

Original article

Meta-analysis of determinants for pet ownership in 12 European birth cohorts on asthma and allergies: a GA²LEN initiative

Background: Studies on pet ownership as a risk or protective factor for asthma and allergy show inconsistent results. This may be on account of insufficient adjustment of confounding factors.

Aim: The objective of this study was to describe determinants of cat and dog ownership in European families with and without allergies.

Methods: Within the EU-funded network of excellence GA²LEN, we performed meta-analyses with data from 12 ongoing European birth cohort studies on asthma and allergy. Each of the birth cohort studies enrolled between 485 and 4089 children. Pet ownership, allergic status (asthma, allergic rhinitis, eczema) of parents and siblings, parental education, access to ground floor, and number of people living at home were assessed by questionnaires.

Results: Among the 25 056 families from seven European countries cats (14.9%) were more common than dogs (12.0%). Allergic family history significantly reduced the odds to own a cat (adjusted combined random-effect OR 0.91; 95% CI 0.85–0.99), or dog (0.90; 0.86–0.94). A higher parental educational level had even more pronounced effects on cat (0.84; 0.71–0.98), and dog ownership (0.61; 0.54–0.70). Elder siblings reduced the odds to own cats, but not dogs. Convenient ground access significantly increased the odds, whereas crowding at home was not associated with cat or dog ownership.

Conclusions: The chances to own a cat or dog were significantly reduced in allergic families, in parents with a higher educational level, and in homes without convenient ground access. In addition to parental allergies, social and housing factors should be considered as potential confounders in studies on pet exposure and allergic diseases.

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The role of pet exposure, especially from cats and dogs, as a risk or protective factor in the development of allergic diseases in children is controversial. Birth cohort (1–5) and cross-sectional studies (6, 7) found that early cat exposure was positively associated with allergic sensitization to cat, whereas other authors reported that early cat exposure was protective for sensitization to cat (8–10) and other allergens (9, 11). Sensitization to cat allergen on account of early cat exposure was in some studies (4, 12) associated with symptoms, especially asthma, but not in others (1, 3, 13). Hesselmar et al. (1999) (8) found a negative association between cat exposure and asthma and eczema. Early dog exposure did not seem to cause specific sensitization to dog (1), but was found to reduce sensitization to other inhalant allergens (1, 9, 14), and to protect children against eczema, asthma and allergic rhinitis (8, 15). The reason for cat exposure being more controversial than dog exposure appears to be the smaller size and more ubiquitous nature of the cat Fel d1 allergen (16).

Health-related benefits from pet exposure may be explained by the different pattern of pet ownership between allergic and non-allergic families. Children with an allergic predisposition could have a reduced exposure to pets compared with children without such predisposition (17). Allergic parents may actively avoid pets, whereas non-allergic families keep or even acquire pets, when they have children (18). A negative association between pet exposure and development of allergy would therefore not be on account of protective effects of pets, but rather to avoidance behaviour (19) in high-risk groups.

However, the pattern of pet ownership is influenced by many additional factors other than parental allergies. Family-dependent factors such as parents' own experience with pets, family size, parental age, socio-economic status and house-dependent factors such as house type,

size, access to ground floor, and neighbourhood could influence the pet-keeping (20). Some of these factors might also play an independent role in development of allergic symptoms and sensitization (21, 22).

Therefore, the aim of the present study was to describe patterns of pet ownership in European families with and without allergies. Furthermore, determinants and possible geographical differences for pet ownership in Europe will be investigated.

Methods

Birth cohort characteristics

Previous reports of this work-group (23) have shown that data from selected European birth cohorts on asthma and allergies were available to describe pet ownership. All 12 included studies are observational population-based birth cohorts collaborating within the GA²LEN Work Package 1.5 'Birth Cohorts'. Most study recruitment areas were urban, only PIAMA-NHS, KOALA (The Netherlands), GINI-B (Germany), and AMICS-Menorca (Spain) included also children from mixed urban/rural or rural background. The cohorts started between 1990 and 2004 and included between 485 and 4089 newborns (Table 1). Most were single-centre studies, except the three German birth cohorts (MAS, LISA, and GINI-B) and the Dutch PIAMA-NHS (24). Nine of the 12 cohorts were unselected cohorts, whereas three birth cohorts may be considered as deriched (GINI-B and PIAMA-NHS) or enriched (MAS) with respect to the parental allergy status. All participating birth cohorts obtained ethical approval from their local review boards.

Definition of pet ownership

Each birth cohort study evolved its own questionnaire specifically designed for the aims of the cohort. The most common single pets in Europe were cats and dogs; therefore, we focussed in the present analyses on these two animals. To assess pet ownership at birth of

the child participating in the study, we looked at the available 'raw' variables on cats and dogs at baseline (either assessed during pregnancy or soon after birth) in all included studies. The available information on cats and dogs was assessed in a similar way across the cohorts; however, most studies did not differentiate between in- and outdoor pet-keeping or whether the animals were kept in the house or e.g. in the barn (in the four studies with study populations from mixed urban/rural background). Therefore, we assessed pet-keeping irrespective of where the pets were kept. Each study's principal investigator had to confirm that all relevant variables were selected from the respective study.

Definition of allergic diseases and social determinants

Allergy was defined for mother, father and siblings as self-reported lifetime asthma, allergic rhinitis, and/or (atopic) eczema. Nine birth cohorts also assessed self-reported pet-related allergy in the parents or siblings.

As a proxy of the socio-economic status of the families, we used the educational level of the parents (longest duration of school years spent by either the mother or father). For each study, the duration of the parental education were categorized into tertiles as high, medium, and low educational level.

Information of the housing conditions including ground access and crowding in the home was available in 9 and 8 cohorts respectively. Easy ground access was defined as living on ground level or first floor compared with inconvenient ground access (living higher than first floor). Crowding at home was defined as the number of people per square meter or per room of the flat/house, and was categorized into quintiles for each cohort to allow comparison.

Statistics

Logistic regression was used to calculate crude odds ratios (OR) to estimate the effect of allergy status of parents and siblings, educational level, ground access, crowding and siblings on cat and dog ownership for each cohort separately. Adjusted ORs were calculated for the factors mentioned above, adjusted for the other available factors for each cohort separately using multiple logistic regression. On account of the heterogeneity between the cohorts, meta-analyses with adjusted combined random-effect ORs were calculated ('combined effect'). Heterogeneity between the included studies was tested using the Chi-squared test for heterogeneity with

the Review Manager Version 4.3 (The Nordic Cochrane Centre, Copenhagen, Denmark). Logistic regression analyses were performed using SAS version 9.1 (SAS Institute, Cary, NC, USA) on a Microsoft Windows 2000 operating system. For the graphs, we used Sigmaplot version 10 (Systat Software, Inc., San Jose, CA, USA). In all analyses, a statistical significance level of 0.05 was applied.

Results

Frequency of pet ownership

At the time of the children's birth cat ownership ranged from 7.2% to 35.0% (average 14.9%), and for dog ownership from 5.4% to 35.0% (average 12.0%) across the 12 European birth cohorts with a total of 25 056 children. The Netherlands had the largest proportion of cat owners, whereas dog owners were most common on the Spanish island of Menorca (Table 1).

Pet ownership and allergic family history

Allergy of parents significantly reduced the odds of owning a cat (OR 0.90; 95% CI 0.84–0.98) or a dog (0.89; 0.84–0.95). There was significant heterogeneity between the studies for both cat ($P < 0.01$) and dog ownership ($P = 0.04$). The highest effect estimates of parental allergy on cats were found in the Swedish and the Danish cohorts, whereas for dogs in the three German cohorts (Fig. 1A, B).

The effect was stronger if both the parents were concurrently allergic compared with only one (vs no allergic parents) for cat ownership (0.56; 0.49–0.64, and 0.79; 0.73–0.85), and, less pronounced, for dog ownership (0.75; 0.65–0.87, and 0.83; 0.73–0.91). Allergic mothers had a stronger effect compared with allergic fathers on cat ownership (0.70; 0.69–0.77, and 0.78; 0.72–0.85), as well as on dog ownership (0.79; 0.72–0.87, and 0.90; 0.83–0.99). There was no relevant difference between parental asthma and allergic rhinitis separately or combined on either cat or dog ownership (data not shown).

Table 1. Birth cohort acronym, study setting, year of recruitment, number of children, and cat and dog ownership in 12 European birth cohorts

Birth cohort acronym	City/country	First year of recruitment	Children recruited (n)	Cat ownership		Dog ownership	
				%	n	%	n
ECA	Oslo/Norway	1992	3754	7.5	282	9.2	344
BAMSE	Stockholm/Sweden	1994	4089	9.9	405	5.4	221
DARC	Odense/Denmark	1998	562	18.8	105	15.3	85
MAS	Multicentre/Germany	1990	1314	14.0	161	8.4	97
LISA	Multicentre/Germany	1997	3097	10.9	318	8.5	250
GINI-B	Multicentre/Germany	1996	3739	7.2	196	7.8	218
KOALA	Maastricht/The Netherlands	2001	2834	23.0	653	22.4	634
PIAMA-NHS	Multicentre/The Netherlands	1996	3291	35.0	1151	17.0	558
CO.N.ER	Bologna/Italy	2004	654	20.0	129	20.0	129
GEPSII	Rome/Italy	2004	704	10.5	74	13.6	96
AMICS-B	Barcelona/Spain	1996	487	10.1	49	19.5	94
AMICS-M	Menorca/Spain	1997	485	14.4	69	35.0	167

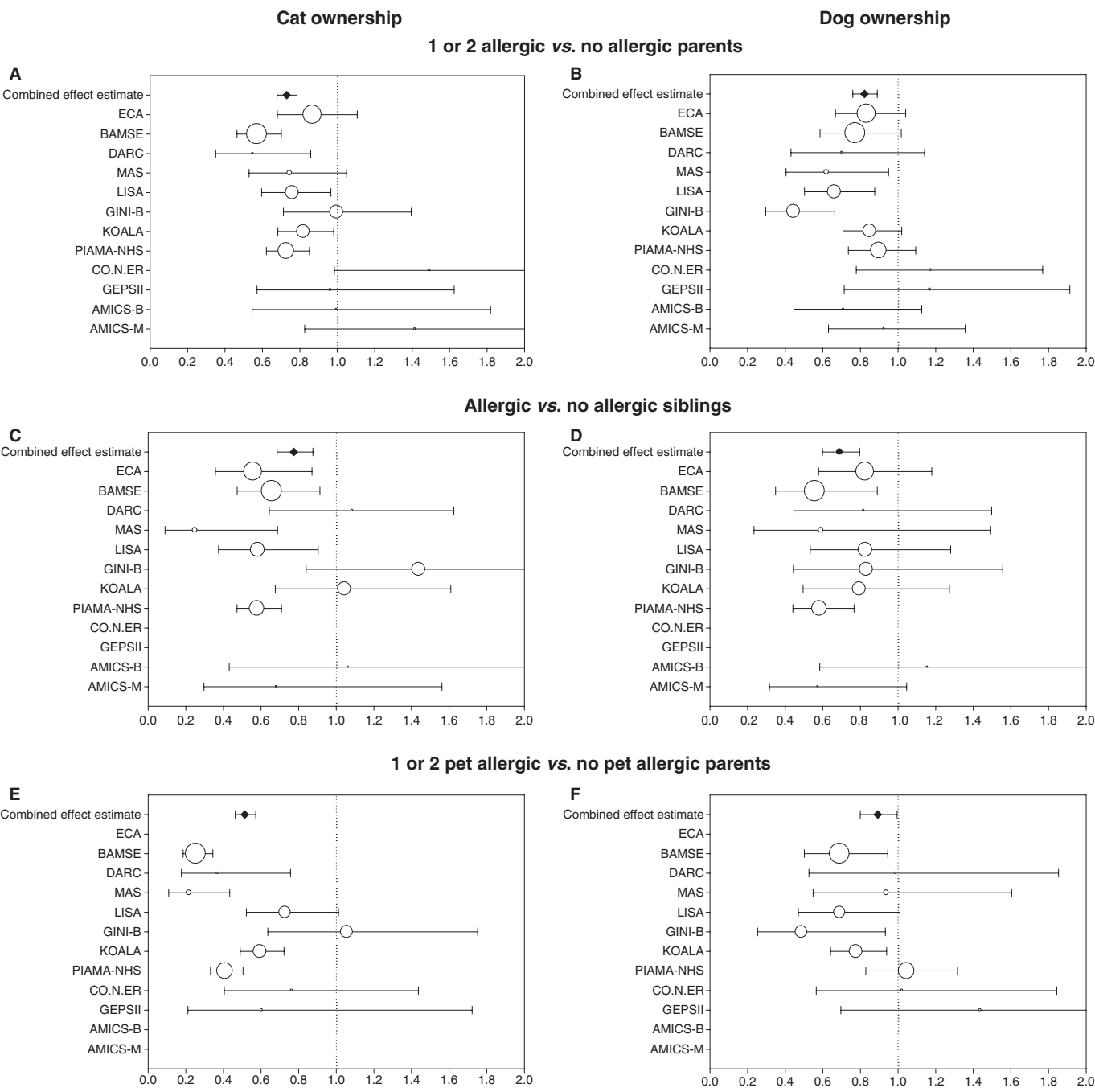


Figure 1. Crude odds ratios and 95% confidence intervals (95% CI) of owning a cat or a dog estimated by meta-analyses (combined effect) and separately for each cohort for parents with allergy (A, B), for siblings with allergy (C, D), and for parents with pet allergy (E, F). For each study, the size of the circle represents the size of the cohort. Studies are listed from northern to southern Europe.

Similarly, allergy of siblings reduced the odds for a family to own a cat (0.86; 0.76–0.96) or a dog (0.84; 0.78–0.90). There were no obvious regional patterns. We found significant heterogeneity between the studies for cat ownership ($P < 0.01$), whereas for dog ownership the cohorts were rather homogeneous ($P = 0.59$) (Fig. 1C, D).

Information on parental pet allergy was only assessed by nine cohorts showing that this factor particularly reduced the odds for cat (0.70; 0.60–0.82), and to a lesser extent for dog ownership (0.91; 0.84–0.99). There were no obvious regional patterns. Significant heterogeneity between the studies was found for cat ($P < 0.01$), but not for dog ownership ($P = 0.14$) (Fig. 1E, F).

Only four cohorts assessed questions on specific pet allergy in siblings showing the same inverse trend as for parental pet allergy.

Pet ownership and social determinants

The odds to own a cat were significantly reduced with a higher educational level (0.84; 0.72–0.97, for the highest vs lowest tertile) and with the presence of siblings (0.91; 0.86–0.97). Having easy ground access, i.e. living at ground level or first floor, slightly increased the odds to own a cat (1.14; 1.04–1.23). However, for all three factors there was significant heterogeneity between the cohorts ($P < 0.01$; 0.02 and 0.03).

More pronounced than for cat ownership, a higher educational level significantly reduced the odds to own a dog (0.62; 0.54–0.70), whereas having easy ground access significantly increased the odds to own a dog (1.34; 1.19–1.51). For both factors, there was significant heterogeneity between the cohorts (both $P < 0.01$). Crowding and siblings did not show relevant effects on dog ownership (data not shown).

Multivariable analyses

After adjustment for all social determinants, allergic family history remained statistically significant to reduce the odds for cat and dog ownership, but only for dog ownership there was homogeneity between the cohorts.

Even more pronounced than family allergy, a higher educational level significantly reduced the odds for cat- and dog ownership; however, for both outcomes there was significant heterogeneity between the cohorts.

Similarly, the increased odds for cat- and dog ownership with easy ground access remained significant after adjustment, as well as the heterogeneity between the cohorts.

With siblings we found a significant reduction for cat, but not for dog ownership, whereas crowding had no significant effects in the overall estimates. However, comparing high vs low crowding in the separate studies, there was a significant reduction of 70% for dog ownership in the Norwegian cohort ECA, and 35% for cat ownership in the Dutch cohort PIAMA-NHS (Table 2).

A family history of pet allergy, adjusted for parental education, ground access and crowding, significantly reduced the odds to own a cat (0.72; 0.61–0.84), similarly as the unadjusted analysis. For dog ownership, the effect was no longer statistically significant after adjustment. For both cat ($P < 0.001$) and dog ownership ($P = 0.03$), there was significant heterogeneity between the cohorts (data not shown).

Sensitivity analyses

We performed sensitivity analyses including only the nine unselected birth cohorts leading to similar effect estimates for family allergy and all social determinants regarding

both cat- and dog ownership as in the meta-analyses of all 12 birth cohorts (data not shown).

Discussion

Our main findings were that a family history of allergy, a high educational level, and inconvenient ground access reduced the odds to own a cat, and, to a greater extent to own a dog. Furthermore, siblings reduced the odds for cat, but not dog ownership. Except for the effect of a family history of allergy on cat ownership, there was significant heterogeneity between the studies regarding the other determinants.

There was regional variation in pet ownership and in effects of influential factors across the European birth cohorts, but no clear regional patterns could be detected.

The assessment methods between the 12 European birth cohort studies were not standardized; however, the available data on pet ownership and family history of allergy were rather similar. This allowed defining of common variables for meta-analyses. Data of social determinants such as educational level and crowding at home were assessed in a more heterogeneous way. Therefore, for these two variables we decided to use tertiles and quintiles to allow comparison between the studies.

Frequency of pet ownership

The only similar study on the frequency of pet ownership on a European level with a comparable age group of the parents, is the European Community Respiratory Health Survey (ECRHS) with 18 500 subjects aged 20–44 years (20). The frequency of cat ownership ranged from 8% to 29% and dog ownership from 6% to 32% in the participating 13 European countries, which was in line with our findings. Two Scandinavian studies (ECA, Norway, and BAMSE, Sweden) showed a lower frequency for cats, dogs and birds than reported in the ECRHS. This could be on account of the fact that the ECRHS was conducted in smaller cities in Norway and Sweden whereas the two birth cohorts (ECA and BAMSE) recruited their families in the capitals with a higher proportion of apartment buildings than separate individual houses.

Determinants of pet ownership

Cross-sectional studies (19, 25, 26) and one longitudinal study (18) have shown that families with a history of allergy seemed to avoid pets in their homes. The results from our birth cohort analyses, after adjusting for a variety of social and housing factors confirmed this. Almquist et al. (2003) previously showed for the Swedish BAMSE cohort, that maternal allergy is more decisive than paternal allergy (18). We found the same effect in the other birth cohorts as well.

Table 2. Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) of owning a cat or a dog for family allergy and social determinants estimated by random effect meta-analyses (combined effect) and separately by each cohort

	Family allergy (allergic vs no allergic parent or sibling), adj. OR (95% CI)	Parental education (highest vs lowest tertile), adj. OR (95% CI)	Convenient ground access (floor level 1–2 vs >2), adj. OR (95% CI)	Crowding (highest vs lowest quintile), adj. OR (95% CI)	Siblings (yes vs no), adj. OR (95% CI)
<i>Cat ownership</i>					
Combined effect	0.91 (0.85, 0.99)	0.84 (0.71, 0.98)	1.15 (1.05, 1.25)	0.92 (0.83, 1.03)	0.92 (0.86, 0.99)
Test for heterogeneity	$P < 0.01$	$P < 0.01$	$P = 0.04$	$P = 0.55$	$P = 0.07$
<i>Birth cohort</i>					
ECA	0.82 (0.64, 1.05)	0.81 (0.51, 1.30)	1.77 (1.34, 2.34)	1.08 (0.66, 1.77)	0.58 (0.43, 0.79)
BAMSE	0.55 (0.45, 0.68)	0.52 (0.40, 0.68)	1.43 (1.14, 1.80)	0.73 (0.52, 1.02)	0.95 (0.76, 1.18)
DARC	0.61 (0.37, 0.99)	1.08 (0.46, 2.52)	2.87 (1.23, 6.69)	n.a.	0.83 (0.52, 1.34)
MAS	0.91 (0.60, 1.38)	0.50 (0.30, 0.84)	0.81 (0.52, 1.25)	0.87 (0.45, 1.68)	0.67 (0.43, 1.05)
LISA	0.83 (0.65, 1.07)	0.25 (0.16, 0.40)	1.18 (0.89, 1.56)	0.73 (0.49, 1.09)	0.82 (0.62, 1.07)
GINI-B	1.12 (0.81, 1.57)	0.69 (0.44, 1.10)	1.34 (0.87, 2.05)	0.86 (0.53, 1.40)	0.71 (0.52, 0.98)
KOALA	0.81 (0.67, 0.98)	1.15 (0.84, 1.58)	n.a.	n.a.	1.11 (0.87, 1.43)
PIAMA-NHS	0.73 (0.62, 0.85)	0.72 (0.56, 0.91)	1.17 (0.91, 1.50)	0.65 (0.46, 0.93)	0.89 (0.70, 1.12)
CO.N.ER	1.44 (0.92, 2.27)	0.44 (0.22, 0.89)	1.02 (0.62, 1.69)	1.18 (0.54, 2.59)	0.80 (0.46, 1.38)
GEPSII	0.97 (0.57, 1.65)	1.71 (0.57, 5.16)	1.60 (0.89, 2.88)	0.59 (0.19, 1.88)	0.69 (0.33, 1.44)
AMICS-B	0.80 (0.42, 1.52)	0.72 (0.31, 1.68)	n.a.	n.a.	1.66 (0.88, 3.15)
AMICS-M	1.39 (0.79, 2.43)	1.35 (0.73, 2.50)	n.a.	n.a.	0.99 (0.59, 1.65)
<i>Dog ownership</i>					
Combined effect	0.90 (0.86, 0.94)	0.61 (0.54, 0.70)	1.27 (1.14, 1.43)	0.99 (0.84, 1.16)	0.96 (0.91, 1.01)
Test for heterogeneity	$P = 0.66$	$P < 0.01$	$P = 0.01$	$P = 0.13$	$P = 0.87$
<i>Birth cohort</i>					
ECA	0.81 (0.64, 1.02)	0.42 (0.28, 0.65)	1.73 (1.33, 2.26)	0.30 (0.18, 0.51)	1.08 (0.83, 1.42)
BAMSE	0.76 (0.58, 1.01)	0.28 (0.20, 0.40)	1.34 (0.99, 1.82)	0.90 (0.57, 1.43)	0.83 (0.62, 1.12)
DARC	0.73 (0.43, 1.24)	0.35 (0.10, 1.19)	4.13 (1.42, 12.0)	n.a.	0.69 (0.42, 1.16)
MAS	0.56 (0.33, 0.94)	0.35 (0.18, 0.65)	0.99 (0.57, 1.75)	0.82 (0.36, 1.86)	0.99 (0.57, 1.71)
LISA	0.75 (0.56, 0.99)	0.44 (0.24, 0.79)	1.41 (1.01, 1.96)	0.66 (0.43, 1.01)	0.97 (0.72, 1.30)
GINI-B	0.60 (0.41, 0.87)	0.52 (0.34, 0.78)	3.22 (1.83, 5.67)	0.90 (0.58, 1.39)	0.87 (0.64, 1.18)
KOALA	0.84 (0.69, 1.02)	0.43 (0.33, 0.56)	n.a.	n.a.	1.10 (0.85, 1.41)
PIAMA-NHS	0.88 (0.71, 1.08)	0.26 (0.20, 0.35)	1.30 (0.94, 1.81)	0.87 (0.55, 1.36)	0.85 (0.63, 1.14)
CO.N.ER	1.02 (0.65, 1.59)	0.58 (0.28, 1.20)	1.20 (0.72, 2.00)	1.21 (0.55, 2.63)	0.87 (0.51, 1.48)
GEPSII	1.11 (0.67, 1.85)	0.25 (0.12, 0.55)	3.11 (1.60, 6.07)	0.94 (0.36, 2.48)	0.74 (0.39, 1.41)
AMICS-B	0.73 (0.43, 1.22)	0.53 (0.26, 1.09)	n.a.	n.a.	0.83 (0.50, 1.39)
AMICS-M	0.84 (0.57, 1.25)	0.84 (0.52, 1.35)	n.a.	n.a.	0.96 (0.66, 1.42)

n.a., not assessed. Each determinant has been adjusted for the four other factors. P -values from heterogeneity tests are presented for each determinant.

All birth cohorts were population-based studies; however, three cohorts in the present meta-analyses may not be considered completely unselected on the basis of parental allergy status. Although we adjusted in our analyses for parental allergy status, we also performed a sensitivity analysis with the unselected cohorts to address this issue. The effect estimates were very similar to the main meta-analyses including all 12 birth cohorts.

A higher socio-economic status was associated with reduced likelihood of cat- and dog ownership in Sweden (18). We chose parental educational level as a proxy for socio-economic status, even though comparability of educational level between countries seems difficult (27). Our findings indicated that a low educational level was associated with a higher chance to own dogs, or cats. One explanation may be that parents with a higher social status are more likely to follow recommendations

by their physicians regarding the potential risk of pet exposure for their children. In 1995, the Swedish Paediatric Society advised allergic parents to avoid furry pets in the first year of the newborn. However, such recommendation seems unlikely to have influenced the results of the present study analyzing only the cohort baseline data at time of birth.

Elder siblings reduced the odds of having cats, but not of having dogs. Cats may be kept rather by couples before the first child is born, and may be considered less convenient with young children in the home, or have been removed during the pregnancy to prevent congenital toxoplasmosis by cat contact. Having more than one sibling in general resulted in an increased probability of dog ownership. This could be a question of families maturing, resulting in an exchange of the flat to a house, and children reaching an age where parents consider a dog as an adequate pet.

Strengths and weaknesses

Along with several strengths of this study such as the European scale and big sample size, this approach has also some weaknesses.

The oldest of the included cohort studies started in 1990 (MAS, Germany) which leaves a gap of 14 years to the youngest cohorts. We do not know whether the frequency of pet ownership has changed in the last two decades in Europe. If awareness of assumed primary preventive measures, such as pet avoidance, increased over time, in line with recommendations, a stronger avoidance should be found in our young cohorts. On the other hand, if the recent debate of protective effects of pets had an effect, one could expect a higher frequency in the younger cohorts.

The representativeness of some of the birth cohorts may pose limitations as not all children who were born during the defined time period were eligible for recruitment. Some newborns were excluded on account of predefined criteria e.g. severe illness; intensive care unit; <37 pregnancy weeks; very small for gestational age (<3rd percentile of body weight and height); or lack of sufficient communication and language skills of the parents. Most cohorts estimated the study participation in the range from 51% to 75% of all eligible children; however, the recruitment procedures also varied between the cohorts on account of different circumstances of delivery practices, e.g. in the Netherlands most children are born at home which made it more difficult to get accurate assessments of the proportion of eligible children compared with a birth cohort completely recruited from a hospital.

Furthermore, ethnic minorities were not represented in sufficient numbers in the European birth cohorts included in the present analyses to evaluate ethnic differences on determinants of cat- and dog ownership.

Avoidance is an active act, where parents give up their pet or deliberately do not acquire one. Only the two Dutch cohorts asked specific questions concerning avoidance of pets; for the remaining cohorts, a lowered prevalence of pet ownership in allergic families could be

interpreted as an indication of pet avoidance. In the PIAMA-NHS cohort, 53% of all families with two allergic parents, reported not to have a cat on account of allergy in the family (28). This is in line with our overall findings showing a negative association between family allergy and cat ownership which can be interpreted as pet avoidance behaviour.

Conclusions

The frequency of pet ownership varies in European birth cohorts without showing clear regional patterns.

The chances to own a cat, or a dog were significantly reduced if there were allergies in the family, and, even more pronounced by a higher educational level and inconvenient ground access. The presence of siblings reduced the chance for cat-, but not dog ownership.

In order to analyze and interpret the influence of pet exposure on allergies and asthma, this study showed that in addition to a family history of allergy there are relevant social and housing factors that need to be taken into consideration as potential confounders.

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