

## ORIGINAL ARTICLE

# Mould/dampness exposure at home is associated with respiratory disorders in Italian children and adolescents: the SIDRIA-2 Study

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**Aims:** To report on the relation between home mould and/or dampness exposure and respiratory disorders in a large sample of children and adolescents in Italy, accounting for age at time of exposure.

**Methods:** 20 016 children (mean age 7 years) and 13 266 adolescents (mean age 13 years) completed questionnaires on indoor exposures and respiratory symptoms/diseases. Statistical analyses were adjusted for sex, age, questionnaire's compiler, area of residence, season of interview, parental educational status, family history of asthma, rhinitis, eczema, chronic obstructive pulmonary disease, presence of gas water heaters, passive smoking, pets, and active smoking (only for adolescents). Population attributable risk % (PAR) was also computed.

**Results:** Asthma was more strongly related to only early than to only current exposure, both in children (OR 1.80, 95% CI 1.41 to 2.30) and adolescents (OR 1.89, 95% CI 1.38 to 2.59). The same result was found for rhino-conjunctivitis (OR 1.46, 95% CI 1.17 to 1.82), in children, and for wheeze among adolescents (OR 1.56, 95% CI 1.15 to 2.11). In children, wheeze (OR 1.98, 95% CI 1.47 to 2.66) and eczema (OR 1.44, 95% CI 1.09 to 1.91) were more strongly related to mould/dampness when exposed both early and currently; the same occurred in adolescents for rhino-conjunctivitis (1.78, 95% CI 1.30 to 2.45). Although persistent cough/phlegm was significantly related to mould/dampness exposure in children, regardless of exposure timing, no significant association between mould/dampness exposure and eczema or cough/phlegm was found among adolescents. PAR estimates were higher for only early than only current exposures. Avoiding early only exposure would abate wheeze by 6%, asthma or cough/phlegm by 7%, rhino-conjunctivitis in children by 4%, and in adolescents, asthma by 6%, and wheeze by 4%.

**Conclusions:** Respiratory disorders such as wheeze and asthma can often be explained by exposure to home mould/dampness, especially early in life. The association seems more evident in children than in adolescents. These findings may suggest the need for environmental prevention strategies.

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The recent increase in allergic and atopic diseases may be the result of complex interactions of environmental and genetic factors. Indeed, there is growing epidemiological evidence that indoor allergen exposure, especially early in life, may contribute to the development of allergic sensitisation.<sup>1–3</sup> House dust is a common source of indoor allergens. It is a complex mixture of contaminants, such as mites, cat or dog allergens, and moulds.<sup>4</sup> Little is known about the contribution of indoor mould levels to allergic sensitisation rates.<sup>4</sup> Although studies that objectively assess exposure would be desirable, there are problems with accurate air sampling. Not all mould components have been identified yet, and there are no methods for a valid quantitative assessment of exposure.<sup>5</sup> Fewer significant relations of respiratory health outcomes with observed specific mould genera than with reported moulds have been found.<sup>6</sup> Moreover, a measure of spores cultured using currently available techniques does not accurately represent the variability of concentration over time, because the measurement periods are too short and the variability in repeated measures is increased over a very short period of time.

The important role indoor moulds or dampness play in respiratory functioning has been highlighted.<sup>7–10</sup> Both self-reported and observed measures of moulds were shown to be associated with increased prevalence of respiratory symptoms and asthma.<sup>11</sup> Data obtained from a prospective study of

adolescents with no history of asthma suggest that a humidifier in the home may contribute to the onset of asthma.<sup>12</sup> However, the relation between mould/dampness exposure and health outcomes, taking into account age at exposure, has seldom been studied.<sup>6, 13</sup>

The aim of this paper is to report on the relation between home mould/dampness exposure and respiratory disorders in a large population sample of children and adolescents in Italy, taking into account age of exposure.

## METHODS

In the framework of the ISAAC Project (International Study of Asthma and Allergies in Childhood),<sup>14</sup> a survey was conducted in Italy between 1994 and 1995 in 10 areas of northern and central Italy in a representative sample of 6–14 year old children/adolescents (1st SIDRIA Study, *Studi Italiani sui Disturbi Respiratori dell'Infanzia e l'Ambiente*).<sup>15–17</sup> A second large, multicentre study on the relation between the environment and respiratory disorders in children and adolescents was carried out in 2002, also including areas of southern Italy (2nd SIDRIA Study).<sup>18</sup>

**Abbreviations:** CI, confidence interval; COPD, chronic obstructive pulmonary disease; ISAAC, International Study of Asthma and Allergies in Childhood; OR, odds ratio; PAR, population attributable risk; SIDRIA, Studi Italiani sui Disturbi Respiratori dell'Infanzia e l'Ambiente

This report concerns the 2nd SIDRIA Study, which involved children and adolescents living in five areas of northern Italy (Turin, Milan, Mantua, Trent, and Emilia-Romagna), five areas of central Italy (Rome, Florence, Empoli, Siena, and Colleferro), and two areas of the south (Bari, Palermo). Each area randomly sampled at least 1000 subjects from the local schools, weighted for the total number of students at the school. If the number of subjects to enrol was less than or equal to 25% of the population, or if there was marked urban or geographic heterogeneity in the area under study, we stratified the population before sampling. Information on children (first and second grade of elementary school) was collected through a questionnaire completed by the parents (QP, children  $n = 20\ 016$ , schools  $n = 235$ , response rate 89%). Information on adolescents (eighth grade) was collected using two questionnaires, one completed by the parents (QP, adolescents  $n = 13\ 616$ , schools  $n = 166$ , response rate 83%), and one completed by the adolescents themselves (QA,  $n = 16\ 175$ , response rate 93%). The highest parental response rate was in the north (92%), followed by the centre (84%) and the south (74%), while the adolescent response rate was quite similar in the different areas (mean 93%). For this report, adolescents with both questionnaires were considered ( $n = 13\ 266$ , 81% of selected adolescents).

For the timing of mould and/or dampness exposure, valid positive or negative answers to the following questions were considered: "Have you ever seen mould/dampness/fungi on the walls or on the ceiling of your child's bedroom in the first year of your child's life?" (*early* exposure); "Recently?" (*current* exposure). With regard to past exposure, the subjects were also allowed to answer "do not remember" (in such case, they were excluded from analyses). The exposure was classified as: *only early*, when it occurred only in the first year of life; *only current*, when it occurred only recently; and *both*, when it occurred in both periods. For both children and adolescents, exposure data were taken from the parental questionnaire. Valid answers about mould/dampness exposure were available for about 90% of both children and adolescents.

The possible effects of mould/dampness exposure on the following symptoms/diseases were assessed:

(a) *Current wheeze*: at least one wheezing episode in the previous 12 months.

(b) *Current asthma*: presence of (1) diagnosis of current asthma made by a physician or hospital admission in the previous 12 months for asthma or current use of medications for asthma AND (2) lifetime asthma or current wheeze or current wheeze after physical exercise or current attacks of dyspnoea with wheeze or current dry cough by night or current chest tightness with wheeze.

(c) *Current rhino-conjunctivitis*: frequent sneezes or runny/stuffy nose, apart from common cold/flu with itching/watery eyes, in the previous 12 months.

(d) *Eczema*: an itchy rash that comes and goes for at least six months, present at any time in the last 12 months, and affecting any of the following places: the folds of the elbows, behind the knees, in front of the ankles, under the buttocks, or around the neck, ears, or eyes OR a skin reddening with itching, at least once in life, in one or more of the following

**Table 1** General characteristics of the samples

Area	Children, n (%) <sup>*</sup>	Adolescents, n (%) <sup>*</sup>
North	10522 (52.6)	5923 (44.6)
Centre	6536 (32.7)	5506 (41.5)
South	2958 (14.8)	1837 (13.8)
Total	20016	13266
Questionnaire's compiler		
Mother	10996 (56.1)	7407 (56.9)
Father	915 (4.7)	638 (4.9)
Both	7600 (38.8)	4841 (37.2)
Other	97 (0.5)	124 (1.0)
Season		
Spring	4657 (23.3)	2902 (21.9)
Mother's education		
0-5 years	1223 (6.3)	1550 (12.0)
8 years	6643 (34.1)	5004 (38.7)
13 years	8592 (44.1)	4873 (37.7)
University degree	3043 (15.6)	1511 (11.7)
Father's education		
0-5 years	1381 (7.1)	1535 (12.0)
8 years	7464 (38.5)	5276 (41.3)
13 years	7425 (38.3)	4291 (33.6)
University degree	3108 (16.0)	1660 (13.0)
Mould/dampness		
Current	1703 (9.5)	1207 (10.1)
Early	2290 (12.8)	1141 (9.5)
Only current	985 (5.5)	867 (7.3)
Only early	1572 (8.8)	801 (6.7)
Both	718 (4.0)	340 (2.8)
Passive smoking		
At home	9731 (50.2)	6573 (50.9)
In the car	-	3981 (31.8)
Current smoking	-	995 (7.6)
Presence of		
Dog	3444 (17.2)	3674 (27.7)
Cat	3484 (17.4)	3743 (28.2)
Gas water heater	4500 (23.4)	2874 (22.7)
Current wheeze	1575 (7.9)	1095 (8.3)
Current asthma	1343 (6.7)	863 (6.5)
Current rhino-conjunctivitis	1307 (6.5)	2157 (16.3)
Eczema	1977 (9.9)	1031 (7.8)
Persistent cough/phlegm	575 (2.9)	415 (3.1)

\*Valid per cent.

sites: elbow folds, back of the knees, ankles, under the gluteus zone, around the neck, around the ears, or around the eyes.<sup>19</sup>

(e) *Persistent cough/phlegm*: presence of cough and/or phlegm for at least four days a week for at least three months a year apart from common cold/flu.

Except for current asthma (some information used to define current asthma was reported only by parents), we used data from the adolescents for information on their respiratory health.

Information on other indoor factors, such as passive smoking, presence of gas water heater, and presence of dog or cat (anytime throughout life) was also collected. In children, passive smoking exposure was assessed with the question "Are there smokers at home?" Adolescents were considered to be exposed to passive smoking at home if there were smokers at home (from QP) or parents smoked in their presence at home (supplementary information from QA). In adolescents, information on passive smoking exposure from the parents in the car was also available (from QA).

**Table 2** Age and sex of samples

Sample (% males)	Mean age (years)	SD (range)	≤ 6 years	7-8 years	≥ 9 years	≤ 13 years	14 years	≥ 15 years
Children (51.4)	6.7	0.7 (5-11)	40.5%	59.2%	0.3%			
Adolescents (51.6)	13.3	0.5 (12-17)				76.3%	20.7%	2.7%

Statistical analyses were performed using the Statistical Package for the Social Sciences 2000 (SPSS Inc, Chicago, IL, USA): frequency distribution,  $\chi^2$  test, and logistic regression analysis. The effects of mould/dampness exposure (compared with "never exposure") were assessed by logistic regression analyses. All analyses were adjusted for sex, age, area of residence, questionnaire's compiler, season of interview (possible higher prevalence of allergic symptoms/diseases in spring than in other seasons could influence the reported health outcomes), parental educational status, and active smoking (only for adolescents). Adjustments were also made for other possible indoor risk factors, such as presence of gas appliances (that is, gas water heaters), dogs or cats, passive smoking at home, passive smoking in the car (only for adolescents), and for family history in parents and/or siblings of asthma, rhinitis, eczema, and chronic obstructive pulmonary disease (COPD). Analyses were also accounted for COPD familiarity because family practitioners could perceive chronic persistent asthma as a form of irreversible airflow obstruction, and thus encompass it within the term COPD. In addition, in our experience, even if a relation between familial history for specific respiratory diseases and the presence of specific diseases during life has been observed, the subjects often reported the presence of more than one specific respiratory disease in the family.<sup>20</sup>

Type of heating system and cleaning products was not significantly related with health outcome in bivariate analysis, and they were excluded from further analyses.

Population attributable risk (PAR) was computed to estimate the amount of disease or condition abatable by eliminating the exposure to the specific risk factor:

$$PAR = 100 \times p(RR - 1) / p(RR - 1) + 1$$

where  $p$  = proportion of population exposed and  $RR$  = relative risk for exposed versus unexposed.

Approval for this study was obtained from the Bioethics Committee of the Catholic University of Rome.

## RESULTS

The percentage of missing values was less than 10% for all variables considered. Only the variable *season of interview* had

different amounts of missing values in children and in adolescents: 7% for adolescents and 0.3% for children. Other missing values were distributed as following: about 2% for compiler, 3% for parental education, 3% for passive smoking, 6% for tobacco exposure in car and 1% for active smoking (adolescents), 4% for presence of gas water heater, and from 3–10% for family history.

Tables 1 and 2 show the general characteristics of the samples. Sex was distributed similarly between subjects. Most data originated from northern Italy. Most parental questionnaires were completed by mothers. Parental educational status was higher in children than in adolescents in view of the increasing educational level in Italian younger generations (parents of children are younger than those of adolescents). In general, the prevalence of *current* mould/dampness exposure was similar in children and adolescents, whereas *early* exposure was more frequent in children than in adolescents. Both age groups were frequently exposed to passive smoking.

Current wheeze, current asthma, eczema, and persistent cough/phlegm were quite similarly distributed in the two samples. However prevalence of current rhino-conjunctivitis was higher in adolescents than in children (table 2).

In general, family history of respiratory and atopic disorders was evenly distributed in the two samples. Family history for eczema was more frequent in the mothers than in other first degree relatives.

With regard to the different geographical areas (data not shown), mould/dampness exposure was more frequent in the north/centre than in the south (about 12% *v* 7% for *current*, 12% *v* 9% for *early* exposure). Parents were less educated in southern Italy. Children/adolescents were more frequently exposed to passive smoking in the centre/south than in the north, whereas the exposure to gas water heaters was higher in the north. Keeping dogs as pets was consistent throughout the country, but cats were more prevalent in the north/centre. In the southern area, 40% of questionnaires were filled in during the spring (20% in the north/centre). In general, except for eczema in children, the prevalence of symptoms/diseases was higher in the south or the centre than in the north.

**Table 3** Estimated odds ratios (OR) and 95% confidence intervals (95% CI) for the association between mould/dampness exposure and respiratory symptoms/diseases in children (reference "never exposure")

Symptom/disease	Mould/dampness	Prevalence rates %	Adjusted* OR (95% CI)	PAR %
Wheeze	Never	6.9	1.00	
	Only current	9.7	1.62 (1.22–2.15)	3.6
	Only early	11.6	1.65 (1.31–2.07)	5.5
	Both	13.1	1.98 (1.47–2.66)	3.8
Asthma	Never	5.9	1.00	
	Only current	7.2	1.39 (1.00–1.93)	2.3
	Only early	10.6	1.80 (1.41–2.30)	6.7
	Both	8.9	1.17 (0.80–1.71)	NA
Rhino-conjunctivitis	Never	6.0	1.00	
	Only current	7.5	1.03 (0.72–1.49)	NA
	Only early	8.1	1.46 (1.13–1.89)	4.0
	Both	9.7	1.46 (1.01–2.09)	1.8
Eczema	Never	9.4	1.00	
	Only current	10.9	1.17 (0.89–1.53)	NA
	Only early	12.3	1.17 (0.94–1.45)	NA
	Both	14.9	1.44 (1.09–1.91)	1.7
Persistent cough/phlegm	Never	2.6	1.00	
	Only current	4.0	1.86 (1.19–2.91)	4.9
	Only early	3.9	1.89 (1.31–2.71)	7.4
	Both	3.8	1.64 (0.96–2.79)	NA

\*Accounting for sex, age, area, respondent, season, parental education, presence of gas water heaters, dog/cat keeping, passive smoking, and immediate family history for asthma, rhinitis, eczema, and COPD. PAR, population attributable risk; NA, not applicable.

**Table 4** Estimated odds ratios (OR) and 95% confidence intervals (95% CI) for the association between mould/dampness exposure and respiratory symptoms/diseases in adolescents (reference "never exposure")

Symptom/disease	Mould/dampness	Prevalence rates %	Adjusted* OR (95% CI)	PAR %
Wheeze	Never	7.7	1.00	
	Only current	10.3	1.33 (0.98–1.82)	NA
	Only early	11.1	1.56 (1.15–2.11)	3.8
	Both	10.6	1.33 (0.84–2.10)	NA
Asthma	Never	5.8	1.00	
	Only current	7.0	1.28 (0.90–1.82)	NA
	Only early	11.4	1.89 (1.38–2.59)	5.9
	Both	10.0	1.62 (1.00–2.62)	1.8
Rhino-conjunctivitis	Never	15.7	1.00	
	Only current	17.0	1.10 (0.86–1.40)	NA
	Only early	16.9	1.15 (0.90–1.47)	NA
	Both	23.2	1.78 (1.30–2.45)	2.3
Eczema	Never	7.6	1.00	
	Only current	8.0	1.03 (0.75–1.42)	NA
	Only early	8.0	0.76 (0.52–1.10)	NA
	Both	9.1	0.81 (0.48–1.35)	NA
Persistent cough/phlegm	Never	3.1	1.00	
	Only current	3.2	1.19 (0.74–1.91)	NA
	Only early	3.6	0.80 (0.46–1.40)	NA
	Both	4.4	1.48 (0.78–2.81)	NA

\*Accounting for sex, age, area, respondent, season, parental education, presence of gas water heaters, dog/cat keeping, passive and active smoking, and immediate family history for asthma, rhinitis, eczema, and COPD. PAR, population attributable risk; NA, not applicable.

## Relation between mould/dampness exposure and health outcomes

### Children

In general, prevalence rates of all health outcomes were significantly higher in exposed than in never exposed children (table 3). Except for cough/phlegm, all symptom/diseases were more prevalent in children exposed *only early* than in those exposed *only currently*.

By logistic regression models adjusted for confounding and other risk factors (table 3), asthma (OR 1.80) and rhino-conjunctivitis (OR 1.46) resulted more strongly associated with *only early* than with *only current* exposure. Current wheeze and eczema were more strongly related to *both* early and current exposure than to the variable separately. Persistent cough/phlegm was significantly related to mould/dampness exposure, regardless of exposure timing. As far as PAR is concerned, about 6% of wheeze and 7% of asthma and cough/phlegm resulted attributable to *only early* exposure.

### Adolescents

Prevalence rates of all health outcomes were significantly higher in exposed than in never exposed subjects. Current asthma figures were similar to those in children. The highest prevalence of asthma was found in subjects exposed to *only early* mould/dampness, whereas prevalence rates of current wheeze were homogeneous across exposure categories (table 4).

Adjusted odds ratios and adjusted PAR% are listed in table 4. Current asthma (OR 1.89) and wheeze (OR 1.56) were more strongly related to *only early* exposure, whereas rhino-conjunctivitis was more strongly related to *both* exposures (OR 1.78). In adolescents, mould/dampness exposure did not appear to be a significant risk factor for having eczema and persistent cough/phlegm. About 4% of wheeze and 6% of asthma were attributable to *only early* exposure.

## DISCUSSION

We found significant relations between mould/dampness exposure and health outcomes in both children and adolescents. Generally, the association seemed more evident

in children than in adolescents, and more evident with early than with current exposure.

The prevalence rate of reported mould/dampness was low (mean 10%). In a previous study in the area of the Po river delta (near Venice) we found visible signs of mould in 35% of dwellings,<sup>21</sup> but this data concerned mould presence in the kitchen, where other reports have shown that dampness is more likely.<sup>22</sup> Reported prevalence rates of home mould/dampness range widely around the world: from 10–13% in Russia<sup>22</sup> and Taiwan,<sup>23</sup> to 15% in United Kingdom,<sup>24</sup> Finland,<sup>25</sup> and Poland,<sup>9</sup> to 25% in the Netherlands,<sup>8</sup> to 27–28% in Sweden,<sup>26</sup> to 38% in China<sup>27</sup> and Canada,<sup>28</sup> and up to 50% in the USA.<sup>8</sup> This wide dispersion, despite different climates, might also reflect different methods of data collection. Indeed, we found a significantly lower prevalence of mould/dampness in southern than in northern/central Italy, probably due to the milder climate of the South. However, it is important to point out that we had only two centres participating from southern Italy.

The association of current wheeze with mould/dampness exposure seemed stronger in children than in adolescents. In the former, the highest OR was found for *both* exposures. In another study, a stronger association of wheeze with current than with "ever" exposure was found in Russian children exposed to mould.<sup>22</sup> In adolescents, the strongest risk factor for having wheeze was *only early* exposure, as also found by other authors.<sup>3</sup> A significant risk for having wheeze after exposure in the first year of life was also reported by Belanger *et al* on infants at risk (with an older asthmatic sibling).<sup>6</sup>

The relation between exposure and current asthma was similar for children and adolescents. In our context, *only early* exposure seems the strongest risk factor for having asthma. This is in agreement with the findings of Forsberg *et al*,<sup>2</sup> who reported a more consistent association of asthma with the exposure in the first two years of life than with current exposure.

Rhino-conjunctivitis was positively related to mould/dampness exposure, as shown by others,<sup>27–29</sup> but the results were somewhat different in children and adolescents. In the former, the association was significant with *only early* but not with *only current* exposure. Among adolescents, rhino-conjunctivitis was significantly related only to exposure to *both*.

**Table 5** Estimated odds ratios (OR) and 95% confidence intervals (95% CI) for the association between mould/dampness current exposure and wheeze/asthma in the literature (questionnaire based studies)

Author (publication year)	n	Age	Design. Definition of mould/dampness exposure	Symptom/disease	OR (95% CI)
Present study	17918	7	Cross sectional. Positive answer to the question: "Have you seen mould/dampness/fungi on the walls or on the ceiling of your child's bedroom recently?"	Wheeze	1.78 (1.43–2.20)
				Asthma	1.29 (1.00–1.67)
				Wheeze	1.33 (1.02–1.74)
Jedrychowski <i>et al</i> (1998) <sup>9</sup>	1129	9	Cross sectional. Presence on the walls of any one of: (1) small moisture stains; (2) larger moisture stains; (3) visible mould on small surface; (4) visible mould on larger surface	Asthma	1.38 (1.03–1.85)
				Wheeze	1.63 (1.07–2.48)
Fisher <i>et al</i> (1998) <sup>36</sup>	16005	7–11	Cross sectional. Presence on the walls of damp spots or mould during the last two years	Wheeze	1.29 (1.06–1.58) to 1.60 (1.30–1.97)
Yang <i>et al</i> (1997) <sup>23</sup>	4164	6–12	Cross sectional. Presence of any one of: (1) subjective dampness assessment (home was considered damp by the residents); (2) visible mould or mildew on surfaces inside the home during the past year; (3) appearance of standing water within the home/water damage/leaks of water into the building	Wheeze	1.81 (1.32–2.47)
				Asthma	1.73 (1.20–2.49)
Dekker <i>et al</i> (1991) <sup>38</sup>	14059	5–8	Cross sectional. Presence of any one of: (1) visible mould growth; (2) wet or damp spots on indoor surfaces; (3) basement water damage or leaking	Wheeze	1.61 (1.39–1.85)
Dales <i>et al</i> (1991) <sup>28</sup>	14948	5–8	Cross sectional. Presence of any one of: (1) visible mould growth; (2) wet or damp spots on indoor surfaces; (3) basement water damage or leaking	Asthma	1.45 (1.23–1.71)

Eczema was significantly associated with exposure to *both* among children, in Italy. Similarly, McNally *et al*<sup>30</sup> found a significant association between dampness at home and eczema in school aged children in UK (OR 1.50, 95% CI 1.05 to 2.16). The association of cough/phlegm and mould/dampness was independent from the type of exposure in our children, in agreement with other authors who reported living in homes with presence of mould/dampness as a risk factor for having cough in childhood.<sup>23, 31</sup> In our adolescents, the association between exposure and cough/phlegm was not significant. This result might be a result of the confounding effect of other important risk factors for cough/phlegm (that is, active smoking or exposure to passive smoking in the car). Indeed, active smoking was strongly related to cough/phlegm (OR 2.07, 95% CI 1.43 to 3.00). Also passive smoking in the car (for which information was available on adolescents only) was a significant risk factor for having cough/phlegm (OR 1.63, 95% CI 1.13 to 2.34).

According to our PAR estimates, avoidance of any *early* exposure would decrease wheeze or cough/phlegm by 9%, asthma by 7%, and rhino-conjunctivitis in children by 6%. Similarly, such exposure avoidance would prevent 5% of wheeze and 8% of asthma in adolescents. These figures seem relevant in public health terms. PAR estimates regarding *only early* exposure were lower than the former (tables 3 and 4), but they were higher than those regarding *only current* exposure. Lee *et al*<sup>32</sup> found very similar PARs for physician diagnosed asthma due to visible mould exposure in Taiwanese schoolchildren: about 6% for boys and 5% for girls. Regarding PAR values for other indoor risk factors, an estimated 15% of asthma and 11% of wheeze were attributable to passive smoking in our SIDRIA 1st Study,<sup>16</sup> and in a study from Greenland 47% of lower respiratory tract infections in children were due to passive smoking.<sup>33</sup> PAR for asthma was 39% due to residential dog exposure, environmental tobacco smoke, or gas stove for heating in children in the United States.<sup>34</sup>

We have reported on the possible effects of moulds and/or dampness. From the wording of the questionnaire it is not possible to distinguish mould and dampness. However, a strong association between dampness and mould has been found by other authors,<sup>24, 35</sup> thus indicating that dampness in the house could be considered a proxy for the presence of mould.<sup>36</sup> Moreover, by comparing the health effects of "home dampness" defined either as "presence of moulds" or as

"presence of moulds or damp or water damage", it has been shown that exposure definitions did not lead to major changes in the results.<sup>25</sup>

Comparing our results and the findings of other authors is not simple for several reasons. Firstly, we performed a cross sectional study on population samples of children and adolescents, whereas several of the other investigations have concerned case control studies or subjects at high risk for respiratory disorders or symptomatic/ill subjects.<sup>1, 6, 12, 35, 37</sup> Few studies have regarded adolescents only.<sup>12, 37</sup> Moreover, there are few studies on the relation between current symptoms/diseases and exposure only in the past; in general, the assessments focus on current exposure. Finally, we collected self-reported data on the presence of mould/dampness, whereas in other studies objective inspections or mould exposure quantification were performed or levels of specific moulds were measured.<sup>1, 4, 6, 9, 24</sup> Nevertheless, our results confirm the associations of mould/dampness exposure with respiratory symptoms/diseases found by other investigators.<sup>7, 8, 10, 11, 13, 23, 38, 39</sup>

However, comparisons between *current* exposures (independent from the presence/absence of early exposure) may be possible. Table 5 shows odds ratios for the association between *current* mould/dampness and wheeze or asthma in children or children/adolescents in our study and in other questionnaire based studies. All studies had the same design and similar methods for the exposure definition. Our odds ratios are consistent with those reported by other authors.<sup>9, 23, 28, 36, 38</sup>

Because of some differences in the characteristics and exposures between areas (north, central, and south), we tried to perform geographically stratified analyses. In general, the associations were similar to those found in the whole sample, but only north and central Italy retained significance. This might be due to the amount of data collected in southern Italy (only two centres were represented), the significantly lower prevalence of mould/dampness, or the higher prevalence of other risk factors in this area (that is, passive smoking exposure) which might confound the effects of mould/dampness.

The main limitation of our study is that exposure to mould or dampness was assessed by using questionnaire data. However, questionnaires have been used in many large scale studies,<sup>9, 22, 23, 25, 37</sup> and their validity has already been established.<sup>10, 40, 41</sup>

Overreporting of exposure might result in overestimation of the associations with disorders, but previous studies have found that overreporting seems unlikely to occur,<sup>35, 42</sup> and underreporting exposure is actually more common.<sup>43</sup> Indeed, we cannot exclude the possibility that the parents of children/adolescents with diseases (that is, current asthma or rhinoconjunctivitis) tend to remember/report the exposure more often than healthy subjects. However, it was found by other authors<sup>24</sup> that self-reported questionnaires underestimated the presence of dampness at home when compared with objective inspection and that the tendency to underestimate dampness in the home was independent from the presence/absence of asthmatic children. Thus, any differential bias of underreporting should have led to conservative results in terms of health outcomes in our study. As a clue of internal validity, it is important to point out that mould/dampness were more prevalent in bedrooms with less exposure to the sun.

In conclusion, exposure to home mould/dampness accounts for a sizeable proportion of respiratory disorders such as wheeze and asthma. The association seems more evident in children than in adolescents, and when the exposure occurs early in life. This finding appears particularly important in view of the increasing trend of allergic sensitisation and atopic diseases worldwide, and given the profound changes that take place in the immune system during its development in infancy. These findings add information on the relations between respiratory health and temporal patterns of mould/dampness exposure, thus suggesting the implementation of environmental preventive strategies.

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