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Sick building syndrome in relation to building dampness in multi-family residential buildings in Stockholm

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Abstract Objectives: The aim was to study relationships between symptoms compatible with sick building syndrome (SBS) on one hand, and different indicators of building dampness in Swedish multi-family buildings on the other. Methods: In Stockholm, 609 multi-family buildings with 14,235 dwellings were identified, and selected by stratified random sampling. The response rate was 77%. Information on weekly symptoms, age, gender, population density in the apartment, water leakage during the past 5 years, mouldy odour, condensation on windows, and high air humidity in the bathroom was assessed by a postal questionnaire. In addition, independent information on building characteristics was gathered from the building owners, and the central building register in Stockholm. Multiple logistic regression analysis was applied, and adjusted odds ratios (OR) were calculated, adjusted for age and gender, population density, and selected building characteristics. Results: Condensation on windows, high air humidity in the bathroom, mouldy odour, and water leakage was reported from 9.0%, 12.4%, 7.7% and 12.7% of the dwellings, respectively. In total 28.5% reported at least one sign of dampness. All indicators of dampness were related to an increase of all types of symptoms, significant even when adjusted for age, gender, population density, type of ventilation system, and ownership of the building. A combination of mouldy odour and signs of high air humidity was related to an increased occurrence of all types of symptoms (OR = 3.7–6.0). Similar findings were observed for a combination of mouldy odour and structural building dampness (water leakage) (OR = 2.9–5.2). In addition, a dose-response relationship between symptoms and number of signs of dampness was observed. In dwellings with all four dampness indicators, OR was 6.5, 7.1, 19.9, 5.8, 6.1, 9.4, 15.0 for ocular, nasal, throat, dermal symptoms, cough, headache and tiredness, respectively. Conclusion: Signs of high air humidity, as well as of structural building dampness, are common in multi-family buildings in Stockholm. Reports of building dampness in dwellings is related to a pronounced increase of symptoms compatible with the SBS, even when adjusted for possible confounding by age, gender, population density, and building-related risk factors.

Key words Air pollution · Building dampness · Dwelling · Mould growth · Indoor environment · Sick building syndrome (SBS) · Questionnaire

Introduction

Since the population spends a large proportion (65%) of the time in the dwelling (Moschandreas 1981), the home environment is an important area for indoor environmental research. Disorders that have been associated with indoor air pollution includes non-specific symptoms from eyes, upper airways, and facial skin, such disorders sometimes being referred to as the sick building syndrome (SBS) (Kreiss 1989; Hodgson 1995; Apter et al. 1994). Most SBS studies have dealt with office workers (Skov et al. 1987; Stenberg et al. 1994; Zweers 1992), and there are few studies on SBS in relation to domestic exposures (Norlen and Andersson 1993; Norbäck and Edling 1991; Bornehag 1994, Valbjørn and Kousgård 1984). Various factors, such as wall-to-wall carpeting, type of ventilation system, high room temperature, low outdoor air supply flow rate, and low air humidity have been shown to influence the prevalence of SBS symptoms (Kreiss 1989; Hodgson 1995; Apter et al. 1994). Some authors have reported an increase of SBS in...
newer buildings (Skov et al. 1987; Nordström et al. 1995; Engvall et al. 2000). In addition, SBS may be related to personal factors, such as female gender (Stenberg et al. 1994; Norbäck et al. 1996; Engvall et al. 2000), age (Engvall et al. 2000), allergic disorders (Björnsson et al. 1998; Norbäck and Edling 1991; Skov et al. 1987), and bronchial hyperresponsiveness (Björnsson et al. 1998).

Building dampness is a common indoor exposure, related to an increase of respiratory symptoms (Husman 1996; Peat et al. 1998; Piecikova and Zdenka 1999). Most of these studies have been on asthma symptoms in children in relation to dampness in dwellings, and there is little information on SBS symptoms among adults in damp dwellings (Platt et al. 1989; Waegemakers et al. 1989; Brunekreef 1992; Dales et al. 1991; Norbäck et al. 1999). Besides the study by Dales et al. (1991), on 14,799 adults, there are fewer larger population studies on SBS in relation to building dampness in dwellings. Such dampness comprises different aspects of the indoor environment facilitating growth of micro-organisms (Björnsson et al. 1995), and house dust mites (Sporik et al. 1990), including high air humidity, condensation on cold surfaces, permanent dampness in the building, and episodes of water leakage (Norbäck et al. 1999). Building dampness may also increase the emission of volatile organic compounds (VOCs) due to degradation of building materials. One example is degradation of phthalate esters, used as plasticisers in poly-vinyl chloride (PVC) floor coatings or glues (Wieslander et al. 1999).

The aim of our investigation was to study relationships between symptoms compatible with SBS on one hand, and different indicators of building dampness in multi-family buildings on the other. The following buildings-related hypothesis was tested: symptoms compatible with SBS are related to previous episodes of water leakage, condensation on windows, high air humidity in the bathroom, and mouldy odour in the dwelling. This was done by applying a standardised self-administered questionnaire in a large random sample of dwellings within an urban area (Stockholm).

**Material and methods**

**Study population**

In November–February 1991, and November–February 1993, 609 out of 11,805 (5%) multi-family buildings in Stockholm were selected from a central building register, by stratified random sampling. The stratification was based on building age, to achieve a sufficient number of buildings in each age class. The division of the buildings into age classes was based on major changes in building technology. The main sampling, of 378 buildings, was done in 1991. An additional sampling of 231 buildings built before 1960 was done in 1993, to obtain a sufficient number of older buildings in the total sample. All dwellings (n = 14,235) in these 609 buildings were selected for the study. Out of these, 12 buildings were used for care of old people only, and were not included in the study. In larger buildings with more than 29 apartments (n = 250), 30 apartments were randomly selected for the study. In buildings with less then 30 apartments (n = 347), all apartments were included. Finally, all buildings (n = 84) with less than ten respondents were excluded.

In each included apartment (n = 14,235), one randomly selected adult person (>= 18 years) was drawn by combining the building register with the civil registration register, irrespective of the number of inhabitants living in the apartment. A self-administered postal questionnaire was sent to these subjects. Since the combined building and civil registration register was approximately 1 year old, 1,368 were found not live at the actual address, according to information from the mail office or the current occupier of the apartment. The proportions of subjects not living at the actual addresses were similar (9.8–11.5%) in all age classes of buildings. In total, 9,808 out of 12,667 with correct addresses (77%) answered the questionnaire. Similar response rates were obtained in 1991 and 1993 (78% and 77%, respectively). In the statistical analysis, further restrictions were made, excluding those who reported in the questionnaire that they had lived in the current dwelling for less than 1 year (n = 736). The proportion of participants were similar in all age classes of the buildings (74–80%), with the lowest response rate for buildings built before 1930, and the highest for buildings built in 1976–84. Moreover, the response rate was similar for publicly owned buildings (69%), buildings owned by the inhabitant (72%), and privately owned buildings (69%).

**Assessment of sick building syndrome symptoms and personal factors**

A validated self-administered postal questionnaire was used, previously developed by selecting relevant questions from a more extensive interview questionnaire (Engvall and Sandstedt 2000). Information on age and gender was obtained from the postal questionnaire. The questionnaire contained seven questions on SBS; one on eye symptoms, one on nasal symptoms, one on throat symptoms, one on cough, one on facial skin symptoms, and two on general symptoms (headache and fatigue). These questions on symptoms were similar to those of the self-administered questionnaire developed by the Department of Occupational Health in Örebro (Andersson 1998). The current version (MM040NA) has been used in subsequent hospital studies (Nordström et al. 1995) and in the large Office Illness Study in northern Sweden (Stenberg et al. 1994). A recall period of 3 months was used for the symptoms. For each symptom, there were three alternative answers: “no, never,” “yes, sometimes,” and “yes, often.” Often means every week. There was one additional question for each symptom, asking if the respondents attributed the symptoms to the indoor environment in the dwelling. The prevalence of weekly symptoms (eye, nose, throat, cough, facial skin, headache, tiredness) was calculated for each symptom. In the multiple logistic regression analysis, weekly symptoms were assigned “1” and both “yes, sometimes,” and “no, never” were assigned a zero value.

**Assessment of building dampness**

The self-administered questionnaire contained questions on episodes of water leakage during the past 5 years, condensation on windows, slow drying of wet towels in the bathroom, and perception of mouldy odour in the dwelling.

**Assessment of other building characteristics and factors in the dwelling**

Information on building age, ownership, and number of apartments in the building was obtained from the central building register in Stockholm. In parallel with the questionnaire study, a telephone interview was made with the owner of each building. Information gathered from the owners included type of ventilation system. Information on the number of subjects living in the dwelling and the number of rooms was obtained from the postal questionnaire, and population density (number of subjects/room) was calculated.