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Parental education and children's respiratory and allergic symptoms in the Pollution and the Young (PATY) study

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ABSTRACT: Inequalities in health between socio-economic groups are a major public health concern. The current authors studied associations between parental socio-economic status (SES) and children's respiratory and allergic symptoms in 13 diverse countries, including the Russian Federation, North America (Canada and the USA), and countries across Eastern and Western Europe.

Data of 57,000 children aged 6–12 yrs, originating from eight cross-sectional studies, were analysed. SES was defined by parental education. Respiratory and allergic symptoms were defined by parental questionnaire reports.

Multiple logistic regressions showed that low parental education was associated with a decreased risk of inhalant allergy and itchy rash in school children. Furthermore, low parental education was associated with an increased prevalence of wheeze and nocturnal dry cough. No clear association was found between parental education and prevalence of doctor-diagnosed asthma and bronchitis. Part of the difference between socio-economic groups with regard to their children's symptoms was explained by established risk factors, such as parental allergy, smoking during pregnancy, pet ownership, crowding, mould/moisture in the home, use of gas for cooking, and air pollution (particulate matter with a diameter of <10 μm). However, differences remained after adjusting for these variables.

Children's health was associated with parental education. The association could not fully be explained by established risk factors.

KEYWORDS: Allergy, asthma, education, respiratory symptoms, socio-economic status

Inequalities in health between socio-economic groups are a major public health concern. Numerous epidemiological studies have found higher rates of mortality and morbidity among groups with a lower socio-economic status (SES) defined by education, income or occupation within countries and across countries [1–8]. Social inequalities in health are not confined to poor health among the most deprived. MARMOT and coworkers [9, 10] reported increasing mortality and morbidity with decreasing SES for British civil servants, not considered to be poor by any usual standard.

Allergies seem to be one of the exceptions with regard to their association with SES. A number of studies performed in industrialised Western countries reported decreased prevalence of eczema [11, 12], hay fever [11, 13], and atopy determined by skin-prick testing and measurements of specific immunoglobulin E [11, 14–16] among children and adults with low SES. The current authors' knowledge about the association between SES and health in populations of the formerly communist countries of Eastern Europe is limited. However, HEINRICH *et al.* [17] and KRÄMER *et al.* [18] reported an increased prevalence of eczema, allergic rhinitis and allergy for children from highly educated parents living in the former East Germany, where differences between social groups with regard to income were relatively small. Asthma which is at least partly attributable to allergy [19] does not follow the same pattern as eczema, hay fever and allergic sensitisation. MIELCK *et al.* [20] reviewed 24 studies on the association between childhood asthma and SES and found that the studies did not reveal a clear picture; positive associations were as frequent as negative ones, and most studies

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showed no association at all. The International Study on Asthma and Allergies in Childhood [21] reported higher prevalence of asthma for urbanised, more ''Westernised'' countries compared with less developed countries.

The mechanisms behind all these (positive and negative) associations between SES and mortality and morbidity are not clear. Differences in susceptibility and differences in exposure were proposed to influence, and to be influenced by, SES and each other [22]. Both exposure and susceptibility may lead to unequal health outcomes, which can then cycle back to affect SES [22]. A number of hypotheses have been proposed as potential partial explanations for between-country and within-country disparities in asthma prevalence including differences in ''hygiene'', diet, cigarette smoking, traffic pollution, antenatal exposures, and physical activity/obesity, but their significance for explaining between-region or between-country disparities in asthma prevalence is uncertain [23]. Within the European Union-funded Pollution and the Young (PATY) project a unique database was established, comprising data on 57,000 children aged 6–12 yrs, originating from eight cross-sectional studies performed in the Russian Federation, North America (Canada and the USA), and countries across Eastern and Western Europe. The current authors used this database to: 1) describe the association between SES and children's respiratory and allergic symptoms in these diverse countries; and 2) find out whether known risk factors for respiratory and allergic symptoms do account for differences between socio-economic groups in terms of their children's respiratory and allergic symptoms.

MATERIALS AND METHODS

Study design and study population

The present study was designed as a combined analysis of data collected within the framework of eight cross-sectional studies performed in Europe, North America, and the Russian Federation. Cross-sectional studies were considered which had assessed respiratory symptoms and individual risk factors by questionnaire, included cough and wheeze as primary health outcomes, and allowed the calculation of annual mean particulate matter measures by study area. Table 1 gives an overview of the selected studies. Between two and 29 study areas were defined per country. These study areas were school catchments in some cases and geographic areas in others. Study areas are not necessarily representative for the respective countries. The study population of the present study was defined as the participants of the original studies who were between 6–12 yrs. Thus, data from 57,363 children from 126 study areas in 13 countries were analysed.

Health outcomes

The health outcomes of interest (respiratory and allergic symptoms of wheeze, asthma, bronchitis, nocturnal dry cough, inhalant allergy and itchy rash), collected in the original studies by parental questionnaire, were chosen on the basis of the compatibility of their wordings, their scientific interest and their availability across the studies. However, the wording of the questions used to define a certain symptom/disease was not exactly the same in all studies and some outcome variables are not available for all studies. The exact definition of the wording of the questions used for the definition of outcomes is given in Appendix 1.

Definition of socio-economic status

SES refers to an individual's relative position in the social hierarchy and can be operationalised as level of education, occupation and/or income [32]. In the present study, parental education was used to define parental SES. Parental education was classified according to a standardised scheme developed by the Organization for Economic Cooperation and Development (OECD) into ''none'', ''elementary'', ''secondary, first stage'', ''secondary, second stage'', and ''post-secondary'' as described by KUNST and coworkers [33, 34]. Based on this classification, three categories of low, medium and high parental education were defined at country level, taking frequency distributions into account to make sure that every country/study had a sufficiently large number of subjects with low and high parental education, respectively. The current authors aimed to construct groupings, which were as comparable as possible across the studies, though it was not possible

TABLE 1 Description of the studies (ordered by per capita gross domestic product)

First author [ref.]	Name of study	Country	Year study conducted	Number of areas	Children n	Age yrs
LEONARDI [24]	CESAR	Bulgaria	1996	3 areas in 3 towns	2926	7–12
SPENGLER [25]	10-cities study	The Russian Federation	1999	13 areas in 10 towns	5559	7–12
LEONARDI [24]	CESAR	Slovakia	1996	4 areas in 3 towns	3038	7–12
LEONARDI [24]	CESAR	Hungary	1996	5 areas in 5 towns	3721	7–12
LEONARDI [24]	CESAR	Poland	1996	4 areas in 4 towns	2932	7–12
LEONARDI [24]	CESAR	Czech Republic	1996	4 areas in 1 town	3478	7–12
AGABITI [26]	SIDRIA	Italy	1994–1995	29 areas in 22 towns	9635	6–12
JANSSEN [27]	24-school study	The Netherlands	1996–1997	24 areas in 19 towns	2065	6–12
HEINRICH [28]	Bitterfeld study	Germany	1992–1993	3 areas in 3 towns	2018	6–12
NEUBERGER [29]	Linz study	Austria	1996–1998	8 areas in 1 town	4155	6–11
DOCKERY [30]	24-cities study	Canada	1988–1990	2 areas in 2 towns	1424	6–12
BRAUN-FAHRLANDER [31]	SCARPOL	Switzerland	1992–1993	10 areas in 10 towns	2783	6–12
DOCKERY [30]	24-cities study	USA	1988–1990	21 areas in 21 towns	13629	6–12
Total			1988–1999	126 areas in 104 towns	57363	6–12

TABLE 2 Definition of parental education

Country/Study	Original categories	Parental education
Bulgaria	Primary	Low
	Apprenticeship/secondary	Medium
	Further education or university	High
The Russian Federation	Incomplete secondary/completed secondary	Low
	Completed special secondary-college/incomplete higher education	Medium
	Completed higher education	High
Slovakia, Hungary, Poland, Czech Republic	Primary	Low
	Apprenticeship	Medium
	Secondary/further education or university	High
Italy	No degree/primary school degree	Low
	Junior high degree vocational school degree/high school degree	Medium
	College degree	High
The Netherlands	None/primary school/low vocational education/medium secondary school	Low
	Medium vocational education/high secondary school	Medium
	Higher vocational education/university	High
Germany	<8 yrs of school attendance/8 yrs degree	Low
	10 yrs degree/12 yrs degree/vocational school	Medium
	University	High
Austria	Pflichtschule	Low
	Fachschule/Berufsschule	Medium
	Matura, Hochschule	High
Switzerland	School degree: Primar-, Ober-, Realschule; professional status: none/<2 yrs apprenticeship	Low
	School degree: Primar-, Ober-, Realschule; professional status: 2–4 yrs apprenticeship	Medium
	School degree: Gymnasium, Kantonsschule, Mittelschule, Seminar; professional status: none/⩽4 yrs apprenticeship	
	School degree: any; professional status: Seminar, Technikum, hohere Fachschule/ Hochschulabschluss	High
USA and Canada	Did not complete 8th grade/completed 8th grade	Low
	Completed high school	Medium
	Some college or post-secondary education or training (includes completion of college or graduate work)	High

to do this perfectly. The definition of educational levels is presented in table 2. Mother's and father's educational levels were classified separately, and the maximum educational level achieved by either parent was then used in analyses hypothesising that the parent with the highest educational level is the determining factor for a family's SES.

Definition of explanatory variables

In the current study, variables that might explain potential associations between parental education and children's health have been termed ''explanatory variables''. Potential explanatory variables, such as parental allergy, maternal smoking during pregnancy, breastfeeding, pet-ownership, crowding, mould/moisture in the child's home, and the use of gas for cooking were identified from review articles (*e.g.* VON MUTIUS [35] and STRACHAN [36]) and defined by parental questionnaire reports. Explanatory variables were defined as similarly as possible between countries from the information that was available. However, definitions differ between countries and not all explanatory variables are available for all countries. This might limit to some extent the present authors' ability to explain SES effects by these variables in some countries as well as the comparability of the explanatory variables adjusted SES effects between countries.

Parental allergy was defined as parental asthma in the past 12 months and/or parental eczema/skin or nasal allergy ever for Bulgaria, Czech Republic, Hungary, Poland and Slovakia; for Germany, Italy and Switzerland, it was defined as parental asthma ever and/or parental eczema/skin or nasal allergy ever; for the Netherlands it was defined as parental asthma ever and/or nasal allergy ever; for North America and the Russian Federation it was defined as parental asthma ever; and for Austria it was defined as asthma, skin allergy, nasal allergy or hay fever ever in either parents or sibling(s) of the child. Pet ownership was defined as ''ever had a furry or feathery animal in the home'' for Austria, Bulgaria, Czech Republic, Hungary, Poland, Slovakia, Italy, The Netherlands and Switzerland; as ''current regular contact with furry or feathery animals'' for Germany; and as ''furry/feathery animal currently in the child's home'' for the Russian Federation and North America. Crowding was defined as the number of persons per room >75th percentile for all countries except the Russian Federation, Switzerland and North America; for the Russian

Federation it was defined as the number of persons per m^2 >75th percentile; for Switzerland as ''child shares bedroom''; and for North America as the number of persons per bedroom >75th percentile. Exposure to particulate matter with a diameter of <10 μm (PM_{10}) was assessed by measurements at fixed ambient monitoring sites in the study areas.

Statistical analysis

All analyses were restricted to children with non-missing information on parental education. Information on parental allergy was missing for up to 13% of the countries' study populations. Therefore, ''missing information on parental allergy'' was defined as a separate category to include these participants in the analysis. Country-specific logistic regression analyses were performed to analyse the effect of parental education on children's respiratory and allergic symptoms on the country level. First, adjustments were made for sex and age only. Afterwards, the current authors adjusted for the explanatory variables listed above and study area (as a proxy for explanatory variables on the study area level) and PM_{10}, respectively, to determine if these variables explained potential associations between parental education and children's health. The current authors then compared country-specific and mean sex, and age-adjusted odds ratios for the comparison of low *versus* high parental education with sex, age, study area, and explanatory variables adjusted odds ratios. Mean odds ratios were calculated with a fixed effects approach. In case of heterogeneity ($p<0.10$) mean odds ratios were calculated using the random effects approach described in DERSIMONIAN and LAIRD [37]. Countries are presented ordered by per capita gross domestic product in tables and figures.

For comparability reasons, all associations between symptoms and parental education are presented as odds ratios with 95% confidence intervals (CI) using high parental educational status as the reference category, although prevalence ratios may be more suitable for common outcomes. The present authors are aware of the fact that the odds ratio depends on the underlying prevalence and therefore largely avoided comparisons of odds ratios between countries.

RESULTS

Description of the study population

A description of the study population including parental education is presented in table 3. Frequency distributions of parental education differed considerably between countries. The percentage of low parental education, as defined here, was lowest in Slovakia (3.1%) and highest in the Netherlands (30.5%); the percentage of high parental education was lowest in Germany (13.8%) and highest in the USA (67.8%).

Prevalence of symptoms and diseases

The frequency distributions of the outcome variables are presented in table 4. Wheeze during the past 12 months, asthma and inhalant allergy are available for all countries. The remaining outcomes were available for all countries except two or three. Variability of prevalence between countries differed considerably by outcome.

Parental education and explanatory variables

The associations between parental education and potential explanatory variables are presented in figure 1. Except for the Czech Republic and North America, the prevalence of parental allergy significantly increases with increasing level of parental education. Smoking during pregnancy and crowding were consistently more prevalent among families with a low parental education compared with high parental education. The reverse trend was seen for breastfeeding (except for Bulgaria), *i.e.* breastfeeding was more prevalent among families with a high parental education. Associations between parental education and pet-ownership, mould/moisture and use of gas for cooking were less clear.

Parental education and health outcomes

First, country-specific age and sex adjusted odds ratios for the association between parental education and respiratory and allergic symptoms were calculated (data not shown). Secondly, the current authors adjusted for a set of explanatory variables such as study area (as a proxy for explanatory variables the study area level), parental allergy, smoking during pregnancy, breastfeeding, pet-ownership, crowding, mould/moisture in the child's home, and use of gas for cooking that were associated with parental education and might account for the effect of parental education on children's health. The results are presented in figure 2.

The additional adjustment resulted in a change in odds ratio (related to the age, and sex-adjusted odds ratio) of -25.4–23.3% (median -1.3%) and -69.9–26.7% (median -1.9%) for the comparison of medium *versus* high parental education and low *versus* high parental education, respectively. The absolute change in odds ratio exceeded 10% for 25.3% and 49.3% of the odds ratios, respectively. Statistically significant differences between low and high parental education with regard to the children's health remained statistically significant after additional adjustment although they became generally slightly smaller. SES effects were heterogeneous ($p<0.10$) for all outcomes except inhalant allergy and itchy rash (fig. 2). Fully adjusted odds ratios were not less heterogeneous than minimum adjusted odds ratios.

The risk of wheeze during the past 12 months was found to increase with decreasing parental education in all Eastern European countries (Bulgaria, the Russian Federation, Poland, Hungary, Slovakia, and the Czech Republic) except (East) Germany along with Austria, but not in the remaining Western European countries of Italy, the Netherlands and Switzerland, and North America (fig. 2). The associations between parental education and asthma and bronchitis are less systematic and less clear. Approximately half of the odds ratios for the comparison of low *versus* high parental education are smaller than one, whereas the other half is larger than one. Nocturnal dry cough is more prevalent among children with low parental education. With one exception each, prevalence of inhalant allergies and itchy rash were highest in children with high parental education and lowest in children with low parental education. Mean odds ratios were statistically significant for wheeze, nocturnal dry cough, inhalant allergy, and itchy rash (for itchy rash low *versus* high SES only). Mean odds ratios for hay fever and eczema (available for seven and five countries only, data not shown) were in line with mean odds ratios for inhalant allergy and itchy rash: there was a decreased prevalence of hay fever (mean OR (95% CI): 0.77 (0.49–1.23))

TABLE 3 Description of the study population

	BUL	RUS	POL	HUN	SLO	CZ	I	NL	GER	A	CAN	CH	USA
Parental education information available n	2873	5537	2920	3694	3038	3478	9586	2018	1963	3988	1315	2664	12990
Parental education#													
Low	89 (3.1)	1052 (19.0)	970 (33.2)	1252 (33.9)	596 (19.6)	1335 (38.4)	552 (5.8)	616 (30.5)	144 (7.3)	345 (8.7)	151 (11.5)	212 (8.0)	770 (5.9)
Medium	1698 (59.1)	3140 (56.7)	1428 (48.9)	1424 (38.5)	1193 (39.3)	1317 (37.9)	6684 (69.7)	574 (28.4)	1548 (78.9)	2255 (56.5)	372 (28.3)	1305 (49.0)	3419 (26.3)
High	1086 (37.8)	1345 (24.3)	522 (17.9)	1018 (27.6)	1249 (41.1)	826 (23.7)	2350 (24.5)	828 (41.0)	271 (13.8)	1388 (34.8)	792 (60.2)	1147 (43.1)	8801 (67.8)
Male sex	1454 (50.6)	2783 (50.3)	1465 (50.2)	1828 (49.5)	1470 (48.4)	1715 (49.3)	4905 (51.2)	985 (48.8)	990 (50.4)	2072 (52.0)	667 (51.5)	1403 (52.7)	6416 (49.4)
Parental allergy	686 (25.6)	104 (2.0)	558 (19.7)	807 (24.8)	810 (29.1)	1152 (38.2)	3306 (37.4)	933 (50.2)	366 (19.7)	1077 (29.4)	145 (11.5)	981 (36.8)	1816 (14.8)
Smoking during pregnancy	154 (5.4)	240 (4.4)	718 (24.8)	461 (12.6)	189 (6.3)	302 (8.8)	1570 (16.8)	545 (28.2)	95 (4.9)	672 (17.3)	361 (28.0)	448 (16.9)	3315 (26.0)
Breastfeeding	2426 (85.3)	NA	1990 (68.3)	3390 (92.4)	2725 (90.4)	3007 (87.2)	6719 (70.7)	1297 (64.7)	1534 (78.5)	NA	NA	2202 (83.4)	NA
Pet-ownership ever	1102 (39.1)	NA	1738 (60.7)	1684 (46.9)	1263 (42.2)	1839 (54.0)	2185 (23.2)	1493 (74.4)	1282 (66.4)	1757 (44.6)	NA	1569 (58.9)	NA
Crowding	606 (21.3)	1054 (19.8)	547 (18.8)	486 (13.2)	411 (13.6)	413 (12.0)	2334 (24.9)	256 (12.8)	296 (15.3)	NA	205 (15.8)	1045 (39.6)	2190 (17.1)
Mould/moisture in the child's home	739 (26.5)	763 (13.9)	947 (33.1)	1140 (31.8)	601 (20.1)	1078 (31.8)	534 (5.6)	489 (24.5)	353 (18.3)	830 (22.5)	370 (28.8)	729 (27.6)	5285 (41.2)
Use of gas for cooking	349 (12.5)	4334 (78.7)	2678 (92.8)	2555 (72.4)	2883 (95.0)	3160 (92.3)	9358 (98.8)	1668 (83.9)	857 (44.7)	390 (10.0)	207 (15.9)	540 (20.4)	3446 (26.7)
Annual average PM_{10} $\mu g \cdot m^{-3}$ min–max	62–71	20–55	60–85	56–72	41–57	65–89	NA	30–39	33–53	24–42	17–23	10–33	15–33

Data are presented as n (%) unless otherwise stated. BUL: Bulgaria, RUS: the Russian Federation, POL: Poland, HUN: Hungary, SLO: Slovakia, CZ: Czech Republic, I: Italy, NL: the Netherlands, GER: Germany, A: Austria, CAN: Canada, CH: Switzerland, USA: United States of America; NA: not available; PM_{10}: particulate matter with a diameter of <10 μm; #: maximum educational level achieved by either mother or father of the child.

TABLE 4 Prevalence of symptoms and diseases

Outcome	BUL	RUS	POL	HUN	SLO	CZ	I	NL	GER	A	CAN	CH	USA
Maximum n	2873	5537	2920	3694	3038	3478	9586	2018	1963	3988	1315	2664	12990
Wheeze past 12 months	439 (15.8)	711 (13.4)	363 (12.4)	340 (9.6)	299 (10.0)	719 (21.1)	646 (6.9)	189 (9.4)	171 (10.1)	534 (13.5)	229 (18.4)	277 (10.4)	2398 (19.4)
Asthma ever	422 (15.8)	104 (1.9)	302 (10.3)	804 (22.2)	198 (6.6)	332 (9.9)	846 (9.0)	160 (8.0)	169 (8.7)	319 (8.7)	88 (6.8)	241 (9.0)	1282 (10.0)
Bronchitis in the past 12 months	655 (23.8)	791 (14.6)	1022 (35.0)	1136 (32.8)	934 (31.4)	1378 (41.5)	1149 (12.4)	150 (7.6)	NA	NA	57 (4.4)	492 (18.5)	819 (6.5)
Nocturnal dry cough	148 (5.3)	NA	400 (13.7)	338 (9.2)	416 (13.7)	688 (20.0)	1516 (16.1)	433 (21.7)	336 (18.7)	408 (10.3)	NA	574 (21.5)	NA
Inhalant allergy	297 (11.2)	351 (6.5)	406 (13.9)	419 (13.9)	427 (14.5)	584 (17.4)	1016 (10.9)	295 (15.3)	108 (5.6)	507 (12.9)	241 (18.9)	362 (13.6)	2636 (21.1)
Itchy rash ever	260 (9.4)	NA	217 (7.4)	253 (6.9)	292 (9.7)	362 (10.5)	1364 (14.5)	443 (22.1)	297 (15.5)	330 (8.4)	NA	356 (13.4)	NA

Data are presented as n (%). BUL: Bulgaria; RUS: the Russian Federation; POL: Poland; HUN: Hungary; SLO: Slovakia; CZ: Czech Republic; I: Italy; NL: the Netherlands; GER: Germany; A: Austria; CAN: Canada; CH: Switzerland; USA: United States of America; NA: not available.

and eczema (mean OR (95% CI): 0.64 (0.53–0.77)) among children with low SES compared with high SES.

With some exceptions, the increase/decrease in risk was stronger for low parental education than for medium parental education. Odds ratios for the comparison of low *versus* high parental education varied between countries. Part of this variation arises from differences in prevalence of symptoms between countries. Furthermore, for wheeze, nocturnal cough and itchy rash the difference was negatively correlated with prevalence of low parental education (data not shown), *i.e.* the difference became larger when the definition of low parental education was stricter. For the other outcomes, no systematic pattern was seen.

Study area was used to control for the overall effect of (unmeasured) explanatory variables on the study area level. Since data on annual average exposure to PM_{10} calculated from monitoring sites in the study areas was available for all countries except Italy (table 3), the current authors also calculated PM_{10} adjusted odds ratios and compared them with the study area adjusted odds ratios. The difference in odds ratios ranged from -14.7–7.5% (median -0.2%) and -18.9–12.7% (median 0.5%) for the comparison of medium *versus* high and low *versus* high parental education. Statistically significant associations between SES and symptoms remained statistically significant (data not shown).

DISCUSSION

Low parental education was associated with a decreased prevalence of inhalant allergy and itchy rash in school children aged 6–12 yrs living in Eastern and Western Europe and Northern America. Furthermore, low parental education was associated with an increased prevalence of wheeze and nocturnal dry cough; whereby the former was mainly restricted to children from Eastern Europe. No clear association was found between parental education and prevalence of asthma and bronchitis. Part of the differences between parental levels of education with regard to the children's health could be explained by differences in prevalence of parental allergy, crowding, mould/moisture in the child's home smoking during pregnancy, pet-ownership, and use of gas for cooking. However, differences remained after adjustment for these variables.

The association between parental education and inhalant allergy and itchy rash was consistent across Eastern and Western European countries and North America. The present authors think that this consistency is particularly noteworthy as the definitions and meanings of low and high SES as defined by parental education differ between countries. This indicates that social inequalities resulting in differences in health outcomes existed not only in Western European countries, but also in former socialist countries with a relatively uniform distribution of resources.

Selective under-reporting or access to healthcare might explain the decrease in prevalence of bronchitis with decreasing SES that was observed in some countries. Selective access to healthcare due to socio-economic reasons is unlikely for those countries whose systems are based on solidarity and equity, where entitlement and level of health insurance benefits do not depend on the amount of contribution paid, and where

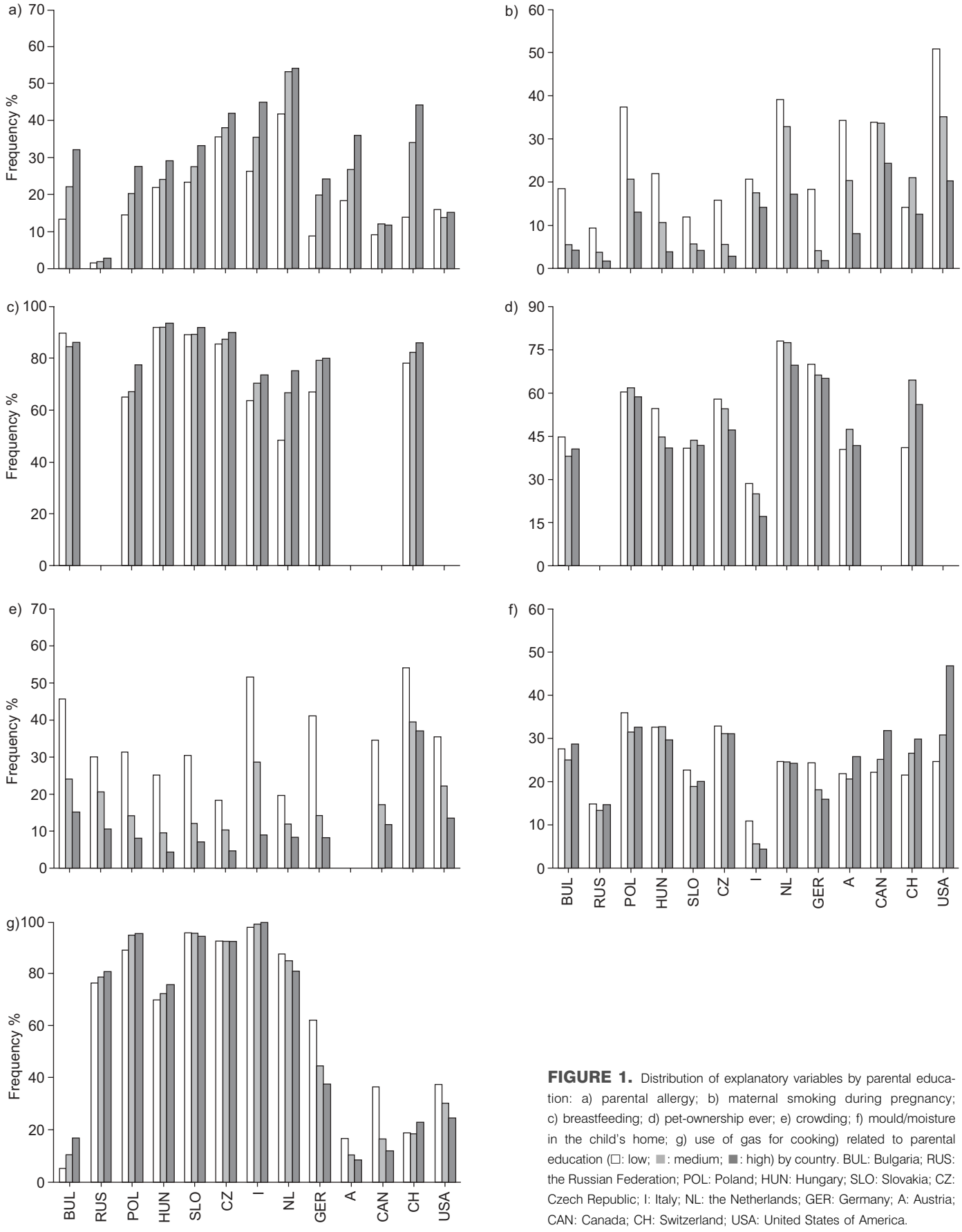

FIGURE 1. Distribution of explanatory variables by parental education: a) parental allergy; b) maternal smoking during pregnancy; c) breastfeeding; d) pet-ownership ever; e) crowding; f) mould/moisture in the child's home; g) use of gas for cooking) related to parental education (□: low; ▒: medium; ■: high) by country. BUL: Bulgaria; RUS: the Russian Federation; POL: Poland; HUN: Hungary; SLO: Slovakia; CZ: Czech Republic; I: Italy; NL: the Netherlands; GER: Germany; A: Austria; CAN: Canada; CH: Switzerland; USA: United States of America.

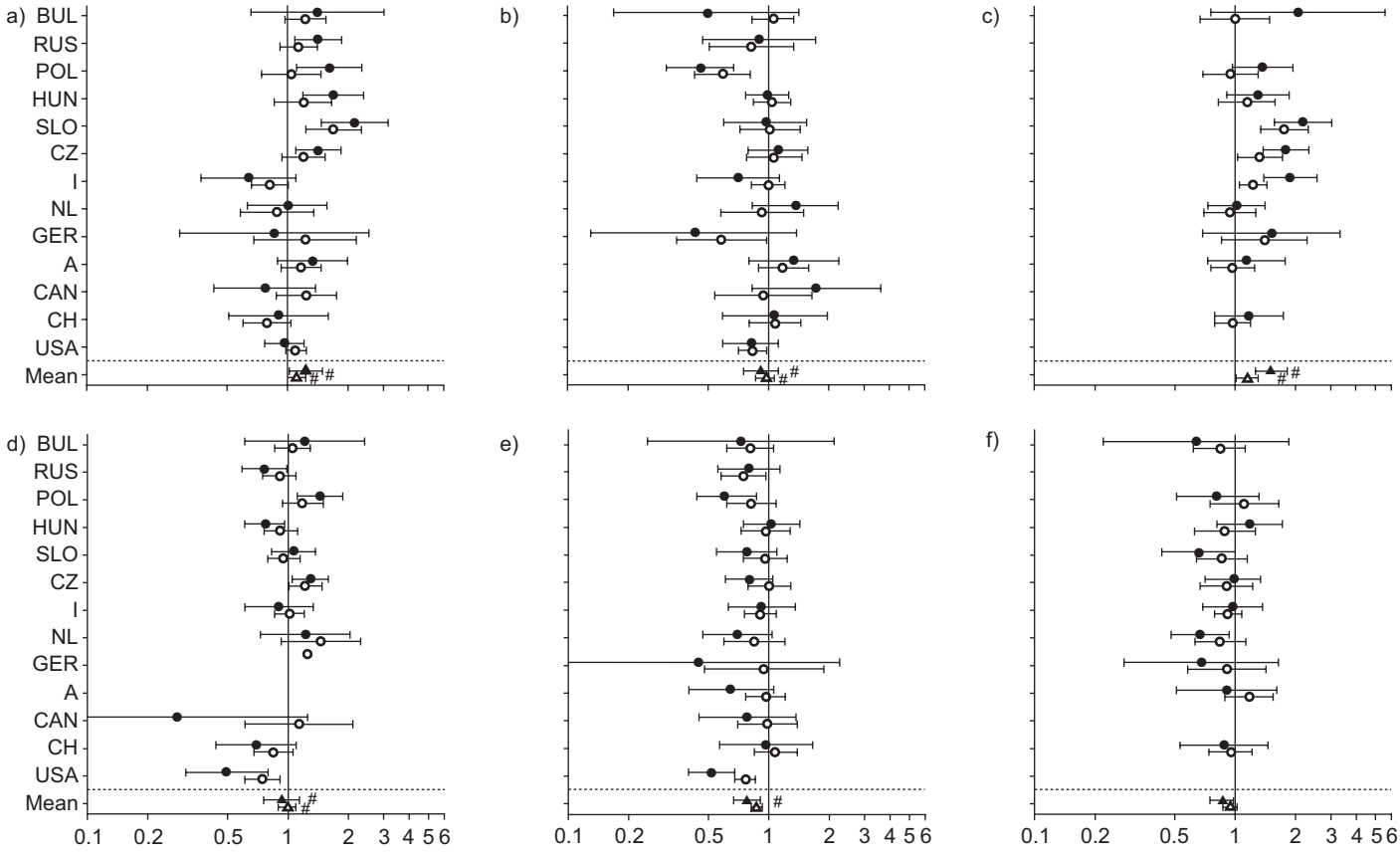

FIGURE 2. Multiple logistic regression results expressed as country-specific and mean odds ratios (95% confidence intervals) for the association between parental education and respiratory and allergic symptoms and diseases a) wheeze past 12 months; b) asthma ever; c) nocturnal dry cough; d) bronchitis past 12 months; e) inhalant allergy; f) itchy rash) in children adjusted for age, sex, study area parental allergy, smoking during pregnancy, breastfeeding, pet-ownership, crowding, mould/moisture in the child's home and use of gas for cooking. ○: medium *versus* high parental education; ●: low *versus* high parental education. BUL: Bulgaria; RUS: the Russian Federation; POL: Poland; HUN: Hungary; SLO: Slovakia; CZ: Czech Republic; I: Italy; NL: The Netherlands; GER: Germany; A: Austria; CAN: Canada; CH: Switzerland; USA: United States of America. #: indicates that test for homogeneity p-value <0.10.

co-payments are reasonable [38]. Severity of disease could also (in part) explain the higher prevalence of bronchitis in children with high parental education in other countries; highly educated parents might take medical advice in mild cases of bronchitis whereas parents with a low level of education take medical advice in more severe cases only. Unfortunately, data on severity of bronchitis were not available for most of the present studies. Moreover, people with low SES are more likely to live in more highly polluted areas and/or to be more susceptible to the health effects of air pollution because of compromised health due to material deprivation and psychosocial stress [22]. The current authors assessed the importance of exposure to air pollution defined as annual average PM_{10} exposure on the study area level, but it did not explain the SES effect. However, using this approach did not take into account within-study area variation of air pollution, which might also play a role.

Several studies conducted in Western European countries reported higher prevalence of eczema, hay fever and sensitisation to inhalant allergens among children, adolescents and adults of the most advantaged socio-economic group [11, 12, 14, 15, 39–43]. To the best knowledge of the current authors, the present study is the first study to show that the positive association between SES and itchy rash and inhalant allergies is not restricted to Western Europe, but also exists in Eastern European countries (besides large differences between countries with regard to the prevalence of symptoms). Again, it cannot be ruled out completely that selective under-reporting or access to healthcare might explain at least part of the decrease in prevalence of allergies with decreasing SES. Furthermore, lifestyle and environmental factors are likely to play a role. A number of hypotheses have been proposed as potential partial explanations for between-country and within-country disparities in prevalence of asthma and allergies including differences in ''hygiene'' (family size, day care, viral exposure, endotoxin, microbial exposure of the infants' large bowel, domestic allergen exposure), diet, cigarette smoking, traffic pollution, antenatal exposures and physical activity/obesity [23], but it is unclear which lifestyle or environmental factor(s) account for the association between SES and prevalence of allergies. The present authors adjusted for a set of explanatory variables, but the associations remained. Other factors potentially associated with SES, such as helminth

infections, early contact with other children and dietary factors, might explain the observed effect, but no data on these factors have been available.

East–West differences in the associations between children's health and parental education were found, for wheeze only: wheeze was positively associated with parental education in all Eastern European countries except (East) Germany along with Austria, but not in the remaining Western European countries and North America. The current authors speculate that atopy might play a role: atopy has been shown to be more prevalent among children and adults with high SES [11, 14–16]; and considerably higher prevalence of atopy was reported for West Germany compared to East Germany [44]. Thus, wheeze is perhaps more likely to be linked to atopy in Western Europe and North America compared with Eastern Europe, and therefore associations between parental social class and wheeze might differ between Eastern and Western Europe. However, this does not explain the Austrian results.

The lack of association between childhood asthma and SES in the present study is consistent with the result of a recent study from New Zealand [45] and a review of 24 studies on the association between childhood asthma and SES by MIELCK *et al.* [20]: the studies did not reveal a clear picture; positive associations were as frequent as negative ones, and most studies showed no association at all. Recent evidence for an inverse gradient between SES and asthma comes from the European Community Respiratory Health Survey [46]. When MIELCK *et al.* [20] analysed data of >4,000 German fourth grade schoolchildren by severity of asthma, they found an increased prevalence of severe asthma (defined as constant wheeze with >10 acute attacks per yr) among children with low SES [20]. This is in line with the studies reviewed by GOLD and WRIGHT [23] that showed a greater disparity in asthma morbidity than in asthma prevalence for impoverished African Americans. However, a differentiation between mild and severe asthma was not possible for the present study. Moreover, associations between education and asthma may be different for atopic and nonatopic asthma [13, 46].

The present authors considered the possibility of a U-shaped association between SES and children's respiratory health with the very poor having more respiratory symptoms due to much higher exposures, and the rich reporting more symptoms due to better access to healthcare and better diagnoses. However, there was no indication of medium-SES children having less symptoms than low- and high-SES children in the PATY study. One potential explanation might be the current definition of SES resulting in sometimes rather large groups of children with low and high SES, respectively. It cannot be ruled out that a more extreme definition of low and high SES reveals a different pattern. However, given the information that is available from the original cross-sectional studies, no alternative definition is possible.

SES was defined by parental education, being aware of the fact that a person's SES is not only defined by his/her educational level but also, for example, by his/her occupation and income. However, parental education was available from all studies, only two studies asked for income and three studies for parental occupation. Moreover, the consistency of the association between parental education and crowding strengthens the current authors' confidence that parental education reflects the children's SES.

The maximum educational level achieved by either parent was used to assess the child's SES, assuming that the parent with the highest educational level is the determining factor for a family's SES. One might argue that maternal SES might be more relevant with regard to a child's health. However, the overall concordance between maternal and paternal education was fair to moderate (58–80%), and the association between maternal education and children's health was rather similar to the association between maximum parental education and children's health (data not shown).

Several studies of social conditions related to health inequalities, healthcare utilitisation and SES have shown that metropolitan area variation is greater than between-country variation [47, 48]. Thus, it is possible that the level of aggregation (the country) may obscure the association between SES and the children's health. The current authors decided against an analysis on the study area level since the term ''study area'' has different meanings in the different studies: it represents school catchments in some of the studies and geographic areas (of different sizes) in others. Therefore, it cannot be ruled out that the results might have been different if the analysis had been performed on the community scale.

CONCLUSION

Children's respiratory and allergic symptoms depended on parental education in 13 diverse countries. The association could not be explained by established risk factors.

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APPENDIX 1: DEFINITION OF HEALTH OUTCOMES

Study/Country	Wording
Wheeze in the past 12 months	
CESAR	Has this child ever had wheezing or whistling in the chest at any time in the past? If yes: Has the child's chest sounded wheezy or whistling in the last 12 months?
Russia	Any yes (or equivalent) from: - Has your child's chest ever sounded wheezy or whistling, as heard from a distance? If yes: When was the last time this wheezing, heard from a distance, occurred? - Has your child ever had wheezing, heard from a distance when he or she had colds? If yes: Has this occurred in the past 12 months? - Has your child ever wheezed when he or she did not have a cold? If yes: Has this occurred in the past 12 months? - Has your child ever had wheezing, heard from a distance, for ⩾3 days in a row during the past 12 months? - During which months of the past 12 months did your child have an episode of wheezing? - Has your child ever had episodes of shortness of breath with wheezing, as heard from a distance? If yes: Has this occurred in the past 12 months? - Has your child ever required medication for wheezing? If yes: Has this occurred in the past 12 months? - Has your child ever had hospital care for wheezing? If yes: During the past 12 months how many times has he or she had hospital care for this wheezing? - Has your child ever been awakened at night when wheezing because of difficult breathing? If yes: When was the last time the wheezing occurred?
Italy	Has your child ever had wheezing or whistling in the chest, when breathing, at any time in its life? If yes: Has your child had wheezing or whistling in the chest, when breathing, in the past 12 months?
The Netherlands	Has your child ever been bothered by wheezing or whistling in the chest at any time in the past? If yes: Has your child in the last 12 months been bothered by whistling in the chest?
Germany	Has this child *ever* had wheezing or whistling in the chest? If yes: - Does your child have this problem currently - OR: At what age did your child last have this problem?
Austria	Has your child in the last 12 months had whistling sounds when breathing or a wheezing in the chest?
Switzerland	Has your child had wheezing or whistling in the chest in the last 12 months?
North America#	Has your child's chest ever sounded wheezy or whistling, including times when he or she had a cold? If yes, when was the last time this wheezing occurred?

(Continued)

Study/Country	Wording
Asthma ever	
CESAR	Has the child ever had asthma, diagnosed by a doctor? OR Has this child ever had asthmatic, spastic, or obstructive bronchitis, diagnosed by a doctor?
Russia	Any yes (or equivalent) from: - Was your child seen by a doctor for a severe chest illness BEFORE the age of 2 years? If yes: What was the diagnosis? Asthma? - Has a doctor ever said that this child had a severe chest illness AFTER the age of 2 years? If yes: What was the diagnosis? Asthma? - Has a doctor ever said that your child has asthma? - If yes: When was the last time your child took medication for asthma? - Which best describes the child's level of asthma symptoms? 1) The child had some episodes of asthma in the past 12 months, but did not require any medication for it. 2) The child has had some episodes of asthma in the past 12 months, requiring medication only for occasional episodes. 3) The child has had asthma in the past 12 months, requiring medication on a routine basis, but did not have any episodes requiring additional treatment. 4) The child has had asthma in the past 12 months, requiring medication on a routine basis, and also had one or more episodes requiring additional treatment.
Italy	Has your child ever had asthma?
The Netherlands	Has your child ever had asthma?
Germany	Did a doctor ever diagnose the following diseases in your child: bronchial asthma OR spastic bronchitis OR asthmatic bronchitis?
Austria	Has your child ever had in its life: bronchial asthma
Switzerland	Has your child ever had asthma?
North America[#]	Has a doctor ever said your child had asthma?
Bronchitis past 12 months	
CESAR	Has the child ever had bronchitis, diagnosed by a doctor? If yes: How many times did this child have bronchitis in the last 12 months?
Russia	During the past 12 months, was this child seen by a doctor for any chest illness? If yes, what was the diagnosis, if the illness was diagnosed? Bronchitis?
Italy	Has a doctor ever said that your child had bronchitis? If yes: Has your child had bronchitis in the last 12 months?
The Netherlands	Has the doctor ever diagnosed bronchitis in your child? If yes: How many times did your child have bronchitis in the last 12 months?
Germany	–
Austria	–
Switzerland	In the last 12 months, has your child had a respiratory disease? If yes: Bronchitis?
North America[#]	During the past 12 months, did this child have any chest illness? If Yes: Was the child seen by a doctor or other health practitioner? What was the diagnosis? Bronchitis?
Nocturnal dry cough	
CESAR	Has this child had a dry cough at night in the last 12 months, apart from coughing with a cold or chest infection?
Russia	–
Italy	In the last 12 months, has your child had a dry cough at night, apart from a cough associated with a cold or chest infection?
The Netherlands	Has your child in the last 12 months been bothered by a dry cough at night without having a cold or chest infection?
Germany	Does your child cough frequently during the day or the night in autumn/winter?
Austria	Has your child had a dry cough in the last 12 months, without having a cold or bronchitis?
Switzerland	In the last 12 months, has your child had a dry cough at night, apart from a cough associated with a cold or the flu?
North America[#]	Does this child usually cough at other times during the day or night (*i.e.* not the morning)?
Inhalant allergy	
CESAR	Is this child allergic to house dust? OR Is this child allergic to pets? OR

(Continued)

Study/Country	Wording
	Is this child allergic to pollen (*e.g.* hay fever)?
Russia	Any yes from: - Has a doctor ever said that your child has allergies? If yes, does the child suffer allergy presently from things that are breathed or inhaled, for example, dust, pollens, moulds, tobacco smoke, animal's (dog, cat) fur? - Have these allergies persisted before the age of 2 years? - Some hand written entries of ''other allergies''
Italy	Has your child had shortness of breath, dry cough, whistling or wheezing when someone sweeps or dusts or when entering in a very dusty room or near feather or down pillows? OR Has your child had shortness of breath, dry cough, whistling or wheezing when he is close to some types of animals? OR Has your child had shortness of breath, dry cough, whistling or wheezing when he is close to a field, with trees or flowers or during spring or summer months?
The Netherlands	Is your child allergic to house dust? OR to pets? OR to pollen (*e.g.* hay fever)?
Germany	Has a doctor ever diagnosed an allergy in your child? If yes, to what? To pets? To pollen?
Austria	Did your child at any time of its life suffer from allergies? If so, are they allergic to: dust/mites? OR to animal hair? OR to pollen?
Switzerland	Has your child ever suffered an allergy? If yes, he/she is allergic to: House dust/mites OR animals OR pollen (grass pollen, tree pollen)
North America[#]	Has a doctor or other health practitioner ever said that your child had allergies? If yes, to: things that are breathed or inhaled, *e.g.* dust, pollen, moulds, animal fur or dander, smoke
Itchy rash, ever	
CESAR	Has this child ever had an itchy rash that was coming and going for $\geqslant$6 months?
Russia	–
Italy	Has your child ever had an itchy rash that was coming and going for $\geqslant$6 months?
The Netherlands	Has your child ever had an itchy rash that was coming and going for $\geqslant$6 months?
Germany	Has your child ever had itchy rash at the knees, elbows or ankles (neurodermatitis, eczema)?
Austria	Has your child ever had an itchy rash that was coming and going for $\geqslant$6 months?
Switzerland	Has your child ever had an itchy rash that was coming and going for $\geqslant$6 months?
North America[#]	–

[#]: Preamble to section ''current health'' states, ''In general we are asking you to recall events that have happened within the last 12 months''.