

Exposure to house dust mite allergen of children admitted to hospital with asthma

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Summary

Eighty-two children admitted to hospital with exacerbations of asthma were studied to determine how many were exposed to house dust mites at the time of admission and displayed immediate hypersensitivity to house dust mites. The concentration of house dust mite allergen (*Der p* I) was measured in dust obtained from the child's mattress, bedroom floor and living room floor. Sixty-two (75%) children admitted had been exposed to $> 10 \mu\text{g Der p I/g}$. Sixty-seven (82%) children were sensitive to house dust mite (RAST $\geq 1+$, or weal ≥ 3 mm): 49 (60%) children were both exposed and sensitive. In contrast in a control group of 44 children, 31 (70%) (n.s.) were exposed to $> 10 \mu\text{g Der p I/g}$, 10 (23%) ($P < 0.001$) were sensitive to house dust mite, and 7 (16%) ($P < 0.001$) were both exposed and sensitive. Seventy-three homes were revisited 6 months after the child's initial admission. During the preceding month 14 children had been readmitted, 12 were fully investigated; of these 10 were both sensitive to house dust mite and still exposed to $> 10 \mu\text{g Der p I/g}$. In contrast, of the remaining 62 children who were not readmitted, only 19 were both sensitive and still exposed to $> 10 \mu\text{g Der p I/g}$ ($P < 0.001$). In conclusion, the majority of children admitted to hospital with exacerbations of asthma were exposed to house dust mite allergen and were house dust mite sensitive. Further the results suggest that continued exposure to higher concentrations of mite allergen may be associated with the risk of readmission.

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Introduction

Increasing evidence has suggested that: asthma is an inflammatory disease [1,2]; allergen exposure can produce inflammation of the bronchi, bronchoconstriction, and increases in bronchial reactivity in susceptible individuals [3,4]; and that prolonged allergen avoidance can improve the symptoms of asthma and decrease bronchial reactivity [5,6]. Whilst many studies have shown that the majority of asthmatic children in the U.K. are sensitized to the house dust mite *Dermatophagoides pteronyssinus* [7–9] only recently has it been possible to measure their exposure to house dust mite allergen (*Der p* I) [10]. The present study investigated the prevalence of sensitization and home allergen exposure of children requiring admission to hospital with exacerbations of wheeze. In addition,

the homes were revisited 6 months later to see whether continued exposure to this allergen was related to hospital readmission.

Subjects and methods

All children over one year of age admitted for treatment of acute asthma to Poole General Hospital during September 1988 and a 6 week period in March/April 1989 were eligible for enrolment. The September period was chosen because of an excess number of admissions noted in previous years. This is in keeping with studies from other units which have consistently reported an autumnal peak in asthma admissions [11]. In contrast the spring period tended to be a 'quiet' period. During the study periods there were 96 admissions of 86 children. The parents were interviewed and 82 children, who consented, underwent allergen skin-prick testing and venepuncture during the course of the admission. The homes of 83

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Table 1.

	Admitted children (n = 84)	Control children (n = 44)
Median age (years)	3.8	11.4
(range)	1.1-15.0	10.6-12.0
Number of previous admissions	2.6	0
Number of first admissions	26	0
Boys	54	18 $P = 0.002$
<i>House dust mite sensitized*</i>	<i>n = 82 (100%)</i>	<i>n = 44 (100%)</i>
Negative	15 (18%)	34 (77%) $P < 0.001$
Positive (1+, 2+)	18 (22%)	4 (9%) n.s.
Strongly positive (3+, 4+)	49 (60%)	6 (13%) $P < 0.001$
<i>Cat sensitized†</i>	<i>n = 77 (100%)</i>	<i>n = 44 (100%)</i>
Negative	20 (26%)	27 (61%) $P < 0.001$
Positive (I, II)	43 (56%)	17 (39%) n.s.
Strongly positive (III, IV)	14 (18%)	0 $P < 0.01$
<i>Allergen exposure</i>		
Exposed to house dust mite ($> 10 \mu\text{g Der p I/g}$)	62 (75%)	31 (70%) n.s.
Exposed to house dust mite and sensitized to mite	49 (60%)	7 (16%) $P < 0.001$
Exposed to cat allergen ($> 8 \mu\text{g Fel d I/g}$)	39 (46%)	17 (40%) n.s.
Exposed to cat allergen and sensitized	22 (29%)	8 (18%) n.s.
Sensitized and exposed to either mite or cat allergen	59 (71%)	11 (25%) $P < 0.001$

* Sensitivity to house dust mite was based on a combination of skin-test and RAST results and was graded: negative (0), if the skin weal was < 3 mm and the RAST value was 0 or I/0; positive (1+), if the skin weal was > 3 mm or the RAST value was I; (2+) if the RAST was II; strongly positive (3+), if the skin weal was > 8 mm or the RAST was III; and very strongly positive (4+), if the RAST was IV.

† Based only on RAST.

n.s. $P > 0.05$.

children were visited within 2 weeks of admission and house dust samples collected. The normal ward protocol to provide information on mite reduction methods to mite sensitive children was then followed (Appendix). Seventy-three of the admitted children were revisited 6 months later and a second set of dust samples was collected. The names of children who had been readmitted with wheeze during the month preceding this second collection were obtained from the ward admission records. A control group of 44 normal children who reported they had not wheezed in the preceding year were also investigated between May and July 1988 and house dust samples collected. The control children were aged 11 years, with one atopic parent and therefore at risk of becoming sensitized, taking part in a study looking at the development of asthma [12]. The study was approved by the Hospital Ethical Committee.

Immediate hypersensitivity to house dust mite was assessed both by allergen skin-prick testing (Bencard, U.K.) [13] and measurement of house dust mite specific

IgE antibody (RAST) [14]. The skin weal was measured after 15 min and considered positive if the mean diameter was 3 mm greater than the negative control. RAST results were graded 0 to IV with 0 representing undetectable, I/0 equivocal, I low, II moderate, III high and IV very high levels. Sensitivity to house dust mite was based on a combination of skin-test and RAST results and was graded; negative (0), if the skin weal was < 3 mm and the RAST value was 0 or I/0; positive (1+), if the skin weal was ≥ 3 mm or the RAST value was I; (2+) if the RAST was II; strongly positive (3+), if the skin weal was ≥ 8 mm or the RAST was III; and very strongly positive (4+), if the RAST was IV. In addition, immediate hypersensitivity to cat was assessed by measurement of cat specific IgE antibody (RAST) and graded 0 to IV with 0 representing undetectable, I low, II moderate, III high and IV very high levels.

Exposure to house dust mite allergen was assessed by measurement of the reservoir concentration of *Der p I* in dust obtained from the child's mattress, bedroom floor

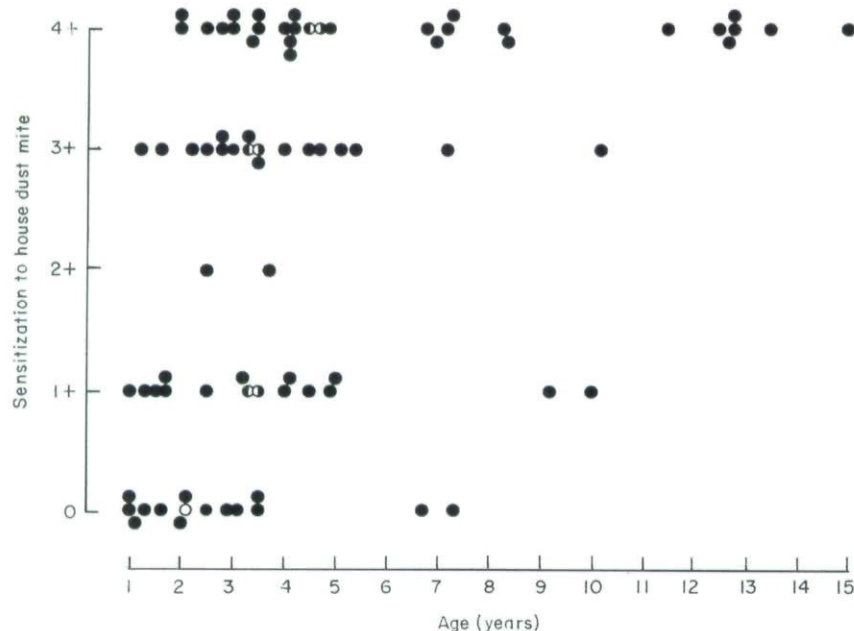


Fig. 1. The prevalence of immediate hypersensitivity to house dust mite of children admitted to hospital with asthma. Immediate hypersensitivity to house dust mite was graded: 0, negative; 1+, positive; 2+, 3+, strongly positive; and 4+, very strongly positive (see methods). The open circles represent the median value for each row.

and living room floor. House dust was collected by the same operator (J.W.) using a hand held vacuum cleaner. The weight of house dust obtained ranged from 0.013 to 2.68 g with a mean of 0.27 g. Samples from which 0.05 g of sieved dust could not be obtained were excluded from analysis. The level of *Der p* I was measured in aqueous extracts by ELISA [10] and the results expressed as a concentration (*Der p* I/g of sieved dust). In addition, exposure to cat allergen was assessed by measurement of the concentration of cat allergen (*Fel d* I/g) in these samples by ELISA [15].

Geometric means and 95% confidence intervals were calculated. Contingency tables were analysed by the chi-square method and Fisher's Exact test. The significance of differences in *Der p* I concentrations from the same sites were calculated using the Wilcoxon signed rank test.

Results

The clinical characteristics of 50 children admitted in September and 34 in March were similar. The median age and sex ratios were similar with a preponderance of preschool boys (Table 1). More children were admitted for the first time in September (20/6, $P < 0.001$). Sixty-seven (82%) of the children admitted were house dust mite sensitized compared with 10 (23%) of the control group ($P < 0.001$). There was no difference in the sensitization of the children admitted during the 2 study periods. The prevalence and degree of sensitization of the hospitalized children increased with age; of the children aged three or over 88% were sensitized ($P < 0.01$ in the

comparison with children under three) and 72% were highly sensitized (3+ or 4+) ($P < 0.05$) (Fig. 1). Of the 26 children who had never been previously admitted 84% were house dust mite sensitized. The correlation between immediate hypersensitivity judged by skin testing and by RAST measurement was fair ($r = 0.49$, $P < 0.001$). On the basis of RAST measurements 57 (74%) of the children admitted were cat sensitized compared with 17 (39%) of control children ($P < 0.001$). Multiple sensitivity to mite and cat was usual: only three children were RAST positive to cat and RAST negative to mite.

The mean concentrations of house dust mite allergen, *Der p* I, from each site were higher in September but there was extensive overlap (Fig. 2). In analysis of exposure the highest concentration measured in each house was used, which was found in mattress dust in 48% of the houses in September, 59% in March, and in 60% of the control houses. Forty (80%) of the children admitted in September, 22 (66%) of those admitted in March, and 29 (70%) of the control children had been exposed to greater than 10 μg *Der p* I/g (a previously proposed 'high' level of exposure, corresponding to ~ 500 mites/g of sieved dust). The mean of the highest concentration (95% confidence intervals) in the houses was 29.5 (21.8–40.0) in September, 13.3 (9.3–19.1) in March, and 17.0 (11.8–24.7) $\mu\text{g}/\text{g}$ in the control group. The only difference in the allergen concentration from corresponding sites in the homes of the admitted children and the control children was found in the living room floor values of children admitted in September (15.1 and 4.3 $\mu\text{g}/\text{g}$ respectively, $P < 0.001$). The degree of mite sensitivity was not related to the current

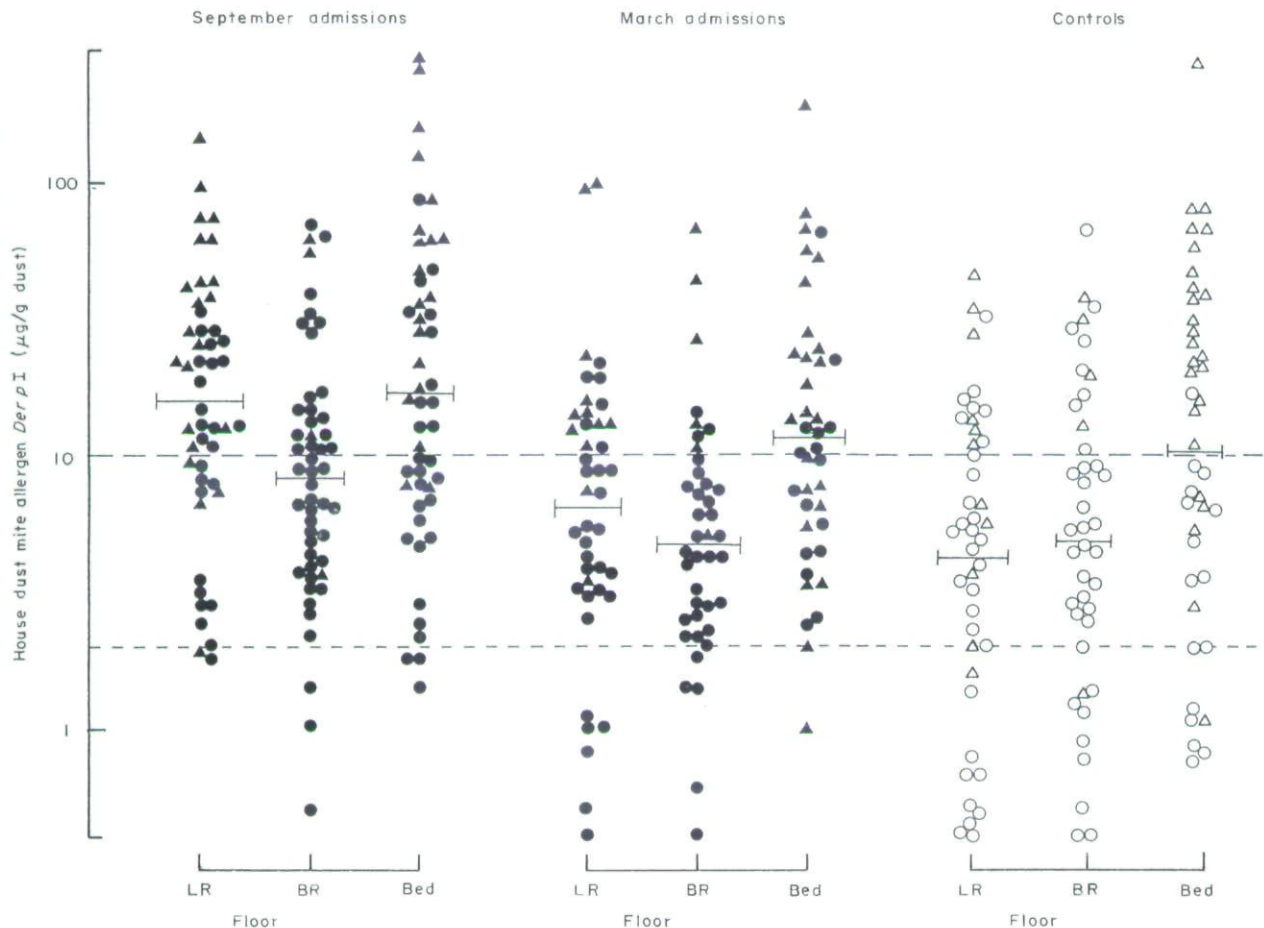


Fig. 2. The concentration of house dust mite allergen (*Der p I*) in the homes of children admitted with asthma and in the homes of control children. Triangles represent the highest concentration of *Der p I* measured in the house. Closed symbols represent samples obtained from the homes of asthmatic children, open symbols represent samples obtained from the homes of control children. Horizontal bars represent the geometric means. The lower dashed bar denotes the proposed minimum concentration of allergen associated with the development of sensitization. The upper dashed line denotes the concentration of allergen proposed to produce symptoms of asthma in sensitized individuals.

highest reservoir concentration of mite allergen ($r=0.20$, $P=0.08$). For the children admitted in September the mean concentration at each site 6 months later was reduced: the differences only reached significance for the living room floor samples (15.1 and 5.9 $\mu\text{g/g}$ respectively, $P<0.001$) (Table 2). The lower concentrations found in the homes of children admitted in March showed little change 6 months later. Twenty-eight (65%) of the children admitted in September and 15 (50%) admitted in March were still exposed to greater than 10 $\mu\text{g Der p I/g}$. The concentration of *Fel d I* measured in the samples reflected the presence of a cat in the household. Thirty-nine (46%) of the admitted children and 17 (40%) (n.s.) of the control children were exposed to >8 $\mu\text{g Fel d I/g}$. There was little variation in the *Fel d I* concentrations when measured 6 months later.

Thirty-two (66%) of the children admitted in September, 17 (51%) of those admitted in March, and seven (16%) of the control children ($P<0.001$ and $P<0.01$ respectively) were exposed to greater than 10 $\mu\text{g Der p I/g}$ and displayed immediate hypersensitivity to the house dust mite. In the sub-group of 24 children studied who were admitted for the first time, 18 (75%) were both sensitized and exposed. Amongst those children who were not sensitized nor exposed to mite allergens 10 children were sensitized to cat and exposed to >8 $\mu\text{g Fel d I/g}$. Overall 59 (71%) of the children were sensitive to mite or cat allergen and exposed to high concentrations of the relevant allergen compared with 11 (25%) of those in the control group ($P<0.001$). This increased to 81% if the children under the age of 5 years were excluded in the analysis.

Table 2.

	Dust mite allergen concentration <i>Der p I</i> ($\mu\text{g/g}$) (mean and 95% confidence intervals)	
	On admission	6 months later
<i>Homes of children admitted in September</i>		
	<i>n</i> = 50	<i>n</i> = 43
Living room floor	15.1 (11.0–20.7)	5.9 (4.2–8.5)
Bedroom floor	8.3 (6.2–11.2)	6.5 (4.4–9.9)
Mattress	16.7 (11.5–24.3)	11.8 (7.3–19.4)
Mean highest	29.5 (21.8–40.0)	19.8 (13.1–29.9)
<i>Homes of children admitted in March</i>		
	<i>n</i> = 33	<i>n</i> = 30
Living room floor	5.9 (4.0–8.6)	5.6 (4.2–7.6)
Bedroom floor	4.3 (3.2–6.9)	4.7 (3.7–6.1)
Mattress	9.6 (6.5–14.0)	7.8 (4.7–13.2)
Mean highest	13.3 (9.3–19.1)	12.0 (8.2–17.6)
<i>Homes of children readmitted with asthma*</i>		
	<i>n</i> = 13	<i>n</i> = 13
Living room floor	11.7 (6.1–22.6)	22.9 (11.8–44.7)
Bedroom floor	7.1 (3.9–13.0)	6.7 (2.9–15.9)
Mattress	14.4 (9.6–21.7)	7.0 (3.0–16.4)
Mean highest	21.5 (13.2–35.1)	28.3 (14.7–54.3)
<i>Homes of children not readmitted with asthma</i>		
	<i>n</i> = 70	<i>n</i> = 60
Living room floor	10.1 (7.5–13.4)	5.7 (4.4–7.5)
Bedroom floor	6.4 (5.0–8.2)	5.5 (4.2–7.3)
Mattress	13.3 (9.6–18.4)	8.5 (5.7–12.8)
Mean highest	21.4 (16.1–28.3)	14.3 (10.4–19.5)

* Children who had been readmitted to hospital in the one month preceding the second sampling of house dust.

Of the children revisited 6 months later, 60 had not been readmitted with wheeze during the preceding month and of these 19 were sensitized and still exposed to $> 10 \mu\text{g}$ *Der p I*/g. In contrast 14 children had been readmitted to hospital in the preceding month, 12 were fully investigated, and of these 10 were sensitized to mite allergens and still exposed to $> 10 \mu\text{g}$ *Der p I*/g ($P < 0.001$, for the comparison with the children who had not been readmitted).

Discussion

The results confirm previous studies showing that the majority of children with asthma were sensitized to house dust mite allergens, which was invariably seen in the older children. The majority of children were exposed to high

concentrations of house dust mite allergen. In contrast a minority of the control children were house dust mite sensitized, despite being older than the majority of the admitted children and despite similar levels of allergen exposure.

The arbitrary threshold concentration $10 \mu\text{g}$ *Der p I*/g used to delineate high and low mite allergen exposure is based on epidemiological studies which have suggested that sensitized individuals were at an increased risk of wheezing when it is exceeded [16–18]. Similarly $8 \mu\text{g}$ *Fel d I*/g is a level proposed to represent significant exposure to cat allergen. Allergen exposure was expressed as a concentration, rather than the absolute amount of allergen recovered, in keeping with the recommendations of an international workshop, which highlighted the variability of house dust collection [19]. The relative deficit of hospital readmissions among those children in whose homes the *Der p I* concentration had fallen below $10 \mu\text{g/g}$ is consistent with the concept that high domestic allergen exposure is harmful. The number of children admitted to hospital with asthmatic exacerbations varies throughout the year showing an autumnal peak, a smaller spring peak, and relatively lower levels throughout the remainder of the year [11]. Deaths due to asthma in young adults have also shown a similar seasonal variation with an excess in the third quarter of the year [20]. At this time of the year conditions are most favourable for mite growth [21]. In this study the autumnal increases in *Der p I* concentration appeared modest, reaching significance only in samples obtained from living room carpets. Surprisingly the samples obtained from homes first visited in March showed no increase in *Der p I* concentrations in September, whether this was due to avoidance measures being undertaken is unclear. It has been shown that non-specific bronchial reactivity increases with seasonal exposure to pollen allergens [22,23]. The relative excess exposure of sensitized children to house dust mite allergen in the autumn may be sufficient to raise their level of bronchial reactivity. They would then be more liable to wheeze following exposure to viruses, allergen alone or other factors. This may explain the autumnal rise in admissions. Indeed such an autumnal rise in non-specific bronchial reactivity has been described in a study of adults in Hampshire [24].

Hospitals are relatively mite and cat free, with low concentrations of mite allergen (*Der p I* $< 0.4 \mu\text{g/g}$). Admission to this environment is in itself a useful adjunct to the treatment of asthma [5]. Attempts to reduce domestic dust mite allergen levels have shown clinical benefit in a number of studies [reviewed in 25]. The current home management of asthmatic children is based on bronchodilators with or without an anti-inflammatory agent, e.g. inhaled steroids or cromoglycate. It has been

suggested that treatment with effective bronchodilation allows inhalation of larger quantities of allergen [26,27] which may increase bronchial inflammation [28]. Indeed, returning a child to a bed or house with a high concentration of dust mite allergen using bronchodilators, which occurred in the majority of children in this study, may compound his or her problem. In view of the present evidence that the majority of children are sensitized and exposed to high levels of domestic allergens, and the suggestion that exposure to higher concentrations of mite allergen may be associated with the risk of readmission, it is clearly important to ask whether aggressive allergen avoidance [25, 29] may help reduce the frequency of hospital admissions of children with asthma.

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Appendix

Recommendations for house dust mite avoidance

The following measures are designed to reduce exposure of your child to the type of house dust mite which causes wheezing.

Important measures in the bedroom

- 1 Thoroughly vacuum the mattress, pillows and the base of the bed or divan prior to enclosing the mattress top surface and sides in a plastic cover (available from Boots if ordered or bedding stores). Semipermeable fabrics which do not allow mite allergen through are also available but relatively expensive.
- 2 Exchange any pillows or quilts containing feathers for ones having a synthetic filling.
- Hot wash (60°C) all sheets and quilts weekly.
- 3 Remove soft toys (teddy bears etc.) from the bed and if possible from the bedroom.

4 Every week:

- damp dust skirting boards, window sills and the mattress cover;
- change and wash pillow cases, sheets and under-blankets;
- vacuum pillows and base of divan or bed.

If your child shares a bedroom, all other beds should be treated in a similar way. Do not put a child with asthma into the bottom bunk of a bunk bed.

- 5 Keep windows open as much as possible.

Desirable measures in the bedroom

- 1 Linoleum, vinyl covered or polished wooden flooring is preferable to carpeting as it is easier to keep dust free.
- 2 Nylon, terylene or cotton cellular blankets are easier to wash than woollen ones. Blankets should be washed frequently.
- 3 During sunny periods air the bedding as sunlight kills the mites.
- 4 Wash bedroom curtains frequently (hot wash).
- 5 Keep domestic animals and birds out of the child's bedroom.

Other rooms

Particular attention should be directed to the removal of dust from upholstered furniture (which harbours mites). Vacuum clean such furniture at least twice a week paying particular attention to the head rest, arms and edges of the seats. Empty the vacuum cleaner bag frequently (disposable paper bags are preferable) and check that the cleaner is working properly. Avoid exposure to cigarette smoke.

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