several risk constructions were introduced in Sweden (Lundholm et al., 1990; Norbäck et al., 2000), but in our study the oldest buildings seemed to have the most dampness problems.

In addition, we identified several potential outdoor pollution sources for the daycare centers. A total of 12% of ordinary sections were situated < 500 m from stables, horses, or animal farms. The general recommendation in Sweden is that the distance between farms/stables and dwellings should be at least 500 m (The National Board of Health and Welfare, 2004). A total of 23% were situated < 50 m from a heavily

trafficked road, which indicates that the children and staff could be significantly exposed to air pollution from traffic. Moreover, 18% were situated < 1 km from an industry with emission to air, and 13% reported weekly smell from wood heating in winter. This indicates that the locations of Swedish daycare centers are not optimal, and when new daycare centers are built, outdoor risk factors should be considered.

The ordinary sections had indoor factors that could contribute to unnecessary accumulation of dust and allergens. Textile wall coverings were common (23%), 81% had cupboards that did not reach up to the ceiling, 67% had more than 1 m of open book shelves, and 71% had long window curtains. In addition, the cleaning routines could be improved. Day time cleaning was prevalent (86%), and vacuum cleaning was quite common (36%), which could cause unnecessary dust exposure. In 27% of the ordinary sections, the furniture was wiped less than once a month, and in only 8% were the curtains washed more than twice a year. Assuming that these factors can be used as proxy variables for dust and allergen exposure, several improvements could be made. Previous studies from schools suggest that such assumptions may be valid (Smedje and Norbäck, 2001b; Wålinder et al., 1999), but there is a need for validation studies of these proxy variables at daycare centers.

There are a few intervention studies from daycare centers, evaluating effects of environmental improvements. One long-term study of two Swedish daycare centers showed that use of electrostatic air cleaners during a 2-year period reduced particle exposure at the daycare centers, and that the absenteeism was also reduced (Rosén and Richardson, 1999). Another intervention study of one daycare center showed that the levels of cat and dog allergens were reduced 6- and 10-fold respectively (Munir et al., 1996). Use of school uniforms as well as a ban on pets at home reduced the allergen levels in schools, and both measures were equally efficient (Karlsson et al., 2004a). Another school study did not demonstrate any significant effects on cat allergen levels from allergen avoidance measures such as increased cleaning and reduction of dust collecting materials in the classrooms (Karlsson et al., 2004b).

Allergen avoidance daycare centers differ from ODC in many respects, not just for proxy variables possible related to allergen exposure. On average, the AADC were newer, but adjusting for building age did not change the findings. Numbers of children per section were lower, none used perfumes, pets at home were very rare, and there were less tobacco smokers in these sections. Moreover, the buildings less often had a history of dampness and indoor molds, and there were fewer complaints about indoor odors in general. Finally, furnishing and fixtures that could accumulate dust were less common, pot plants were rare, and the

frequency of floor cleaning, wiping of furniture, and washing of pillows, mattresses and curtains was higher. To our knowledge, there are no international publications available on large-scale surveys of allergen avoidance ('allergy adapted') daycare centers. Two smaller studies from Stockholm, comparing the indoor environments at allergen avoidance and ODC have demonstrated that allergen avoidance sections have lower total dust concentrations in indoor air (Christensson and Juringe, 1995), six times lower levels of cat allergens and nine times lower levels of dog allergens in settled dust (Wickman et al., 1999).

In conclusion, there is a need to improve the indoor environment at daycare centers, to reduce exposure to allergens, irritants, and building dampness. The

experience of AADC in Sweden has demonstrated that it is possible to reduce a number of environmental risk factors at daycare centers. Data suggest indirectly that AADC have lower levels of pet allergens, which is beneficial to children with pet allergy. The effects of these improvements on indoor exposures and the health of the children need to be further evaluated.

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