

‘Dampness’ at home and its association with airway, nose, and skin symptoms among 10,851 preschool children in Sweden: a cross-sectional study

Abstract There is convincing epidemiological evidence that ‘dampness’ in buildings is associated with respiratory effects. In order to identify health-relevant exposures in buildings with ‘dampness’, the study ‘Dampness in Buildings and Health’ (DBH) was initiated. In the first step of the study, cross-sectional data on home characteristics including ‘dampness’ problems, and symptoms in airway, nose, and skin among 10,851 children (1–6 years), were collected by means of a questionnaire to the parents. The prevalence of wheezing during the last 12 months was 18.9% and doctor-diagnosed asthma 5.4%. Rhinitis during the last 12 months was reported for 11.1% of the children and eczema during the last 12 months 18.7%. Gender, allergic symptoms among parents, and age of the child were associated with symptoms. Water leakage was reported in 17.8% of the buildings, condensation on windows in 14.3%, and detached flooring materials in 8.3%. Visible mould or damp spots were reported in only 1.5% of the buildings. The four ‘dampness’ indices were associated to higher prevalence of symptoms in both crude and adjusted analysis. Furthermore, it was found that the combination of water leakage in the home and PVC as flooring material in the child’s or parent’s bedroom was associated to higher prevalence of symptoms among children. However, the interpretation of this finding is unclear. The combination of water leakage and PVC may be a proxy, for example, reconstruction because of water damages.

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Practical Implications

The study have showed that moisture-related problems in buildings are a risk factor for asthma and allergic symptoms among preschool children. The recommendation to the general public is to remediate damp buildings.

Background

There is convincing epidemiological evidence that ‘dampness’ in buildings is associated with health effects as shown in reviews of the scientific literature (Bornehag et al., 2001, 2004). ‘Dampness’ in buildings appears to increase the risk of cough, wheeze, and asthma. Relative risks expressed as ORs are mainly reported in the range 1.4–2.2. In the reviews it was concluded that the causal moisture-related exposures have not been identified.

In order to identify health-relevant exposures in buildings with moisture-related problems, the study

‘Dampness in Buildings and Health’ (DBH) started in the year 2000. The aim of the present study was to estimate the prevalence of symptoms in airways, nose, and skin among preschool children in a typical rural area including small- and middle-sized towns in Sweden and to identify associations between such health effects and building characteristics including ‘dampness’ in the home.

Method

The study is part of an investigation of the indoor environment in the home and its importance for asthma

and allergy among preschool children in Sweden. The first step (DBH-Step 1) was carried out in the year 2000 as a cross-sectional questionnaire study.

A questionnaire was distributed to the parents of all 14,077 children aged 1–6 years in the Swedish county of Värmland, with about 280,000 inhabitants. It was distributed by post, with three postal reminders. The questionnaire was tested and modified in a pilot study on 100 randomly selected families.

The questionnaire included questions on the index child (e.g. age, sex, birth weight, length of breast-feeding), and family characteristics such as family size, smoking in the home, etc. Furthermore, there were questions on the health of the index child and family members. Symptoms among children were collected with the same questions as used in the ISAAC Study (Pearce et al., 1993).

Data on the home, e.g. surroundings, age, type, and area of the building, type of foundation, type of ventilation system, and surface materials on walls and floors were collected. Eleven 'dampness'-related questions were asked. Answers to the single question were 'Yes', 'No' or 'Don't know'. 'Dampness' indexes were calculated where 'Yes' and 'No' were used and the answer 'Don't know' was excluded. The following four indexes were calculated: (1) *Water leakage*: Flooding and/or water leakage during the previous year or earlier during the child's lifetime, in the child's or parent's bedroom or in kitchen or bathroom. (2) *Floor moisture*: Loosening or bubbled or discolored flooring material in the child's or parent's bedroom or in the bathroom. (3) *Visible dampness*: Visible mould or damp spots in the child's or parent's bedroom. (4) *Condensation on window*: More than 5 cm of condensation on the inside of the windowpane during winter.

Statistical methods

Statistical analyses were performed with Statistical Package for Social Science (SPSS). Associations between building characteristics including 'dampness' and symptoms among children were estimated in logistic regression models. Odds ratios (ORs) were estimated including 95% confidence interval. Adjustments for potential confounders in multiple logistic regression models were made for: *sex*: boys/(girls), *age*: > 3 years/(< 3 years), *asthma, rhinitis and/or eczema symptoms among parents*: at least one symptom among parents/(no symptoms among parents), *smoking*: any smoking parent during pregnancy and/or child's first year/(no smoking), *type of dwelling*: multi-family houses (MH)/[single-family houses (SH) and row houses], *construction period*: after 1960/(before 1960). Reference category is given in parenthesis.

The local Ethics Committee approved the study.

Results

Of the study population, 100 randomly selected children participated in a pilot study for development of the questionnaire and 200 children could not be found by post. In total, the parents of 10,851 children responded to the questionnaire, corresponding to a response rate of 78.8%. These children lived in 8918 homes.

In order to investigate whether there was a selection bias in the baseline material, 200 families were randomly selected from those who did not answer the questionnaire. Of these, 116 were reached by telephone, 17 families refused to answer any question at all and 67 parents could not be reached by phone. The 116 families were asked to respond to five questions. There were no significant differences in prevalence of symptoms between responding and non-responding families, i.e. 'wheezing ever' (24.3 vs. 23.1 for responders and non-responders, respectively), 'doctor-diagnosed asthma' (5.4% vs. 4.3%), and 'eczema ever' (23.5% vs. 12.1%). Neither was there any significant difference between responders and non-responders as regards type of building 'SH' (82.0% vs. 81.0%), and 'suspected mould problem in the dwelling' (7.8% vs. 9.5%).

Self-reported symptoms

The most frequently reported symptoms were wheezing, eczema, and rhinitis (Table 1). Almost half of the children were reported to have at least one of these symptoms. They were more common among boys (OR: 1.22–1.63), except for eczema. Parental symptoms of asthma, rhinitis and/or eczema increased the risk of symptoms for the index child, with OR in the range 1.59–3.34; the strongest association was for rhinitis. Wheezing and cough at night decreased slightly with age. The prevalence of 'doctor diagnosed asthma' and 'doctor-diagnosed rhinitis' as well as 'rhinitis on pet and pollen exposure' increased with age.

Building characteristics of the home are given in Table 2. The majority of the children lived in SH and the majority of these were constructed before 1960. Reports of water leakage in recent years were twice as common from SH compared to multi-family houses (MH). Floor moisture indications such as loosening or discolored floor material were less often reported in SH, while visible mould and/or damp spots were found in only 1.2% of the SH and 1.9% of the MH. More than 5 cm of condensation on the inside of the windowpane and flooding were more frequently reported from SH.

Building characteristics and symptoms

Parents living in MH reported more symptoms of their children than parents living in other types of building. Living in MH increased the risk of symptoms with OR 1.18–2.40 in crude analysis (Table 3). For SH, but not

Table 1 Prevalence of airway, nose, and skin symptoms among 10,851 children and the association with allergic symptoms in family, sex, and age

Symptom	Total population (%) (n = 10,851)	OR (95% CI)		Age (%)					Trend analysis (P-value ^a)
		Sex (Boys) (n = 5441)	Allergic symptoms in family (Yes) (n = 5230)	1–2 years	2–3 years	3–4 years	4–5 years	5–6 years	
Wheezing last 12 month	18.9	1.44 (1.30–1.58)	1.90 (1.72–2.10)	25.6	23.6	19.2	16.6	13.3	<0.001
Cough at night	7.4	1.04 (0.90–1.20)	1.59 (1.37–1.84)	8.1	9.2	6.8	7.0	6.5	0.004
Asthma (doctor-diagnosed)	5.4	1.72 (1.45–2.04)	2.78 (2.31–3.34)	3.7	5.8	6.0	6.1	5.4	0.023
Rhinitis last 12 month	11.1	1.25 (1.11–1.41)	2.15 (1.90–2.44)	12.7	11.2	11.7	11.0	10.2	0.016
Rhinitis on pet exposure	3.9	1.41 (1.16–1.72)	3.16 (2.53–3.94)	1.8	2.6	4.6	4.6	5.6	<0.001
Rhinitis on pollen/grass exposure	3.7	1.58 (1.29–1.94)	3.34 (2.66–4.20)	1.3	2.3	3.7	5.0	5.9	<0.001
Rhinitis (doctor-diagnosed allergy)	2.2	1.63 (1.25–2.12)	3.06 (2.29–4.10)	0.7	1.3	2.2	3.0	3.5	<0.001
Eczema last 12 month	18.7	0.87 (0.79–0.96)	2.11 (1.91–2.33)	15.1	20.3	20.8	19.3	18.2	0.083
At least one symptom	48.8	1.22 (1.13–1.32)	1.95 (1.80–2.10)	49.3	51.5	50.5	50.0	48.7	0.395

^a Linear by linear association used for trend analysis.

for MH, there was an increased risk of symptoms when the home was constructed after 1960, and even more pronounced when the house was constructed after 1977. In a crude analysis there was a significantly increased risk of cough at night, rhinitis, and eczema for children with PVC as flooring material in the bedroom compared with wood flooring.

‘Dampness’ at home increased the risk of symptoms in crude analyses (Table 4). Reports of visible mould and/

Table 2 Frequencies of building characteristics and different ‘dampness’ indexes in 8918 homes

Characteristics ^a	Total population [n (%)]	Single-family houses [n (%)]	Multi-family houses [n (%)]
Type of dwelling			
Single-family house	6282 (70.4)	–	–
Row house	782 (8.8)	–	–
Multi-family house	1617 (18.1)	–	–
Construction period			
Before 1960	4065 (45.6)	3454 (55.0)	456 (28.2)
1961–1976	2038 (22.9)	1233 (19.6)	489 (30.2)
After 1976	2198 (24.6)	1404 (22.3)	367 (22.7)
Ventilation system			
Natural	5729 (64.2)	4467 (71.1)	734 (45.4)
Mechanical exhaust	934 (10.5)	529 (8.4)	240 (14.8)
Mechanical supply and exhaust	824 (9.2)	600 (9.6)	104 (6.4)
Surroundings			
Rural	2991 (33.5)	2792 (44.4)	84 (5.2)
Suburban	4729 (53.0)	3075 (48.9)	947 (58.6)
Urban	818 (9.2)	226 (3.6)	510 (31.5)
Flooring material			
Wood	2770 (31.1)	2396 (38.1)	173 (10.7)
PVC	3629 (40.7)	2317 (36.9)	811 (50.2)
Linoleum	773 (8.7)	451 (7.2)	225 (13.9)
Dampness indexes			
No dampness problems	3862 (43.3)	3286 (46.5)	486 (30.1)
Water leakage	1588 (17.8)	1256 (20.0)	167 (10.3)
Floor moisture	737 (8.3)	404 (6.4)	230 (14.2)
Visible dampness	130 (1.5)	78 (1.2)	30 (1.9)
Condensation on window	1274 (14.3)	957 (15.2)	168 (10.4)
Bad odor	377 (4.2)	131 (2.1)	195 (12.1)

^a Missing data for different building characteristics not included in the table.

or damp spots indoors had the strongest association to symptoms with ORs in the range 1.53–2.70, followed by floor moisture problems (OR: 1.41–2.00). In adjusted analyses the same associations remained in general (Table 5). However, the association between PVC as flooring material and symptoms found in the crude analyses disappeared in the adjusted analyses. For linoleum as flooring material all estimated OR were below entity but significantly so only for ‘doctor-diagnosed asthma’ in the models containing visible moulds and condensation. For ‘wheezing’ this was found in the model with flooding.

Reports of water leakage in any of the rooms in the home in combination with PVC on the floor in the child’s or parent’s bedroom significantly increased the risk of several symptoms in the total population (Table 6). However, the association was not significant for rhinitis. Water leakage in combination with linoleum did not increase the risk of symptoms. When the analysis was restricted to SH, about the same associations were found. Regarding MH the picture was unclear. The combination of water leakage and PVC in such buildings increased the risk of all symptoms but only for cough at night and rhinitis during the last 12 months was it significant. In these buildings, asthma was associated with leakage and wood flooring and rhinitis was associated with leakage/linoleum floors.

Discussion

The general agreement between responders and non-responders in the non-responder analysis in combination with a high response rate (78.8%) indicate that any impact of selection bias on the results would be limited.

In Sweden, there is a broad opinion that moisture and mould problems indoors are a risk factor for asthma and allergy. This, in combination with dependent collection of data, i.e. parents reported both on exposures (‘dampness’) and health effects (symptoms) in the questionnaire, increases the risk of reporting bias. Parents of symptomatic children may be more concerned about

Association of dampness with airway, nose, and skin symptoms

Table 3 Association between building characteristics and airway, nose, and skin symptoms among children ($n = 10,851$). Association expressed as crude Odds Ratio (OR) including 95% confidence interval (95% CI)

Building characteristic	n^a	OR (95% CI)					
		Wheezing last 12 month	Cough at night last 12 month	Asthma (doctor-diagnosed)	Rhinitis last 12 month	Rhinitis (doctor-diagnosed)	Eczema last 12 month
Type of dwelling							
Single-family house	7659	1.0	1.0	1.0	1.0	1.0	1.0
Row house	922	0.92 (0.77–1.10)	1.24 (0.96–1.61)	0.92 (0.67–1.26)	1.53 (1.24–1.88)	1.24 (0.79–1.95)	1.28 (1.08–1.51)
Multi-family house	1794	1.18 (1.04–1.34)	2.06 (1.74–2.44)	1.39 (1.13–1.71)	2.40 (2.08–2.76)	1.78 (1.31–2.40)	1.36 (1.20–1.54)
Construction period							
Before 1960	4880	1.0	1.0	1.0	1.0	1.0	1.0
1961–1977	2433	1.09 (0.97–1.24)	1.28 (1.06–1.54)	1.27 (1.03–1.57)	1.23 (1.05–1.43)	1.44 (1.04–2.00)	1.26 (1.12–1.43)
After 1977	2626	1.12 (1.00–1.27)	1.28 (1.06–1.53)	1.16 (0.94–1.42)	1.23 (1.06–1.43)	1.42 (1.03–1.96)	1.22 (1.08–1.37)
Single-family house							
Before 1960	4282	1.0	1.0	1.0	1.0	1.0	1.0
1961–1977	1868	1.07 (0.93–1.23)	1.11 (0.88–1.39)	1.24 (0.98–1.57)	1.11 (0.92–1.34)	1.40 (0.95–2.06)	1.26 (1.10–1.45)
After 1977	2160	1.10 (0.97–1.26)	1.35 (1.10–1.66)	1.06 (0.83–1.34)	1.35 (1.14–1.60)	1.56 (1.09–2.24)	1.29 (1.13–1.47)
Multi-family house							
Before 1960	498	1.0	1.0	1.0	1.0	1.0	1.0
1961–1977	553	1.13 (0.84–1.52)	1.31 (0.90–1.91)	1.26 (0.77–2.07)	1.03 (0.76–1.40)	1.18 (0.61–2.28)	1.04 (0.78–1.38)
After 1977	405	1.24 (0.90–1.70)	0.98 (0.64–1.51)	1.50 (0.90–2.51)	0.74 (0.52–1.05)	0.83 (0.38–1.81)	0.84 (0.61–1.15)
Ventilation system							
Natural	6875	1.0	1.0	1.0	1.0	1.0	1.0
Mechanical exhaust	1104	1.01 (0.86–1.19)	1.12 (0.88–1.43)	1.22 (0.94–1.58)	1.17 (0.96–1.42)	1.58 (1.07–2.35)	1.23 (1.06–1.44)
Mechanical supply and exhaust	997	0.98 (0.83–1.16)	1.09 (0.85–1.41)	0.98 (0.73–1.33)	1.33 (1.09–1.63)	1.04 (0.64–1.69)	1.24 (1.06–1.46)
Surroundings							
Rural	3606	1.0	1.0	1.0	1.0	1.0	1.0
Suburban	5669	1.10 (0.99–1.22)	1.42 (1.20–1.68)	1.19 (0.99–1.43)	1.39 (1.21–1.60)	1.09 (0.82–1.45)	1.43 (1.28–1.60)
Urban	932	1.06 (0.88–1.27)	1.90 (1.48–2.44)	1.05 (0.76–1.46)	1.87 (1.52–2.31)	1.19 (0.74–1.91)	1.47 (1.22–1.76)
Flooring material ^b							
Wood	3327	1.0	1.0	1.0	1.0	1.0	1.0
PVC	4204	1.06 (0.95–1.20)	1.37 (1.15–1.64)	1.13 (0.93–1.38)	1.37 (1.18–1.59)	1.30 (0.96–1.78)	1.16 (1.03–1.30)
Linoleum	923	0.91 (0.76–1.10)	1.16 (0.87–1.55)	0.88 (0.63–1.24)	1.29 (1.02–1.62)	0.82 (0.47–1.45)	1.01 (0.84–1.22)

^a Number of children in analysis.

^b Flooring material in the index child's bedroom.

Table 4 Association between dampness indexes in homes and airway, nose, and skin symptoms among children ($n = 10,851$). Association expressed as crude Odds Ratio (OR) for each 'dampness' index

Dampness index ^a	n^b	OR (95% CI)					
		Wheezing last 12 month	Cough at night last 12 month	Asthma (doctor-diagnosed)	Rhinitis last 12 month	Rhinitis (doctor-diagnosed)	Eczema last 12 month
Water leakage							
No	7607	1.0	1.0	1.0	1.0	1.0	1.0
Yes	1896	1.15 (1.02–1.31)	1.22 (1.01–1.47)	1.28 (1.04–1.58)	1.25 (1.07–1.46)	1.13 (0.80–1.58)	1.17 (1.03–1.32)
Floor moisture							
No	9395	1.0	1.0	1.0	1.0	1.0	1.0
Yes	856	1.49 (1.27–1.75)	1.59 (1.26–2.00)	1.40 (1.06–1.84)	2.00 (1.66–2.40)	1.41 (0.92–2.14)	1.41 (1.20–1.66)
Visible dampness							
No	10202	1.0	1.0	1.0	1.0	1.0	1.0
Yes	162	1.53 (1.08–2.18)	2.50 (1.63–3.82)	1.67 (0.96–2.91)	2.07 (1.41–3.05)	2.70 (1.36–5.35)	1.25 (0.86–1.81)
Condensation on window							
No	8406	1.0	1.0	1.0	1.0	1.0	1.0
Yes	1550	1.04 (0.90–1.19)	1.54 (1.28–1.86)	1.35 (1.09–1.69)	1.45 (1.24–1.70)	1.40 (1.00–1.97)	1.12 (0.98–1.28)

^a For definition of 'dampness' indexes (see Method).

^b Number of children in the analysis.

moisture problems and/or families living in homes with moisture problems may be more observant of symptoms, and more inclined to report them among their children. This could partly explain the associations. However, it was shown in the Nordic and European literature reviews (Bornehag et al., 2001, 2004), that studies including independent measurement of exposures (i.e. inspections) and health effects (self-reported symptoms and/or doctor diagnosed-diseases), showed an even stronger association between ‘dampness’ and health effects compared with results from questionnaire studies.

The prevalence of symptoms in our study group are in accordance with a recent study by Bjorksten et al. (1998) using the same questions concerning children aged 6–7 years. They reported the prevalence of wheezing during the last 12 months to be 10.4% whereas we found in the group of children aged 5–6 years, a prevalence of

13.3%. However, our data shows a 3% decrease in prevalence for each year from 3 to 6, indicating that we would have found about the same prevalence at age 6–7 years in Värmland. For eczema during the last 12 months Bjorksten et al. reported a prevalence of 18.4%, compared to 18.7% in this study. However, for rhinitis during the last 12 months we found a higher prevalence, 11.1% vs. 5.9%. The reason for this difference is unclear.

The frequency of dampness indications and the association with health effects in our study is supported by several other recent Nordic studies. In a case–control study on asthma among children in Stockholm, Emenius et al. (2004a) found a frequency of windowpane condensation of 14.4% among 181 cases and 7.2% among 359 controls, resulting in an adjusted OR of 2.2 (95% CI: 1.1–4.5). They also found a trend in the risk for recurrent wheeze in relation to the number of indicators of

Table 5 Association between airway, nose, and skin symptoms among 10,851 children and four dampness indexes in four different models. Associations expressed as adjusted^a Odds Ratio (OR)

Models	OR (95% CI)					
	Wheezing last 12 month	Cough at night last 12 month	Asthma (doctor-diagnosed)	Rhinitis last 12 month	Rhinitis (doctor-diagnosed)	Eczema last 12 month
<i>Model I</i>						
Water leakage	1.14 (0.99–1.33)	1.24 (0.99–1.55)	1.23 (0.96–1.58)	1.35 (1.12–1.62)	1.23 (0.83–1.82)	1.23 (1.06–1.42)
Type of dwelling ^b	1.07 (0.88–1.30)	1.56 (1.19–2.03)	1.53 (1.13–2.07)	1.93 (1.56–2.40)	2.10 (1.35–3.28)	1.52 (1.27–1.82)
Construction period ^c	1.12 (0.99–1.28)	1.21 (0.99–1.47)	1.14 (0.92–1.43)	1.21 (1.02–1.43)	1.55 (1.09–2.21)	1.24 (1.09–1.41)
Flooring material ^d						
Wood	1.0	1.0	1.0	1.0	1.0	1.0
PVC	1.01 (0.88–1.16)	1.15 (0.93–1.43)	0.98 (0.77–1.24)	1.09 (0.91–1.30)	0.90 (0.62–1.31)	1.10 (0.96–1.26)
Linoleum	0.78 (0.62–0.98)	0.88 (0.62–1.26)	0.74 (0.50–1.11)	0.91 (0.68–1.22)	0.60 (0.30–1.17)	0.95 (0.76–1.18)
<i>Model II</i>						
Floor moisture	1.53 (1.25–1.87)	1.45 (1.09–1.93)	1.39 (1.00–1.93)	1.75 (1.39–2.21)	1.46 (0.88–2.41)	1.40 (1.15–1.72)
Type of dwelling ^b	1.06 (0.90–1.27)	1.70 (1.35–2.15)	1.30 (0.98–1.73)	1.81 (1.49–2.21)	1.79 (1.17–2.75)	1.30 (1.10–1.54)
Construction period ^c	1.11 (0.98–1.26)	1.21 (1.00–1.46)	1.17 (0.94–1.44)	1.17 (1.00–1.37)	1.40 (1.00–1.97)	1.25 (1.11–1.42)
Flooring material ^d						
Wood	1.0	1.0	1.0	1.0	1.0	1.0
PVC	1.02 (0.89–1.16)	1.14 (0.93–1.40)	1.02 (0.81–1.28)	1.06 (0.89–1.24)	0.87 (0.61–1.25)	1.04 (0.91–1.18)
Linoleum	0.83 (0.66–1.03)	0.88 (0.63–1.22)	0.69 (0.47–1.03)	0.95 (0.72–1.24)	0.57 (0.30–2.41)	0.89 (0.72–1.10)
<i>Model III</i>						
Visible dampness	1.12 (0.68–1.87)	1.61 (0.82–3.16)	2.14 (1.09–4.24)	1.67 (0.94–2.96)	2.95 (1.15–7.59)	1.09 (0.64–1.84)
Type of dwelling ^b	1.10 (0.92–1.30)	1.63 (1.29–2.06)	1.38 (1.04–1.83)	1.83 (1.51–2.23)	1.92 (1.26–2.92)	1.35 (1.14–1.59)
Construction period ^c	1.12 (0.99–1.26)	1.22 (1.01–1.48)	1.17 (0.95–1.45)	1.20 (1.03–1.41)	1.44 (1.03–2.02)	1.26 (1.12–1.43)
Flooring material ^d						
Wood	1.0	1.0	1.0	1.0	1.0	1.0
PVC	1.02 (0.90–1.17)	1.13 (0.92–1.39)	0.98 (0.78–1.24)	1.05 (0.89–1.25)	0.85 (0.60–1.21)	1.04 (0.91–1.19)
Linoleum	0.86 (0.70–1.07)	0.93 (0.67–1.29)	0.64 (0.43–0.96)	1.00 (0.77–1.30)	0.56 (0.29–1.07)	0.88 (0.71–1.09)
<i>Model IV</i>						
Condensation	1.04 (0.88–1.23)	1.61 (1.28–2.02)	1.50 (1.16–1.94)	1.60 (1.32–1.94)	1.49 (1.00–2.23)	1.08 (0.92–1.28)
Type of dwelling ^b	1.08 (0.90–1.29)	1.66 (1.30–2.11)	1.37 (1.02–1.83)	1.80 (1.47–2.21)	1.77 (1.14–2.74)	1.31 (1.10–1.56)
Construction period ^c	1.12 (0.98–1.26)	1.24 (1.02–1.51)	1.26 (1.01–1.56)	1.27 (1.08–1.49)	1.54 (1.09–2.18)	1.29 (1.14–1.46)
Flooring material ^d						
Wood	1.0	1.0	1.0	1.0	1.0	1.0
PVC	1.00 (0.88–1.15)	1.12 (0.91–1.39)	0.97 (0.77–1.22)	1.00 (0.84–1.19)	0.84 (0.58–1.20)	1.02 (0.89–1.16)
Linoleum	0.84 (0.68–1.05)	0.89 (0.64–1.25)	0.67 (0.44–1.00)	0.94 (0.72–1.24)	0.57 (0.30–1.09)	0.87 (0.70–1.09)

^a Adjustments made for sex, age, allergic symptoms in family, and smoking in household (see Method for categories).

^b OR estimated for multi-family houses compared with single-family houses plus row houses.

^c OR estimated for buildings constructed after 1960 compared with buildings constructed before 1960.

^d Flooring material in the index child's bedroom.

Table 6 Association between airway, nose, and skin symptoms among 10,851 children and the combination of ‘dampness’ (water leakage) and different flooring material (wood, linoleum, and PVC). Associations expressed as adjusted^a Odds Ratio (OR)

Leakage-flooring ^b	n ^c	OR (95% CI)					
		Wheezing last 12 month	Cough at night last 12 month	Asthma (doctor-diagnosed)	Rhinitis last 12 month	Rhinitis (doctor-diagnosed)	Eczema last 12 month
All buildings							
Type of dwelling ^d		1.08 (0.90–1.30)	1.54 (1.18–2.00)	1.60 (1.19–2.14)	1.76 (1.42–2.18)	1.96 (1.26–3.03)	1.36 (1.14–1.62)
Construction period ^e		1.15 (1.02–1.29)	1.17 (0.97–1.41)	1.13 (0.92–1.40)	1.12 (0.96–1.31)	1.56 (1.12–2.17)	1.13 (1.00–1.27)
Combination							
No Leakage	6593	1.0	1.0	1.0	1.0	1.0	1.0
Leakage/Wood	562	1.02 (0.81–1.28)	1.18 (0.84–1.67)	1.00 (0.67–1.50)	1.34 (1.02–1.76)	1.22 (0.66–2.23)	1.08 (0.86–1.35)
Leakage/Linoleum	142	0.93 (0.60–1.44)	0.77 (0.36–1.66)	0.60 (0.24–1.48)	1.17 (0.70–1.98)	0.90 (0.28–2.89)	0.82 (0.51–1.30)
Leakage/PVC	749	1.24 (1.03–1.49)	1.60 (1.23–2.08)	1.48 (1.11–1.98)	1.22 (0.96–1.55)	1.18 (0.73–1.91)	1.38 (1.15–1.65)
Single-family houses							
Construction period ^e		1.18 (1.04–1.36)	1.12 (0.90–1.39)	1.04 (0.82–1.33)	1.08 (0.90–1.30)	1.53 (1.04–2.24)	1.11 (0.97–1.27)
Combination							
No Leakage	5156	1.0	1.0	1.0	1.0	1.0	1.0
Leakage/Wood	503	0.95 (0.74–1.21)	1.14 (0.79–1.66)	0.87 (0.55–1.38)	1.29 (0.96–1.74)	1.11 (0.55–2.22)	1.11 (0.88–1.41)
Leakage/Linoleum	123	0.99 (0.62–1.58)	0.94 (0.43–2.04)	0.77 (0.31–1.91)	0.87 (0.45–1.68)	0.74 (0.18–3.07)	0.66 (0.38–1.14)
Leakage/PVC	585	1.24 (1.00–1.52)	1.46 (1.06–1.99)	1.65 (1.19–2.29)	1.13 (0.85–1.51)	1.16 (0.65–2.05)	1.43 (1.16–1.76)
Multi-family houses							
Construction period ^e		1.14 (0.80–1.62)	1.27 (0.78–2.06)	1.71 (0.95–3.07)	0.87 (0.60–1.26)	0.98 (0.46–2.08)	0.96 (0.70–1.33)
Combination							
No Leakage	865	1.0	1.0	1.0	1.0	1.0	1.0
Leakage/Wood	23	1.28 (0.44–3.69)	1.14 (0.25–5.14)	5.77 (1.84–18.17)	1.29 (0.41–4.04)	1.33 (0.16–11.37)	0.76 (0.25–2.30)
Leakage/Linoleum	11	0.97 (0.24–3.85)	–	–	4.87 (1.41–16.78)	2.40 (0.28–20.53)	3.60 (1.04–12.41)
Leakage/PVC	82	1.51 (0.89–2.58)	3.20 (1.79–5.74)	1.20 (0.52–2.77)	1.78 (1.04–3.07)	1.97 (0.73–5.36)	1.46 (0.88–2.40)

^a Adjustments made for sex, age, allergic symptoms in family, smoking in the household and surroundings (for categories see Method).

^b Combinations of leakage most recent years of the child’s lifetime in bedroom, kitchen or bathroom with type of flooring in the child’s or parent’s bedroom.

^c Number of children in the analysis.

^d OR estimated for multi-family houses compared with single-family houses plus row houses.

^e OR estimated for buildings constructed after 1960 compared with buildings constructed before 1960.

‘dampness’ (Emenius et al., 2004b). In a Norwegian matched case–control study including 251 children with bronchial obstruction and 251 controls, ‘dampness’ was found in 27% of the case homes and in 14% of the control homes (Nafstad et al., 1998). Home ‘dampness’ was defined as the presence of water damage, damp stains, or visible mold/mildew growth during the last 2 years. Such self-reported ‘dampness’ increased the risk of bronchial obstruction (OR: 2.5; 95% CI: 1.1–5.5). One important finding in the Norwegian study was that confirmed self-reported ‘dampness’ by inspectors was even more strongly associated with bronchial obstruction (OR: 3.8; 95% CI: 2.0–7.2). A somewhat higher frequency of home ‘dampness’ has been reported from Finland. Haverinen et al. (2001) inspected 630 private homes and used a three-level grading system for ‘dampness’ problems, which took into account the number of damage sites in the building and the severity of the damage. They found that in 34% of the buildings there were observations of ‘dampness’ problems, i.e. levels 2 and 3. However, she did not find a dose–response relationship between severity of ‘dampness’ and self-reported symptoms. Jaakkola et al. (1993) found in a Finnish study on 2568 children (1–6 years) that any self-reported ‘dampness’ at home was significantly associated

with respiratory symptoms. However, asthma was not associated with ‘dampness’.

In other parts of the world ‘dampness’ seems to be more commonly found, especially with regard to reports on visible mould and damp spots. In a study in Germany (Nicolai et al., 1998) damp spots were found in 20% of homes of 55 children with asthma symptoms and in 16.3% of homes of 100 children without asthma. Yang et al. (1998a) used a ‘dampness’ index including visible mould or standing water or water damage or leakage in a case–control study in Taiwan ($n = 86$ children with asthma and 86 controls). Forty-nine of the cases and 31 of the controls reported ‘dampness’. In another case–control study from Taiwan the same ‘dampness’ index was found in 121 homes of 165 children with current asthma and in 80 of 165 controls (Yang et al., 1998b). Consequently, in many studies, visible mould and damp spots on wall and roof surfaces indoors are reported in much higher frequencies than in our study where such indications were reported in only 1.5% of the buildings. Such a low frequency is presumably because of our climate with cold and dry winters in combination with the current building code in Sweden focusing on energy savings, which means that the buildings have good insulation. This means that condensation on, for

example, walls indoor – with increasing risk of surface mould – is rarely seen in Sweden. On the other hand, moisture and mould problems in Swedish buildings may be more frequently located inside the building construction in floors and walls. This is indicated by the reports of, for example, water leakage and detached floor covering materials. However, hidden moisture problems are hard if not impossible to identify in questionnaire studies.

The associations between ‘dampness’ and symptoms are well in accordance with a large number of other studies (Bornehag et al., 2001, 2004). It is an enigma that the prevalence of symptoms and the strength of such associations are mainly the same in this study, with very limited visible mold growth, as in regions with much more severe moisture problems. This indicates, at least, that there are other exposures in ‘damp’ buildings than water that are of importance for health effects.

PVC as flooring material was not unequivocally associated with symptoms in this study in adjusted multivariate analyses. However, the finding that PVC as flooring material in combination with water leakage is associated with symptoms is reported here for the first time. Jaakkola et al. (1999) found in a case-control study in Norway, that the risk of bronchial obstruction was related to the presence of PVC flooring (adjusted OR: 1.89; 95% CI: 1.14–3.14). However, they also found that ‘dampness’ was associated with bronchial obstruction (Nafstad et al., 1998) but they did not combine these exposures.

The association between the combination of water leakage, PVC flooring and symptoms was found in both SH and MH. However, for MH water leakage in combination with wood flooring also increased the risk

of doctor-diagnosed asthma, and the combination of water leakage and linoleum was associated with rhinitis and eczema.

The reason for the combination of water leakage and PVC flooring to be associated with symptoms is unclear. A possible explanation is that water/moisture in the floor construction increases the degradation processes in the PVC material with emission of odors and irritative compounds. However, it should be pointed out that water leakage was mainly reported from kitchen and/or bathroom while the flooring material was reported for bedrooms, indicating that such a mechanism is less probable. Another, perhaps more reasonable, explanation is that the combination of water leakage and PVC is a proxy for something else. For example, a renovation because of water leakage often includes new PVC flooring.

In conclusion, this study shows that self-reported ‘dampness’ at home is associated with the risk of self-reported airway, nose, and skin symptoms among preschool children. However, this association can be due partly to reporting bias, which will be investigated in the next step of the study. Furthermore, water leakage in combination with PVC flooring seems to be associated with symptoms. However, the interpretation of such a finding is still unclear.

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