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Early View

Original article

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Dampness, mould, onset and remission of adult respiratory symptoms, asthma and rhinitis

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Summary

Dampness and mould at home and in the workplace building can increase onset and decrease remission of respiratory symptoms, doctor diagnosed asthma and rhinitis among adults. Our study adds new evidence on the health significance of dampness and mould.

ABSTRACT

The question addressed by the study Is dampness and indoor mould associated with onset and remission of respiratory symptoms, asthma and rhinitis among adults?

Materials and methods Associations between dampness, mould and mould odour at home and at work and respiratory health were investigated in cohort of 11,506 adults from Iceland, Norway, Sweden, Denmark and Estonia. They answered a questionnaire at baseline and ten years later, with questions on respiratory health, home and work environment.

Results Baseline water damage, floor dampness, mould and mould odour at home were associated with onset of respiratory symptoms and asthma (ORs from 1.23 to 2.24). Dampness at home during follow up was associated with onset of respiratory symptoms, asthma and rhinitis (ORs from 1.21 to 1.52). Dampness at work during follow up was associated with onset of respiratory symptoms, asthma and rhinitis (ORs from 1.31 to 1.50). Combined dampness at home and at work increased the risk of onset of respiratory symptoms and rhinitis. Dampness and mould at home and at work decreased remission of respiratory symptoms and rhinitis.

The answer to the question Dampness and mould at home and at work can increase onset of respiratory symptoms, asthma and rhinitis, and decrease remission.

INTRODUCTION

Respiratory illnesses can be affected by the home environment [1-4]. Indoor dampness and mould is associated with respiratory illness, but most studies are cross-sectional studies which limits conclusions on causality [1-4]. One review included 16 studies on associations between residential dampness and mould and incidence of asthma [1]: concluding that dampness and mould at home are determinants of incident asthma. However, only two studies investigated adult asthma [5, 6]. Later, a longitudinal multicentre study in Europe demonstrated that water damage and indoor moulds in homes was related to asthma onset [7].

Asthma and rhinitis coexist [8, 9]. An association between adult asthma and allergic rhinitis has been documented in a population study in Sweden [10]. A systematic review concluded

that dampness and mould was associated with rhinitis [2] but only two out of 31 studies were on adult rhinitis [11, 12]. None were prospective studies.

Few studies exist on asthma or rhinitis in relation to dampness at work. Working in a damp office building was associated with work-related asthma [13]. An incident case-control study found that mould and mould odour in the workplace were related to adult-onset asthma [6, 14]. One hospital study showed that water damage was associated with onset of asthma [15]. An intervention study found that remediation of mould in an office building decreased asthmatic symptoms [16].

Mould odour at home has been shown to be associated with incident asthma [1]. As compared to other dampness indicators, mould odour had the strongest association with asthma onset [1] and rhinitis [2].

More longitudinal studies are needed on respiratory effects of dampness and mould. The RHINE (Respiratory Health in Northern Europe) study is a large population based cohort study among adults [5]. Our aim was to study associations between onset and remission of respiratory symptoms, asthma and rhinitis among adults and indoor dampness, mould and mould odour at home and in the workplace building, in a RHINE follow up from 1999-2000 (baseline) to 2010-2012 (follow up).

MATERIALS AND METHODS

Ethics statement

This study was conducted with the approval of the appropriate body at each centre. All participants gave informed consent prior to participation.

Study design and target population

The RHINE II study is a follow up study of subjects from seven Nordic study centres from the European Community Respiratory Health Survey stage I (ECRHS I) in 1989-1992. In ECRHS I, 3000-4000 subjects (aged 20-44 years) were randomly selected from the population register in each centre. A postal questionnaire was then sent to those subjects.

The RHINE II study included all subjects from seven centres in northern Europe; Reykjavik in Iceland, Bergen in Norway, Umeå, Uppsala and Göteborg in Sweden, Aarhus in Denmark and Tartu in Estonia. In total, 21,681 subjects participated in ECRHS I (response rate 86%) [17]. In RHINE II, participants received a follow up postal questionnaire in 1999-2000. The

RHINE II questionnaire included questions on respiratory health and the indoor environment at home and at work. The RHINE II participants were invited for a second follow up (RHINE III) in 2010-2012, with identical questions on respiratory health as in RHINE II. Totally 11,506 participated in RHINE II and RHINE III (response rate 71%) (Figure 1). Participation was defined as answering at least one of five questions on respiratory symptoms (wheeze, nocturnal chest tightness, nocturnal attacks of breathlessness, nocturnal cough or asthma attack, see detailed description below). In the present study, we define RHINE II as the baseline study and the RHINE III survey as the follow up.

Assessment of health and demographic data

Questions regarding respiratory symptoms (same at baseline and follow up) included:

(1) "Wheezing or whistling in the chest in the last 12 months ('wheeze')";

(2) "Been woken up with a feeling of tightness in the chest at any time in the last 12 months ('nocturnal chest tightness')";

(3) "Been woken up by an attack of shortness of breath in the last 12 months ('nocturnal attacks of breathlessness')";

(4) "Been woken up by an attack of coughing in the last 12 months ('nocturnal cough')";

(5) "An asthma attack in the last 12 months ('asthma attack')";

(6) "Usually bring up phlegm or have any problem with bringing up phlegm in the last 12 months ('productive cough')";

(7) "Currently taking any medication (including inhalers, aerosols or tablets) for asthma".

Current asthma was defined as having either asthma attacks in the last 12 months or current asthma medication, or both [18].

There was one question regarding doctor diagnosed asthma:

(1) "Ever had asthma diagnosed by a doctor ('ever doctor diagnosed asthma')". This question measured cumulative incidence;

Questions regarding allergic rhinitis and rhinitis symptoms included:

(1) "Any nasal allergies including hay fever ('allergic rhinitis')";

(2) "Ever had nose symptoms such as stuffy nose, runny nose and/or sneezing when not having a cold ('ever rhinitis symptoms')". This question measured cumulative incidence of rhinitis.

Onset of doctor diagnosed asthma, allergic rhinitis and rhinitis symptoms was defined as not reporting the particular respiratory illnesses at baseline but reporting it at follow up.

Onset of a particular respiratory symptom such as wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough, productive cough or current asthma was defined as not reporting the particular symptom at baseline but reporting the particular symptom at follow up [5]. Participants with doctor diagnosed asthma at baseline were excluded when calculating onset of these respiratory symptoms.

Remission of a particular respiratory symptom (wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough, productive cough and current asthma) was defined as reporting the particular symptom at baseline but not at follow up including those with doctor diagnosed asthma at baseline.

Remission of allergic rhinitis was defined as reporting allergic rhinitis at baseline but not at follow up.

Data on gender, age, height and weight were obtained from the baseline data, while education level was only available at follow up. Smoking habit (never/ever smokers/current smokers) were available both at baseline and follow up. Body mass index (BMI) was calculated as the ratio of weight in kilograms to height in meters squared (kg/m^2). Change of smoking habit from baseline to follow up (no change/start smoking/stop smoking) was calculated. Education level was categorized as primary school, high school or university education at follow up.

Assessment of indoor dampness, mould and mould odour

Four questions about the home environment asked about the current home in the last 12 months:

(1) "Water leakage or water damage indoors on walls, floor or ceilings ('water damage')";

(2) “Bubbles or yellow discoloration on plastic floor covering or black discoloration of parquet floor (‘floor dampness’)”;

(3) “Visible mould growth indoors on walls, floors or ceilings (‘visible mould’)”;

(4) “Mould odour in one or several rooms (other than the cellar)”;

The variable “any dampness” was defined as answering yes on question (1), (2) or (3) above.

Moreover, two questions asked about home and workplace exposure during the follow up period:

(1) “Any dampness damage, water leakage or visible mould at home during the past 10 years (‘dampness or mould at home during follow up’)”;

(2) “Any dampness damage, water leakage or visible mound in the workplace building during the past 10 years (‘dampness or mould at work during follow up’)”.

A categorized variable with four alternatives was created: no dampness/mould, dampness/mould at home only, dampness/mould at work only and dampness/mould at home and at work.

Statistical analysis

We used Stata 13.0 (Stata Corporation, College Station, Texas, USA). Two level (centre, individual) logistic regression models were performed to estimate associations between dampness indicators at baseline or during follow up and onset of respiratory symptoms (wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough, productive cough and current asthma), doctor diagnosed asthma, allergic rhinitis and rhinitis symptoms, adjusting for gender, age, smoking habit at baseline, change of smoking habit from baseline to follow up, BMI at baseline and education level at follow up. Subjects with doctor diagnosed asthma at baseline were excluded when analysing onset of respiratory symptoms. Similar two level logistic regression models were then applied to estimate associations between dampness indicators and remission of respiratory symptoms and allergic rhinitis. Additionally, associations between combination of dampness and mould at home and at work during follow up (categorized as none, at home, at work or both) and onset of respiratory symptoms and allergic rhinitis were estimated using similar logistic regression models.

Associations were expressed as odds ratios (OR) with a 95% confidence interval (CI), with 5% significance.

RESULTS

Totally 11,506 respondents were included, 54.3% were females, 26.3% current smokers and 26.4% were ex-smokers at baseline. During follow up, 2.4% started smoking and 12.1% stopped smoking. There were no associations between smoking habit and dampness indicators at baseline (RHINE II). The mean age at baseline was 40 (SD=7.3) years. The mean follow up time was 11.3±1.1 years. Non-participants in RHINE II had slightly higher prevalence of wheeze, nocturnal chest tightness and nocturnal attacks of breathlessness but lower prevalence of allergic rhinitis in ECRHS I as compared to participants (data not shown). Moreover, non-participants in RHINE III had slightly higher prevalence of respiratory symptoms and asthma in RHINE II as compared to participants (Table 1). However, prevalence of dampness indicators at home at baseline (RHINE II) did not differ between participants and non-respondents for RHINE III (Table 1).

The highest onset rate over the study period was for rhinitis symptoms (25.9%). Onset rates of wheeze (9.9%), productive cough (9.3%) and allergic rhinitis (9.5%) were similar. The onset rate for doctor diagnosed asthma was 4.3%. Among all the centres, Tartu hade the highest onset rate for most respiratory symptoms. Around half of the participants with wheeze, nocturnal cough or productive cough at baseline were free from having the particular symptoms at follow up. The highest remission rate was for nocturnal chest tightness (66.9%) (Table 2).

Among environmental factors reported at baseline, water damage (13.4%) and visible mould (6.7%) were most common (Table 3). A quarter (25.2%) of the participants in follow up reported dampness at home in their current or previous home during the past 10 years, and 19.4% reported dampness in their current or previous workplace building in the past 10 years. All signs of indoor dampness, except floor dampness, were most common in Tartu. Floor dampness was most common in Reykjavik. Mould odour was most common in Tartu. In general, the signs of indoor dampness and mould were less common in Bergen, Göteborg and Umeå.

Dampness indicators at baseline and during follow up were risk factors for onset of wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough, productive cough,

current asthma or doctor diagnosed asthma (Table 4). Mould odour at baseline was associated with onset of wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough and doctor diagnosed asthma (Table 4).

There were few associations between dampness indicators and rhinitis. Dampness or mould at home during follow up was the only risk factor for onset of allergic rhinitis. Dampness or mould at home during follow up and dampness or mould at work during follow up were both associated with onset of rhinitis symptoms (Table 4).

Dampness and indoor mould decreased the remission rate. Water damage at baseline was related to less remission of nocturnal chest tightness and nocturnal cough at follow up. Visible mould at baseline was associated with less remission of nocturnal chest tightness and nocturnal breathlessness. Any dampness at baseline decreased the likelihood for remission of nocturnal chest tightness, nocturnal breathlessness and productive cough. Dampness or mould at home during follow up was related to decreased remission of nocturnal cough and allergic rhinitis. Dampness or mould at work during follow up was associated with decreased remission of wheeze (Table 5).

Participants exposed to dampness both at home and in the workplace buildings had the strongest associations with onset of wheeze, nocturnal chest tightness, nocturnal breathlessness, nocturnal cough, productive cough, doctor diagnosed asthma and rhinitis symptoms (Table 6).

Table 1. Respiratory health and dampness indicators in RHINE II among participants and non-participants in RHINE II.

		Participants in RHINE III (N=11,506)	Non-respondents in RHINE III (N=4,625)	p
Health RHINE II	Wheeze	19.4	23.6	<0.001
	Nocturnal chest tightness	10.6	12.8	<0.001
	Nocturnal attacks of breathlessness	4.7	6.7	<0.001
	Nocturnal cough	28.3	30.8	0.002
	Productive cough	16.6	21.1	<0.001
	Current asthma [a]	6.5	7.5	0.022
	Ever doctor diagnosed asthma	7.9	9.1	0.010
	Allergic rhinitis	23.3	22.9	0.525
	Ever rhinitis symptoms	47.9	48.9	0.265
Dampness RHINE II	Water damage	13.4	13.6	0.713
	Floor dampness	3.8	3.8	0.862
	Visible mould	6.7	6.7	0.963
	Mould odour	3.5	3.8	0.349
	Any dampness [b]	17.9	18.1	0.685

[a] Current asthma was defined as either asthma attack in the last 12 months, current asthma medication or both.

[b] Any dampness was defined as water damage, floor dampness or visible mould in the last 12 months at baseline.

Table 2. Onset and remission over the study period of respiratory symptoms, asthma, allergic rhinitis and rhinitis symptoms (%).

		Aarhus (%)	Reykjavik (%)	Bergen (%)	Göteborg (%)	Umeå (%)	Uppsala (%)	Tartu (%)	Total (%)
Onset	Wheeze	8.7	13.0	9.4	9.5	7.7	8.8	13.7	9.9
	Nocturnal chest tightness	8.5	8.4	6.3	6.9	4.1	4.6	13.9	7.2
	Nocturnal attacks of breathlessness	2.4	2.2	3.8	2.9	3.1	2.9	11.0	3.7
	Nocturnal cough	13.4	16.6	12.3	17.5	18.4	16.7	31.5	17.0
	Productive cough	6.6	12.0	9.0	9.8	9.7	7.5	12.6	9.3
	Current asthma [a]	2.6	6.3	4.8	3.7	3.3	4.7	3.6	4.1
	Ever doctor diagnosed asthma	3.4	7.0	5.9	2.4	3.9	3.7	3.8	4.3
	Allergic rhinitis	11.2	12.7	7.8	7.3	7.1	7.5	14.4	9.5
	Ever rhinitis symptoms	25.2	27.6	24.8	24.4	22.0	22.1	40.9	25.9
Remission	Wheeze	54.8	44.9	45.7	46.2	47.4	51.0	41.0	47.5
	Nocturnal chest tightness	72.4	73.4	63.0	71.3	66.7	69.0	56.1	66.9
	Nocturnal attacks of breathlessness	70.9	76.7	66.2	66.3	71.3	61.9	57.3	65.8
	Nocturnal cough	61.5	49.8	52.6	47.2	44.3	46.7	32.2	48.2
	Productive cough	62.7	56.1	55.5	49.5	51.7	54.5	57.8	54.8
	Current asthma [a]	41.4	42.6	42.1	42.6	32.3	35.9	45.5	38.9
	Allergic rhinitis	24.2	33.6	19.9	24.1	22.0	19.9	36.0	24.7

[a] Current asthma was defined as either asthma attack in the last 12 months, current asthma medication or both.

Table 3. Prevalence of signs of indoor dampness and mould at home and in the workplace building in seven centres (%).

		Aarhus (%)	Reykjavik (%)	Bergen (%)	Göteborg (%)	Umeå (%)	Uppsala (%)	Tartu (%)	Total (%)
Baseline (at home)	Water damage	13.3	20.0	13.3	8.1	10.0	8.9	23.3	13.4
	Floor dampness	1.6	6.7	2.1	4.2	5.7	3.9	2.9	3.8
	Visible mould	9.8	6.1	4.7	4.6	3.9	6.4	13.0	6.7
	Mould odour	4.2	4.8	2.3	2.4	2.5	3.2	5.9	3.6
	Any dampness [a]	17.8	22.7	16.2	12.4	14.0	14.9	31.7	17.9
Follow up	Dampness or mould at home during follow up	23.8	32.6	24.5	20.9	20.9	23.2	34.2	25.2
	Dampness or mould in the workplace building during follow up	11.6	22.1	17.1	19.4	21.0	23.5	23.7	19.4

[a] Any dampness was defined as water damage, floor dampness or visible mould in the last 12 months at baseline.

Table 4. Adjusted odds ratio (OR) with 95% confidence intervals (CI) for onset of respiratory symptoms, doctors diagnosed asthma, and rhinitis.

	Water Damage	Floor dampness	Visible mould	Mould odour	Any dampness [a]	Dampness or mould at home during follow up	Dampness or mould in the workplace building during follow up
Wheeze	1.60(1.31,1.97)	2.24(1.61,3.13)	1.49(1.12,1.98)	1.56(1.07,2.29)	1.61(1.33,1.94)	1.38(1.17,1.64)	1.46(1.21,1.75)
p	**<0.001**	**<0.001**	**0.006**	**0.022**	**<0.001**	**<0.001**	**<0.001**
Nocturnal chest tightness	1.28(1.02,1.60)	1.61(1.08,22.39)	1.21(0.88,1.66)	1.81(1.25,2.63)	1.28(1.04,1.58)	1.34(1.11,1.61)	1.50(1.22,1.83)
p	**0.035**	**0.018**	0.247	**0.002**	**0.018**	**0.002**	**<0.001**
Nocturnal breathlessness	1.32(0.98,1.79)	2.11(1.32,3.38)	1.43(0.96,2.12)	2.01(1.26,3.22)	1.48(1.13,1.93)	1.24(0.97,1.60)	1.41(1.08,1.84)
p	0.069	**0.002**	0.075	**0.004**	**0.004**	0.088	**0.012**
Nocturnal cough	1.23(1.02,1.49)	1.51(1.08,2.11)	1.34(1.03,1.73)	1.46(1.04,2.06)	1.31(1.11,1.55)	1.21(1.04,1.40)	1.47(1.25,1.72)
p	**0.032**	**0.015**	**0.029**	**0.030**	**0.002**	**0.013**	**<0.001**
Productive cough	1.21(0.97,1.51)	1.48(1.02,2.14)	1.46(1.10,1.95)	1.37(0.92,2.04)	1.35(1.12,1.65)	1.52(1.29,1.81)	1.33(1.11,1.61)
p	0.088	**0.038**	**0.010**	0.116	**0.002**	**<0.001**	**0.003**
Current asthma	1.34(1.01,1.77)	1.44(0.90,2.31)	1.25(0.84,1.86)	1.46(0.89,2.39)	1.36(1.05,1.76)	1.09(0.86,1.38)	1.25(0.97,1.61)
p	**0.044**	0.129	0.279	0.136	**0.018**	0.482	0.084
Doctor diagnosed asthma	1.36(1.04,1.78)	1.96(1.30,2.96)	1.36(0.93,1.97)	2.23(1.48,3.37)	1.43(1.12,1.83)	1.32(1.06,1.65)	1.40(1.10,1.79)
p	**0.027**	**0.001**	0.109	**<0.001**	**0.004**	**0.014**	**0.006**
Allergic rhinitis	1.14(0.92,1.41)	0.99(0.65,1.49)	1.05(0.77,1.43)	0.89 (0.57,1.40)	1.10(0.90,1.34)	1.28(1.08,1.52)	1.21(1.00,1.47)

p	0.239	0.948	0.752	0.613	0.360	**0.005**	0.050
Ever rhinitis symptoms	1.01(0.84,1.23)	1.03(0.70,1.52)	0.98(0.74,1.30)	1.23(0.84,1.79)	1.06(0.89,1.26)	1.36(1.18,1.58)	1.31(1.11,1.54)
p	0.905	0.867	0.909	0.286	0.509	**<0.001**	**0.001**

Two level logistic regression models (centre, individual), adjusted for age (baseline), gender (baseline), smoking (baseline), change of smoking habit from baseline to follow up, BMI (baseline) and education (follow up).

[a] Any dampness was defined water damage, floor dampness or visible mould in the last 12 months at baseline.

Table 5. Adjusted odds ratio (OR) with 95% confidence intervals (CI) for remission of respiratory symptoms and allergic rhinitis.

	Water Damage	Floor dampness	Visible mould	Mould odour	Any dampness [a]	Dampness or mould at home during follow up	Dampness or mould in the workplace building during follow up
Wheeze	0.89(0.70,1.15)	1.01(0.68,1.49)	1.21(0.88,1.67)	1.02(0.69,1.53)	0.93(0.75,1.16)	0.87(0.71,1.06)	0.71(0.57,0.89)
p	0.376	0.973	0.242	0.906	0.531	0.162	**0.003**
Nocturnal chest tightness	0.70(0.51,0.97)	0.69(0.42,1.14)	0.64(0.42,0.96)	0.71(0.42,1.20)	0.68(0.51,0.92)	0.84(0.64,1.12)	0.76(0.56,1.02)
p	**0.032**	0.150	**0.031**	0.196	**0.011**	0.235	0.070
Nocturnal breathlessness	0.63(0.39,1.02)	0.55(0.27,1.09)	0.52(0.29,0.95)	0.70(0.35,1.42)	0.59(0.38,0.91)	0.83(0.54,1.27)	0.68(0.43,1.09)
p	0.059	0.085	**0.035**	0.325	**0.018**	0.389	0.108
Nocturnal cough	0.79(0.64,0.98)	0.82(0.59,1.15)	0.82(0.63,1.08)	0.96(0.67,1.38)	0.84(0.70,1.01)	0.81(0.68,0.96)	0.88(0.74,1.06)
p	**0.030**	0.257	0.163	0.828	0.057	**0.013**	0.194
Productive cough	0.77(0.59,1.01)	0.82(0.54,1.26)	0.73(0.51,1.03)	0.87(0.55,1.36)	0.76(0.60,0.97)	1.01(0.82,1.26)	0.90(0.70,1.15)
p	0.055	0.368	0.077	0.541	**0.026**	0.909	0.387
Current asthma	1.36(0.86,2.17)	0.99(0.51,1.91)	1.03(0.60,1.78)	1.08(0.52,2.22)	0.97(0.65,1.44)	1.07(0.74,1.56)	1.05(0.71,1.55)
P	0.192	0.970	0.912	0.843	0.885	0.705	0.816
Allergic rhinitis	1.00(0.76,1.32)	1.10(0.70,1.75)	1.10(0.78,1.56)	1.36(0.90,2.06)	1.07(0.84,1.37)	0.77(0.61,0.96)	0.93(0.73,1.18)
p	0.991	0.676	0.576	0.148	0.581	**0.021**	0.535

Two level logistic regression models (centre, individual), adjusted for age (baseline), gender (baseline), smoking (baseline), change of smoking habit from baseline to follow up, BMI (baseline) and education (follow up).

[a] Any dampness was defined as water damage, floor dampness or visible mould in the last 12 months at baseline.

Table 6. Associations between onset of respiratory symptoms and allergic rhinitis and dampness or mould during follow up (four categories: none, at home, at work and both). Adjusted odds ratio (OR) with 95% confidence intervals (CI).

	None	Only at home	Only at work	Both
Wheeze	1.00	1.34(1.09,1.65)	1.45(1.14,1.84)	1.75(1.34,2.28)
p		**0.005**	**0.003**	**<0.001**
Nocturnal chest tightness	1.00	1.26(1.003,1.58)	1.49(1.15,1.94)	1.75(1.32,2.33)
p		**0.047**	**0.003**	**<0.001**
Nocturnal breathlessness	1.00	1.23(0.90,1.67)	1.47(1.05,2.07)	1.54(1.04,2.28)
p		0.191	**0.026**	**0.031**
Nocturnal cough	1.00	1.16(0.97,1.38)	1.44(1.18,1.76)	1.61(1.28,2.04)
p		0.115	**<0.001**	**<0.001**
Productive cough	1.00	1.51(1.23,1.85)	1.24(0.96,1.59)	1.80(1.38,2.33)
p		**<0.001**	0.096	**<0.001**
Current asthma	1.00	1.11(0.83,1.48)	1.42(1.04,1.94)	1.07(0.72,1.60)
p		0.487	**0.027**	0.741
Doctor diagnosed asthma	1.00	1.29(0.98,1.69)	1.47(1.08,2.01)	1.51(1.06,2.15)
p		0.068	**0.016**	**0.021**
Allergic rhinitis	1.00	1.31(1.07,1.60)	1.29(1.01,1.65)	1.32(0.99,1.75)
p		**0.010**	**0.044**	0.055
Ever rhinitis symptoms	1.00	1.28(1.07,1.52)	1.16(0.94,1.43)	1.75(1.37,2.25)
p		**0.006**	0.167	**<0.001**

Two level logistic regression models (centre, individual), adjusted for age (baseline), gender (baseline), smoking (baseline), change of smoking habit from baseline to follow up, BMI (baseline) and education (follow up).

DISCUSSION

In this prospective study we found associations between dampness and mould at home at baseline and onset of respiratory symptoms and doctor diagnosed asthma. Moreover, dampness and mould decreased the remission of respiratory symptoms and allergic rhinitis. Moreover, mould odour at home at baseline was associated with onset of respiratory symptoms and doctor diagnosed asthma. Dampness or mould at home and at work during follow up were related to onset of respiratory symptoms and doctor diagnosed asthma as well as allergic rhinitis and rhinitis symptoms. Exposed to dampness during follow up both at home and at work increased the risk of onset of respiratory symptoms and rhinitis symptoms.

Totally 17.9% of the homes had dampness at baseline (in the past 12 months). This prevalence is similar as reported from a previous review (16.5%) including 31 studies on dampness and mould in the European housing stock [19]. Water damage (in the past 12 months) at baseline was 13.4% in our study. This is higher than the mean prevalence of water damage (10.0%) in Europe reported from the ECRHS study [20]. In our study, the prevalence of water damage differed from 7.7% in Göteborg to 23.4% in Tartu, possibly due to different building technologies in different Nordic countries. It has been reported that dampness in homes in Europe is associated with annual precipitation and higher ambient temperature [20]. Thus, differences in climate between the centres may also play role for the differences in prevalence of dampness. However, the prevalence of visible mould in our study (6.7%) was much lower as compared to the multicentre study (16%) [20].

Participants with doctor diagnosed asthma at baseline were excluded from the calculation of onset of respiratory symptoms, since the aim was to study onset of symptoms, and not worsening of existing asthma. The associations between dampness at home and onset of respiratory symptoms and asthma in our study is consistent with two previous studies [5, 7]. Dampness at home increased onset of respiratory symptoms in the RHINE II study [5], with slightly lower odds ratios as compared to our study. The other multicentre study in Europe found stronger associations between water damage (OR=1.46), visible mould (OR=1.30) and onset of asthma than our study. Dampness problems on floors have been reported to cause higher emission of ammonia [21] and 2-etyl-1-hexanol to indoor air [22]. Previous prevalence studies reported that dampness in the floor construction can be associated with reduced lung function (FEV_1) [23, 24], asthma symptoms [5, 23-25] and asthma [26].

Our study suggested that mould odour at baseline can increase onset of respiratory symptoms and doctor diagnosed asthma. This is in agreement with a previous review on incident asthma

[1]. However, this review included mainly childhood studies [1]. Previous prevalence studies have shown associations between mould odour at home and asthma or asthmatic symptoms among adults [11, 27]. Mould odour can be enhanced by poor ventilation. One Swedish study found that mould odour at home was associated with asthma symptoms in the initial model, but the association disappeared when adjusting for measured air exchange ventilation in the home [25]. An experimental study found that increased ventilation was associated with less report of odour in university classrooms [28]. Unfortunately, we have no information on ventilation flow in the RHINE study.

We found that dampness and mould in the workplace building during follow up was associated with onset of respiratory symptoms and doctor diagnosed asthma. This is in agreement with previous studies on respiratory effects of dampness in workplace buildings. One recent review concluded that exposure to mould in workplace buildings is associated with incidence of occupational asthma [29]. A population-based incident case-control study in Finland reported that visible mould and mould odour in the workplace were associated with adult-onset asthma [6, 14]. Water damage was related to new-onset of asthma among employees in two hospitals in USA [15]. Higher level of fungal exposure in dust from a water-damaged office building was found to be associated with a higher prevalence of respiratory symptoms among the office workers in USA [30]. A prospective study from Sweden found that dampness and mould in the workplace building were associated with increased incidence and decreased remission of work-related symptoms [31].

Dampness at home and in the workplace building were related to onset of allergic rhinitis and rhinitis symptoms in our study. We have not found any other incident study on rhinitis among adults in relation to indoor dampness and mould. However, one prevalence study from China found that water damage at home was associated with current rhinitis, and visible indoor mould was associated with allergic rhinitis [27]. One Swedish population study found that mould odour was associated with pollen allergy (hay fever) [32]. Another Swedish study found that measured moisture load in the home, a marker of the excess water vapour, was associated with the prevalence of rhinitis [25].

Strengths and limitations

Selection bias initially is less likely since the participation rate for the initial ECRHS I postal questionnaire was high (86%) [17], and the response rate from RHINE II to RHINE III was reasonable (71%). Non-participants in RHINE II had slightly higher prevalence of respiratory

symptoms but lower prevalence of allergic rhinitis in ECRHS I. Non-participants in RHINE III (N=4,625) had slightly higher prevalence of respiratory symptoms and asthma in RHINE II as compared to participants. However, the prevalence of dampness indicators at baseline (RHINE II) did not differ between participants and non-respondents in RHINE III. Most of the exposure data was assessed at baseline to avoid recall bias. Similar results were obtained both in the crude and multivariate analysis with adjusting of potential confounders. Thus, our results are unlikely to be influenced by selection or information bias. One limitation is that we did not ask about family history of allergies or respiratory diseases.

CONCLUSIONS

Dampness and mould at home and in the workplace building can be risk factors for onset of respiratory symptoms, doctor diagnosed asthma and rhinitis. Mould odour can be a risk factor for onset of respiratory symptoms and asthma. Dampness and indoor mould can decrease remission of respiratory symptoms and allergic rhinitis. There is a need to reduce indoor dampness and mould as it may increase the risk of respiratory illnesses.

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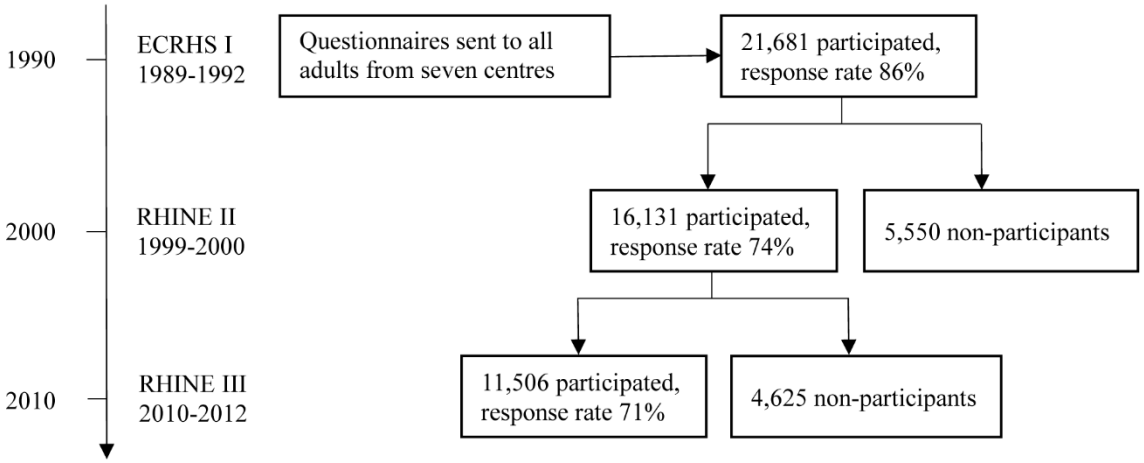

Figure 1. The flow-chart of the study design.

Support statement

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