
Environmental exposure reduction in high-risk newborns: where do we start?

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Background: When analyzing the effect of environmental exposure reduction measures on asthma in high-risk children, one must know how far asthmatic families already have applied such measures, because this would affect the effectiveness and efficiency of interventions aimed at reducing environmental exposure.

Objective: To describe the room for improvement by asthmatic families in mite, pet, and food allergen reducing measures and in parental passive smoking and to determine the resulting levels of mite and pet allergens by the applied sanitation measures.

Methods: Data were sampled by observation, weekly diary entries, and questionnaire when the infant was 6 months old and 1 year old. Dust samples were collected by vacuuming the living room floor and the parental and infant mattresses. Multiple logistic regression analyses were applied with the use of mattress encasing, having a smooth floor covering, having pets, exclusive breast-feeding and/or hypoallergenic formula during the infant's first 6 months, and passive smoking as the dependent variables.

Results: Frequencies of applied measures were as follows: having a smooth floor covering, 36%; daily house cleaning, 27%; use of parental and infant antimite mattress encasings, 13% and 9%, respectively; keeping no pets, 66%; no cow's milk-based regular formula, 13%; no solid foods in the first 6 months of life, 28%; and abstinence of smoking by the mother prenatally, 89%; by the mother postnatally, 85%; and by her partner, 76%. Having a smooth floor covering and daily cleaning but not use of antimite mattress encasings resulted in significantly lower mite and pet allergen levels.

Conclusions: There is (still) enough room for improvement to reduce exposure to inhalant and food allergens, especially by application of mattress encasings, exclusive breast-feeding and/or hypoallergenic formula feeding, and postponing the time until first solids are given.

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INTRODUCTION

Asthma is the most common chronic disease of childhood. Prevalence of asthma is still increasing,¹ and the disease forms an important burden for children and their parents.² Therefore, interest in the primary prevention of asthma by influencing relevant environmental factors is growing. The best-known environmental exposures in Western Europe are allergens of the house dust mite and pets, food allergens, and passive smoking. These exposures can be effectively reduced,^{3,4} although the relevance of reduction of some environmental factors is currently under debate.⁵ The effectiveness of such preventive measures in high-risk families has still to be proved in daily care.⁶ To study the effect of

environmental exposure-reducing measures to prevent asthma, insight into the room for improvement (RFI) of these preventive measures is necessary. In this article, we examine (1) the application of environmental exposure-reducing measures in asthma-affected families expecting a child and the existing RFI in measures to reduce mite, pet, and food allergens and prenatal and postnatal smoking; (2) the influence of different types of preventive measures on the levels of mite and pet allergens in homes; and (3) the determinants of preventive behavior of asthmatic families.

MATERIALS AND METHODS

Study Subjects

Data were collected from the Prevention of Asthma in Children (PREVASC) study, which explores risk factors for asthma in children from the southeastern part of The Netherlands. High-risk infants (ie, mother, father, or both and/or sibling[s] have physician-diagnosed asthma) were recruited by primary caregivers (family physicians and midwives) when the mother visited their practices in early pregnancy. The mothers were asked to participate in a study to elucidate the role of environmental exposure on the development of asthma. To avoid changes in preventive behavior, induced by information about the study, no information was given about the specific prenatal and postnatal environmental exposures

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and their hypothesized positive association with the development of asthma. Exposure was determined as (1) the measures applied to reduce exposure to mite, pet, and food allergens and passive smoking and (2) the prenatal and postnatal levels of exposure to mite and pet allergens in samples of settled house dust from the living room and parental and crib mattresses. The study was approved by the Ethical Committee of the University of Maastricht, Maastricht, The Netherlands.

Preventive Measures Studied

Reduction or avoidance of the following were studied: (1) mite and pet allergens by sanitation measures, such as the use of antimite bed covers, duvets, and pillows (hereafter referred to as *encasing*), a frequent cleaning of the newborn's living environment, having a smooth floor covering in the living room and the bedroom, and removing pets from the home by disposing of them or keeping them outside; (2) food allergens by feeding the infant breast milk and/or hydrolyzed cow milk instead of humanized cow milk and postponing the first weaning solids, such as juice, fruits, or vegetables, until 6 months of age; and (3) prenatal smoking by the mother and postnatal smoking by the mother, her partner, and others in the house.

Data Sampling and Measuring

Data were sampled by observation (housing characteristics), weekly diary entries (kind of feeding), and questionnaire when the infant was 6 months old (the first solids) and 1 year old (sanitation measures, smoking). Special attention was paid to the timing of the parental questionnaires, because parents might change their existing preventive lifestyle just by asking questions about the applied measures (Hawthorn effect). Questions were included regarding whether reported measures were applied or induced by information or advice given by the family physician, midwife, specialist, or specialized nurse. To trace changes in exposure to inhalant allergens, concentration of the allergens was evaluated prenatally and postnatally (at baseline and, to avoid seasonal influences, 1 year later). Sociodemographic characteristics (age and education level of the mother, number of siblings, family history of asthma, duration of pregnancy, birth weight of infant, place of birth, and mode of delivery) were recorded.

To know whether the study population was representative, we compared the eligible families who had been recruited by the family physician but had refused to participate (hereafter referred to as *nonparticipants*) with the participants. For this purpose, the nonparticipants were asked to answer a few additional questions on relevant characteristics, including age and education of the mother, family history of asthma, smoking behavior, presence of pets, and furnishings of the house.

Collection and Measurement of Inhalant Allergens

Dust samples were collected by vacuuming (1,300-W vacuum; Bosch, Hoofddorp, The Netherlands) the floor of the living room (2 areas of 1 m² for 2 minutes each) and the parental and infant mattresses (1 m² for 2 minutes) with

covers but without sheets. Parents were asked not to vacuum the bedroom and living room floor before the dust collection.

The preparation of dust samples for measurement and the measurement of mite allergen (Der p 1), cat allergen (Fel d 1), and dog allergen (Can f 1) have been previously described.⁷ The detection limit was 2 ng/g for Der p 1 and 1 ng/g for Fel d 1 and Can f 1.

Data Analysis

Differences between participants and nonparticipants were analyzed using the χ^2 test and *t* test when appropriate. Frequencies of measures already applied were computed. Differences between prenatal and postnatal levels of the inhalant allergens were tested with the Wilcoxon signed rank test. For each case, exposure to Der p 1, Can f 1, and Fel d 1 was calculated as the mean of the prenatal and postnatal allergen content in dust samples of the infant and parental mattresses and as the mean of prenatal and postnatal allergen content in dust samples of the living room. To receive one expression for the overall exposure (prenatal and postnatal), the mean allergen content in the mattresses and living room floor was calculated. The RFI was expressed as the number of households that had not applied the prevailing preventive measures for each exposure.

Several multiple logistic regression analyses were applied with the preventive measures as the dependent variables: the use of mattress encasing, having a smooth floor covering, having pets, exclusive breast-feeding and/or hypoallergenic formula during the infant's first 6 months, and passive smoking. Family characteristics served as independent variables (Table 1). SPSS statistical software version 10 (SPSS Inc, Chicago, IL) was used for all analyses. For all analyses, *P* < .05 was considered statistically significant.

RESULTS

Of the 311 families who were asked to participate, 227 gave their informed consent. There were 16 dropouts: 5 were lost during follow-up and 11 were excluded (stillbirth and abortion, 7; long-lasting hospitalization, 1; moved abroad, 3). The data of 211 patients were available for analysis. Table 1 shows the baseline characteristics of the participants and the comparison with nonparticipants. Participating mothers had a higher education and were more often nonsmokers compared with nonparticipating mothers.

Table 2 reports data on already applied measures and behavior to reduce the exposure to mite, pet, and food allergens and passive smoking. It also shows whether the reported measures and behavior were applied at the advice of professionals. Only half of the used encasings had proven antimite efficacy (data not shown).

Exposure to Allergens of House Dust Mite and Pets

There was no difference between the prenatal and postnatal concentrations of allergens in the house during the study period. Mite and pet allergens were found in nearly all the houses (Fig 1). The exposure to allergen levels of mite, cat, and dog was above the sensitization threshold in 37%, 17%,

Table 1. Comparison of Family Characteristics and Environmental Exposure in Participating and Nonparticipating Subjects*

Variable	Participants (n = 211)	Nonparticipants (n = 84)
Age of mother, mean (SD), y	31.0 (3.65)	33.2 (4.0)†
Education level of mother‡		
Low	18 (8)	17 (19)†
Middle	103 (49)	44 (49)
High	90 (43)	28 (32)
Family history of asthma		
Mother	62 (29)	20 (26)
Father	41 (19)	16 (20)
Both parents	15 (7)	4 (5)
Siblings	41 (19)	15 (19)
Mother and sibling	28 (13)	10 (13)
Father and sibling	19 (9)	11 (14)
Both parents and sibling	5 (2)	2 (3)
Birth order		
First born	79 (37)	29 (33)
Second born	84 (40)	32 (36)
Third or later born	60 (28)	28 (31)
Pets		
No	122 (58)	52 (60)
Only a cat	26 (12)	8 (9)
Only a dog	41 (19)	22 (26)
Both	5 (2)	4 (5)
Anti-house dust mite covers on parents' bed	27 (13)	11 (12)
Smoking mother	22 (11)	24 (27)†
Smooth floor covering in the house	110 (53)	48 (54)

* Data are number (percent) of subjects unless otherwise indicated.

† $P < .05$.

‡ Low indicates primary school; middle, secondary school; and high, university.

and 18% of the cases, respectively. The levels of mite and pet allergens in relation to sanitation measures are shown in Tables 3 and 4. On daily cleaned living room floors and floors with a smooth cover, lower mite and pet allergens levels were found compared with living room floors that were not daily cleaned and textile covered floors (Table 3). In the bedrooms, neither a smooth floor covering nor daily floor cleaning reduced the allergen levels in dust samples of the mattresses (Table 4). Levels of mite and pet allergens on parental and infant mattress encasings differed but not significantly from the levels on nonencased mattresses (Table 4).

Table 5 shows higher levels of the pet-specific allergen in dust samples of the living room and mattresses in the houses of pet-owning families compared with non-pet-owning families.

The additional RFI in preventive measures is shown in Figure 2. Theoretically, plenty of RFI was present regarding the advice to use parental and infant mattress encasings, exclusive breast-feeding, hypoallergenic formula feeding, and postponing the first solids until 6 months after birth. Less RFI existed for reduction of passive smoking.

Table 2. Presence of Reported Exposure to Allergens and Passive Smoking in Asthmatic Families Expecting a Child and the Influence of Advice of Professionals on Measures to Reduce Exposure*

Variable	No. (%) with exposure (n = 211)	No. influenced by professional advice
House dust mite		
Smooth floor covering†	76 (36.0)	17
Daily cleaning of floor‡	56 (26.5)	11
Antimite encasing on infant mattress	19 (9.0)	7
Antimite encasing on parental mattress	27 (12.8)	12
New infant mattress	83 (39.3)	3
Pets		
Presence of cats	31 (14.7)	
Removed	1 (3.2)	0
Keeping outside	3 (9.7)	NA
Presence of dogs	46 (21.8)	
Removed	6 (13.0)	2
Keeping outside	6 (13.0)	NA
Food		
Exclusive breast-feeding during 6 months after birth	62 (29.4)	10
Solid foods at 6 months or more after birth	66 (27.5)	NA
Passive smoking		
Prenatal and/or postnatal smoking by mother	32 (16.3)	NA
Smoking partner	45 (24.1)	NA
Smoking by others in the house	91 (43.1)	NA

Abbreviation: NA, not asked in the study.

* Professionals included family physician, midwife, specialist, specialized nurse, and healthy child clinic.

† Smooth floor covering included polished wood, vinyl, or tiled floor covering.

‡ Daily cleaning of floors by vacuum cleaner or damp mop.

Determinants of Preventive Behavior

Multiple logistic regression analyses showed that the type of floor covering in the house and use of encasings were not influenced by family history, education of the mother, or family size. Older (>31 years) mothers less frequently had smooth floors in their houses compared with younger mothers (odds ratio [OR], 0.40; 95% confidence interval [CI], 0.19–0.83; $P = .02$). In those houses where encasings were used, textile floor coverings (OR, 2.4; 95% CI, 1.01–5.7; $P = .048$) and pets (OR, 3.4; 95% CI, 1.3–8.5; $P = .009$) were also present less frequently. With regard to pets, analysis revealed that older mothers had pets less frequently compared with younger mothers (OR, 2.2; 95% CI, 1.1–4.7, $P = .03$).

Breast-feeding was not influenced by family history, the age of the mother, birthplace, mode of delivery, and birth weight but was negatively associated with the education of the mother and the infant being born before 36 weeks of

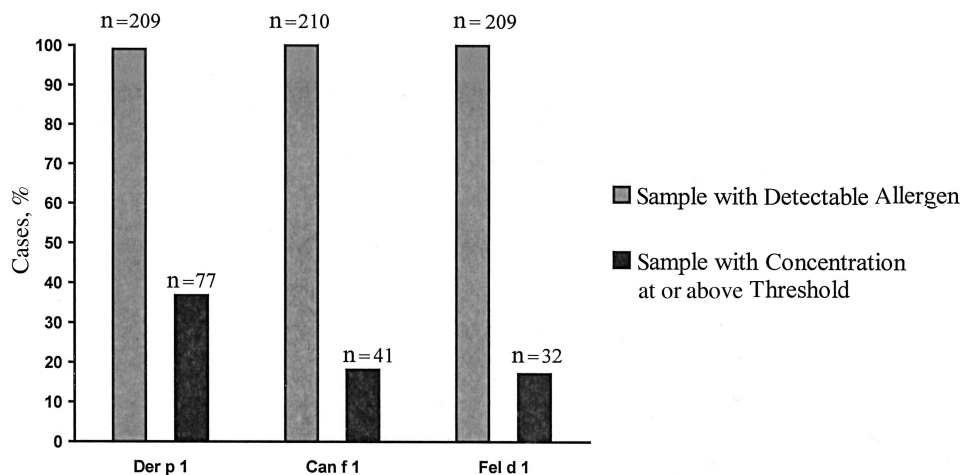


Figure 1. Percentage and numbers of cases with detectable levels of Der p 1, Can f 1, and Fel d 1 and with levels at or above the threshold value for sensitization in either the living room or parent or infant mattress (during pregnancy and the first year of the infant's life). (Threshold values were 2,000 ng/g for Der p 1, 10,000 ng/g for Can f 1, and 8,000 ng/g for Fel d 1.)

gestation (testing the likelihood ratio, $P = .003$ and $P = .04$, respectively). (Odds ratios could not be calculated because numbers were too small.)

Postponement of the first weaning solids was independently positively associated with exclusive breast-feeding (OR, 5.1; 95% CI, 2.3–11.9; $P < .001$) and being born second or later (OR, 3.0; 95% CI, 1.2–7.1; $P = .01$).

Prenatal and postnatal maternal smoking was not influenced by family history, age, or education of the mother or presence of other children (OR, 4.5; 95% CI, 1.8–11.5; $P = .001$) but was significantly associated with a smoking partner (OR, 7.7; 95% CI, 2.5–23.0; $P = .04$).

DISCUSSION

In this study of asthmatic families expecting a child, we analyzed the RFI in preventive measures that aimed to reduce exposure to mite, pet, and food allergens and passive smoking. Because we planned to investigate the (combined) effect of preventive measures on the development of asthma, we sought insight into what extent these preventive measures are

already applied, since this would affect the RFI in the preventive measures.

We established that a number of asthmatic families had applied preventive measures already. We also showed that most measures were not applied as a consequence of specific professional advice but most probably on the family's own initiative. Some (mite-reducing) measures, such as having a smooth (tiled) floor, may not have been planned but already existed in the houses before the family moved in.

We were able to ascertain to what extent applied sanitation measures were effective in reducing allergen levels. Allergens in the floor dust were reduced, in two thirds of the cases, when there was a smooth floor covering in the living room, as others have reported.^{8,9} We found no reduction of allergens in the mattress dust in bedrooms with a smooth floor, which disagrees with other studies.¹⁰ In addition, a daily cleaning of the house floors resulted in low levels of mite and cat allergens in living room floor dust samples, in conformity with other reports.^{10,11} If floors were cleaned daily, we found lower levels of cat allergens but not lower levels of mite allergens

Table 3. Relationship between Applied Sanitation Measures to Reduce Exposure to Allergens in the Living Room of High-Risk Families and the Resulting Levels of Der p 1, Fel d 1, and Can f 1*

Applied measure	Median (IQR) levels of allergens in living room, ng/g					
	Der p 1	P value§	Fel d 1	P value§	Can f 1	P value§
Smooth floor covering†						
Yes (n = 79)	56.0 (153.5)	<.001	448 (1,125.0)	.03	198.5 (1,005.0)	.009
No (n = 131)	427 (106,831.0)		556.0 (1,166.5)		310.0 (1,790.0)	
Daily cleaning‡						
Yes (n = 56)	43.8 (229.9)	<.001	259.5 (701.9)	.002	357.5 (11,252.5)	.07
No (n = 129)	99.7 (519.2)		565.0 (1,299.3)		242.5 (995.6)	

* Levels of Der p 1, Fel d 1, and Can f 1 are measured as the mean of prenatal and postnatal levels in settled dust of the living room and parental and baby mattresses.

† Smooth floor covering included polished wood, vinyl, or tiled floor covering.

‡ Daily cleaning of floors by vacuuming or damp mop.

§ Mann-Whitney U test.

Table 4. Relationship between Applied Sanitation Measures to Reduce Exposure in Bedrooms of High-Risk Families to Allergens of the House Dust Mite, Cat, and Dog and the Resulting Levels of Der p 1, Fel d 1, and Can f 1*

Applied Measure	Median (IQR) levels of allergens on mattresses of infants and parents, ng/g					
	Der p 1	P value§	Fel d 1	P value§	Can f 1	P value§
Smooth floor covering†						
Yes (n = 110)	511.3 (1,873.9)	.30	506.3 (1,893.3)	.90	254.5 (938.3)	.60
No (n = 97)	941.0 (3,132.4)		503.3 (1,572.7)		212.8 (1,311.9)	
Daily cleaning‡						
Yes (n = 56)	486.7 (2,450.0)	.50	308 (830.5)	.03	183.3 (719.7)	.002
No (n = 129)	600.0 (2,883.8)		496.3 (1,710.1)		422.5 (5,770.0)	
Anti-house dust mite encasings on parental and crib mattresses						
Yes (n = 42)	412.3 (1,890.6)	.40	594.0 (3,724.7)	.50	163.8 (319.6)	.10
No (n = 146)	648.2 (2,785.8)		457.7 (1,003.1)		265.0 (1,455.6)	

* Levels of Der p 1, Fel d 1, and Can f 1 are measured as the mean of prenatal and postnatal levels in settled dust of living room and parental and infant mattresses.

† Smooth floor covering included polished wood, vinyl, or tiled floor covering.

‡ Every day cleaning by vacuuming or damp mop.

§ Mann-Whitney U test.

in mattress dust samples. Surprisingly, we found higher levels of dog allergens in dust samples of both the living room and the mattresses when the house floors were cleaned daily compared with when they were not. We do not have an explanation for this.

When mattresses were encased, however, we did not find significantly lower allergen levels compared with mattresses that were not encased. One explanation for this might be that half of the used encasings did not have approved antimite protection and therefore were not approved by the Dutch Asthma Foundation.

As others have found,^{12,13} houses with pets contain much higher pet-specific allergens in floor and mattress dust than houses without pets.

Allergens of the mite were detectable in nearly all houses, and allergens of both cat and dog were detectable in all the houses. Exposure above the supposed threshold of sensitization for mite allergens¹⁴ occurred in one third of the cases. For cat and dog allergens, this was the case in approximately 1 in 5 cases.

RFI in Measures to Reduce Exposure to Mite and Pet Allergens

We found considerable RFI in sanitation measures, which were applied independently of family history, family size, or education. However, we expect the largest reducing effect to be caused by the advice to use encasings, especially because mite levels were much higher on mattresses than on living room floors and encasings are efficacious in reducing these levels.¹⁵ The RFI in encasing the crib mattresses was substantial. However, we should realize that the RFI may differ from country to country. In the United States, for instance, nearly all new crib mattresses are manufactured with plastic encasings. The RFI is also large when it comes to encasing the parental mattress. The advice to use encasings seems far more feasible to execute than having smooth floors or cleaning daily. Therefore, the use of encasings seems the most efficient measure to reduce overall exposure to mite allergens.

With regard to disposing of pets, it seems unlikely that families will get rid of their pet(s). The feasibility and effec-

Table 5. Relationship between Presence of Pets in Asthmatic Families and the Resulting Levels of Fel d 1 and Can f 1*

Pets	Median (IQR), ng/g			
	Dust from living room		Dust from infant and parent mattresses	
	Fel d 1	Can f 1	Fel d 1	Can f 1
None (n = 122)	451 (623.4)†	307.9 (280.0)†	345.3 (851.1)†	147.9 (278.8)†
Dog (n = 41)	182.5 (381.8)	51,102.5 (87,020.0)	341.7 (435.4)	7,191.3 (17,937.2)
Cat (n = 26)	63,180.0 (145,698.0)	108.0 (145.3)	74,125.2 (173,245.7)	133.3 (250.0)
Both (n = 5)	4,994.3 (12,200.6)	65,930.0 (98,727.5)	9,895.5 (26,322.9)	12,965.0 (52,311.0)

* Levels of Fel d 1 and Can f 1 are measured as the mean of prenatal and postnatal levels in settled dust of living room and parental and infant mattresses, respectively. Pet categories are mutually exclusive.

† $P < .001$ (statistic test of levels in the 4 categories: Kruskal-Wallis test).

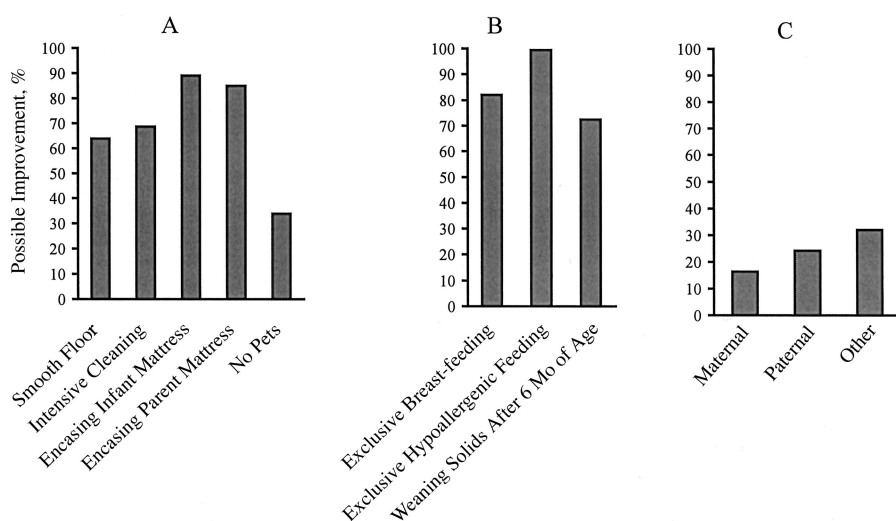


Figure 2. The room for improvement by asthmatic families in preventive measures to reduce exposure to house dust mite and pets (A), food allergens (B), and passive smoking (C).

tiveness of alternatives, such as keeping pets outside and/or washing them, have yet to be established. We found that families who used mattress encasings had significantly fewer pets and more often had smooth floors. This finding suggests that some asthmatic families are inclined to a more comprehensive preventive approach as they take sanitation measures to reduce exposure to both mite and pet allergens.

Because the general public may have been aware of the ongoing discussion about the suggested protective effect of owning pets on asthma,^{16,17} some asthmatic families may have bought a pet instead of disposed of their pet. Only recently, however, reports have shown that allergic families do not have more pets than nonallergic families.^{13,18} Furthermore, the Dutch Guidelines for Asthma¹⁹ advise pet-keeping allergic asthma patients to dispose of their pets.

RFI in Reduction of Food Allergens

As reported by others,²⁰ a high proportion of children in this study were exposed to cow's milk and solid foods before the age of 6 months. Women who formula feed their infants are also more likely to introduce solid foods early,²¹ and this relation is an additional argument to stimulate breast-feeding. We demonstrated that there was much RFI in avoiding food allergens: by promoting breast-feeding only and/or hypoallergenic formula feeding and by postponing the introduction of the first weaning solids until after 6 months of life. We expect, however, that parents will comply with the latter 2 measures because these measures seem more feasible compared with the advice to breast-feed exclusively during the first 6 months of life. Special attention has to be paid to mothers with a lower education, because we found that they breast-fed their infants less often than mothers with a higher education.

Despite the lack of evidence regarding a beneficial effect of hypoallergenic formula on asthma,⁵ we studied the RFI in the preventive advice to give hypoallergenic milk instead of

regular formula in case breast-feeding is stopped or supplementary milk feeding is needed. However, since asthma is a multifactorial disease and is related to exposure to food, mite, and pet allergens and passive smoking, avoidance of only a single exposure might be marginally or not effective when other exposures still exist.^{1,10} On the contrary, a *simultaneous* avoidance of the relevant environmental exposures in high-risk cases might be effective. The combined effect of these 4 environmental reduction measures will be investigated in another part of the PREVASC study.

RFI in Reduction of Passive Smoking

Like others, we found that approximately 1 in 4 infants was prenatally and postnatally exposed to smoke from maternal and/or paternal smoking.²² Smoking mothers more often had smoking partners. No relation was found between low education and smoking behavior. Other researchers, however, found such a relation.²³ Whether relatively successful smoking cessation programs also are successful in reducing passive smoking in asthmatic families expecting a child has still to be proved. A considerable proportion of the infants (30%) were regularly exposed to smoke from people other than the parents, which also should be a subject for improvement.

In our cohort, smoking mothers were underrepresented and therefore the (theoretical) RFI concerning smoking might be larger than reported herein. The participating families all had a higher education. As a result, this may lead to an underestimation of the real RFI for breast-feeding in the population at risk, whereas we found that mothers with a higher education breast-fed their infants more frequently than mothers with a lower education.

Ideally, estimation of the size of exposure has to be objectified by measuring the level of the irritant of interest. We were able to do that for exposure to mite and pet allergens.

For food allergens and smoking, we used "proxy" measures, with the possible disadvantage of inaccuracy. For food allergens, we used self-report of the kind of feeding given to the infant because objective measures are lacking. For smoking, cotinine, a metabolite product of nicotine in the urine or blood, would be more suitable for measuring the actual exposure to smoke. However, for prenatal smoking, this method is not feasible. Furthermore, parent-reported smoking correlates well with cotinine values in the infant and is a reliable method of measuring the burden of passive smoking.²⁴

Recall bias must be considered, because some data on applied measures were sampled by questionnaires when the infant was 1 year old. However, this seems unlikely for obvious issues such as presence of pets, daily cleaning, use of mattress encasings, and passive smoking. Reporting bias is also possible because parents, asked for their actual behavior of exposure reduction, might give socially desirable answers. This holds true especially for smoking and may lead to an underestimation of the exposure to passive smoking in the population at risk.

For the sake of clearness, our figures on RFI only concern the theoretical potential for preventive advice to reduce environmental exposures. Whether the preventive advice will be adhered to by asthmatic families, will be effective in reducing exposures, and will prevent asthma is yet to be established in long-term follow-up intervention studies.

In summary, there appears to be much RFI in the avoidance behavior of asthmatic families. Most RFI exists in the reduction of inhalant allergens by use of anti-house dust mite encasings for parent (and infant) mattresses and in the reduction of exposure to food allergens by stimulating breast-feeding during the first 6 months of the infant's life and/or hypoallergenic formula feeding and by postponing the first solids until 6 months after birth. A modest RFI exists in the reduction of exposure to pet allergens by disposing of pets or keeping them outside the house. A modest RFI also exists in the reduction of nonparental passive smoking. Less RFI is available for reduction of passive smoking by parents. The data presented herein should aid physicians in determining the effectiveness and efficiency of primary prevention programs for asthma that focus on reducing environmental exposures.

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