

Magnitude of the mould and moisture problem in Danish homes

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ABSTRACT

The purpose of this study was to quantify the extent of moisture problems in Danish homes. A questionnaire-based survey was made and a representative sample of 3800 Danes older than 15 years responded. Main results are that 17.6% of the people have had moisture damages in their dwelling during the last 5 years and among those as much as 36.4% have not yet remedied the damages. A total of 17.7% have moisture or mould spots on their walls, ceilings or floors. As many as 40.1% have mist on the inside of their bedroom windows during winter. A total of 91.5% of the people air out their dwelling daily by opening windows but 10.8% perceive noise, air pollution, risk of burglary or others as a barrier for sufficient opening of windows. A reduction of moisture problems are only likely to be achieved by a joint effort towards ventilation systems, user behaviour, maintenance and source control.

INDEX TERMS

Dampness; Moisture; Mould; Questionnaire; Ventilation

INTRODUCTION

People spend much time at home (Schmidt *et al.*, 1989). It is therefore probable that inadequate conditions in the home can harm the health of the occupants. Dampness in the home is acknowledged as a risk factor for reduced health. Increased moisture may lead to speeded degradation of construction products resulting in increased emission of chemicals to the indoor air. Infestation with microorganisms like fungi and house dust mites may also be the result of elevated moisture content in room air and surface materials. People may develop allergy to compounds originating from the fungi or the mites. Furthermore, some fungi may produce toxic substances and many people have general inflammatory reactions to increased or prolonged exposure to mould. Finally, it is probable that other mechanisms that are not yet fully understood also may be involved in the associations between health and dampness in buildings.

Moisture damages and spots from mould or water may indicate too high content of moisture in surface materials. Valbjørn and Kousgård (1986) have demonstrated that occurrence of spots from mould or water on walls or ceilings in the home correlates to the prevalence of headache.

Bornehag *et al.* (2001) have in a review paper found that in spite there are many different definitions of damp buildings strong associations between dampness and bad health are most often found. The risk of health effects in the airways is increased for people living in damp buildings and dampness is also often associated with tiredness and headache.

The extent of the problem of damp buildings in Denmark is uncertain. A previous study (Gunnarsen, 2001) in rented apartments has shown that as many as 22% of the occupants reported that they had mould or moisture spots in their home. A visual inspection by experts confirmed this figure. However, the samples taken in the apartments by the experts on the spots could only confirm mould growth in 13% of the apartments. It is likely that inspection and self-reported spots overestimate the extent of the mould problem. There is a need for more comprehensive data on the extent of the mould and moisture problems.

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The purpose of the present study was to quantify the extent of the mould and moisture problems in the homes of Danes based on a survey using questionnaires and acknowledging the inherent limitations of the method.

METHODS

The study was part of a bigger health and morbidity survey (Keiding *et al.*, 2003). Such surveys have previously been made in Denmark in 1987 and 1994. The data gathering in this study was done spread over all seasons in the year 2000. A random sample of 5802 Danish citizens of 16 years or older was drawn from the central personal registry. Persons living in Denmark who were not Danish citizens were not included. They comprised 4.9% of the population in Denmark in the year 2000. The persons in the sample were introduced to the study through a letter. Some time after they had received the letter an interviewer visited each of the selected persons at home to get answers to both some oral questions and to questions in a questionnaire to be filled out and returned by mail after the interviewer had left. All interviewers had participated in a common introduction to make sure they had a similar approach. In case an interviewer did not meet the chosen person at home the first time he or she made additional attempts. The interview comprised approximately 120 questions and the questionnaire had approximately 40 questions. From the total sample 4357 persons were successfully interviewed and 3800 of these returned the completed questionnaire. The share of successfully returned completed questionnaires was 65.5% of the total sample. The study did not include any measurements or validations. It was therefore essential that the posed questions were easily understood and that they concerned things the occupants had or easily could get information about. This paper is based on the questions in Table 1 that were included in the self-administered questionnaire.

Furthermore, the area of the dwellings was acquired from the Danish Building and Housing Register. The area comprises all rooms to live in including entry rooms, hallways, kitchens and bathrooms and it is measured to the outer side of walls. Rooms in attics and basements, which are not suited to live in, are not included. For buildings including more than one dwelling the area of common stairs and entry rooms has been divided between each of the dwellings.

The replies were analysed by logistic regression in relation to age, gender, duration of education, marital status, age of children and dwelling type. This information was obtained during the interview. In the following only significant results ($p < 0.05$) are mentioned.

Table 1 Questions used to gather information. Original questions were in Danish

How many hours are you normally away from your home on a weekday (24 h)? Please write the closest number of whole hours:	Are there moisture or mould spots on walls, ceilings or floors at the moment?
Hours —— ——	Yes, with a combined extent of 50 cm × 50 cm or more <input checked="" type="checkbox"/>
	Yes, with a smaller extent <input checked="" type="checkbox"/>
	No, there is neither moisture nor mould spots <input checked="" type="checkbox"/>

Has there been any moisture damages in your home during the last five years?

Yes ☒
 No ☒ → proceed to next question

What caused the moisture damage?

Penetration of water through floors or walls ☒
 Leaky roof ☒
 Leaky plumbing ☒
 Spilling of water from drain or sewer ☒
 Others ☒

Do you in the morning have mist on the inside of your windows in your bedroom?

Yes, a little
 (few cm at the bottom) ☒
 Yes, a lot
 (also on the middle of the windows) ☒
 No, no mist ☒

How many adults of 16 years or more live in this household?

Write number |——|——|

How many children of 15 years or less live in this household?

Write number |——|——|

How soon was the last moisture damage remedied (meaning that the reason for the damage was fixed and the damaged dried or replaced)?

In less than 4 months ☒
 After 4 months or more ☒
 Has not yet been remedied ☒

How often during the last 14 days have you aired out your dwelling?

Daily or almost daily ☒
 Not daily but at least once per week ☒
 Maximum once during the last 14 days ☒
 Not during the last 14 days ☒

Are there any conditions reducing your ability to air out your dwelling sufficiently?

Yes, noise outside ☒
 Yes, air pollution outside ☒
 Yes, the risk of burglary ☒
 Yes, other conditions ☒
 No ☒

RESULTS

Danes spend on average many hours at home each day. Figure 1 shows a cumulative chart of the average hours spent at home on a weekday for different age groups. The number of hours spent at home is increasing with age. The average value for persons in the age 16–74 years was 16.3 h. A total of 24% of the persons stated that they spend more than 20 h at home on a weekday. This fraction is increasing with age and it is higher for women than for men. With increasing length of education the fraction is decreased. In urbanized regions, people spend less time at home. Married, widows and people living with small children spend relatively more time at home. Apparently, the type of dwelling is not significant for the fraction spending more than 20 h at home.

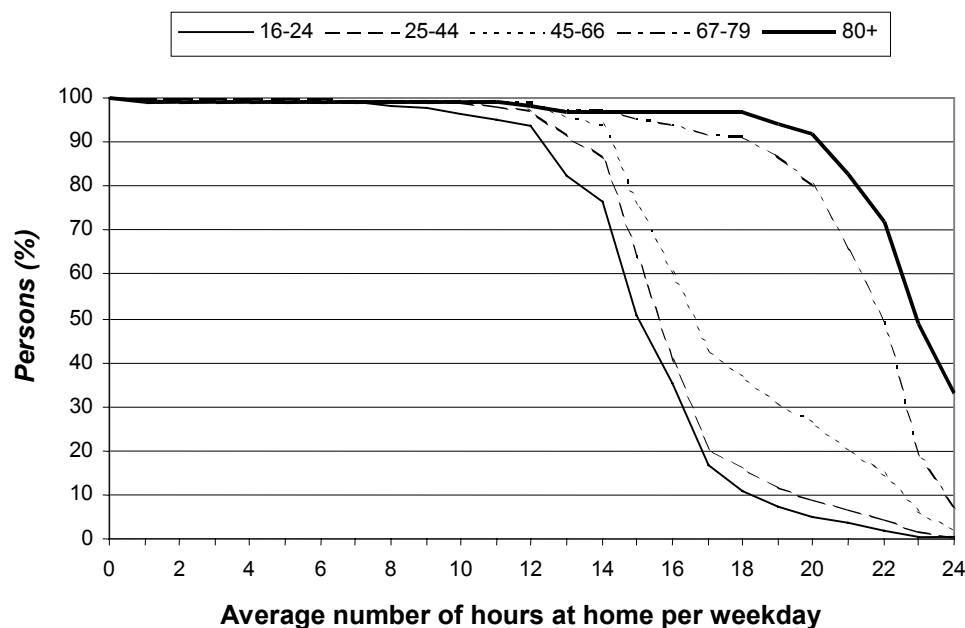


Figure 1 Cumulative chart of the average hours spent at home on a weekday in different age groups.

The average size of the dwellings is 123.9 m^2 , the household of the average person comprises 2.5 persons and the average area per person is 48.9 m^2 . A cumulative chart of the area of dwelling per person is shown in Figure 2.

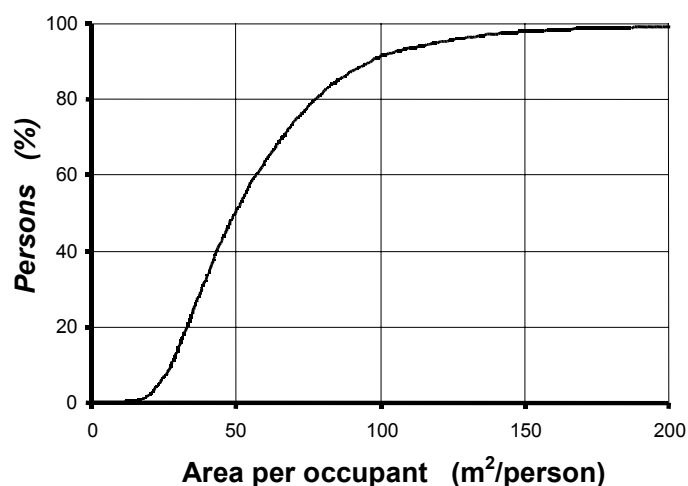


Figure 2 Cumulative frequency distribution of the dwelling area per occupant.

Mould or moisture spots could be seen in 17.7% of the homes of the persons. Only 3.5% reported the spots to be bigger than $50 \times 50 \text{ cm}^2$. The rest (14.4%) reported smaller spots. People in the age group 25–44 years reported spots more frequently.

Moisture damages had a similar prevalence; 17.6% reported that they had had a moisture damage within the last 5 years. The most frequent reason for the damage was 'Penetration of water through floors or walls'. A total of 7.2% reported this reason. 'Leaky roof' was the reason for 5.4% of the damages, 'Leaky plumbing' resulted in 2.7% of the damages and 'Spilling of water from drain or sewer' gave 1.8%. Finally, 4.0% reported other reasons. Also here the age group 25–44 years reported more moisture damages. Moisture damages are often

neglected. As many as 36.4% of persons with moisture damages reported that the damages had not yet been remedied.

Most Danes live in houses with double pane windows. When mist forms in winter on the inside of such windows it indicate elevated humidity of the indoor air. House dust mites may proliferate at such humidity and the risk of mould growth is increased. 40.1% of the 1270 persons responding during winter stated they had a little mist on the inside of their windows, 5.8% stated they had a lot and 54.1% had no mist. Older people reported less mist. People with children older than 6 years reported more mist and people living in multi-storied houses had relatively low probability to report mist.

Danes are often quite active to air out their dwellings. A total of 91.5% reported that they did it daily. In particular, the younger men but also younger women have a relatively high fraction that does not air out daily. The married and the divorced as well as those with children over 6 years do have a large fraction doing it on a daily basis. Apparently there are no significant differences in this behaviour between those living in the different dwelling categories.

A total fraction of 10.8% perceive barriers to air out sufficiently. 4.2% perceive outside noise as a barrier, 2.3% outside air pollution, 5.8 risk of burglary and 2.7% have other barriers. Some name several barriers therefore the barriers add up to more than 10.8%.

DISCUSSION

Often a weekday is considered to comprise 8 h work, 8 h leisure time and 8 h sleep. If both leisure time and sleep were fully spent at home the total time at home would make only 16 h. Nevertheless, the results show that the average person in the age group 16–74 years spends as much as 16.3 h at home on a weekday. Some overestimation of the time spent at home could be expected based on the reversed question where people should state the number of hours spent away from the home. Forgotten activities away from home would in this way be counted as hours spent at home. The results are, however, in line with a previous presentation of time budgets for Danes (Schmidt *et al.*, 1989).

Slightly more than 1 in every 6 persons report to have moisture damages (17.6%) or spots of moisture or mould (17.7%) in their home. More than 1/3 of the moisture damages (36.4%) have not yet been remedied. This high share of untreated damages indicates widespread neglect of the possible health impact of such damages. There is a need for efficient communication of the risks and the required alleviating measures to occupants, owners and people responsible for building maintenance.

Construction products are not infested with mould at water activities less than 75%RH (Nielsen, 2000). The indoor air will during the heating season normally be much drier in dwellings in Denmark. Fungi infestation therefore normally occurs as a result of water leaks or other direct wetting of materials. The infestation may also be the found behind furniture and on other surfaces with low temperatures due to insufficient insulation. The result of the links between dampness problems, ventilation systems, occupant behavior, insulation of structures, moisture sources, damages and maintenance is a shared responsibility between owners and occupants. It is essential that people living in dwellings with low ventilation rates and rather poor insulation air out their dwelling frequently and always when high moisture production occurs. Water damages should be remedied efficiently and without delay. Moisture sources such as washing, clothes drying, bathing and cooking should be limited or handled by increased and preferable localized exhaust. The often-found lack of remedial action towards moisture damages may also be a result of the shared and unclear responsibility. Owners may claim that the tenants are causing the dampness problems by their behaviour and tenants may claim that they are blameless because of insufficient structures or installations.

The 10.8% of the population perceiving barriers to air out sufficiently face particular constraints to moisture sources in their dwelling.

CONCLUSIONS AND IMPLICATIONS

One in every six Danes has mould or moisture spots in his or her dwelling. A similar fraction states that they have had a moisture damage in their dwelling within the last 5 years. More than one-third of the reported moisture damages have not been remedied.

Moisture damages and probably other dampness problems are often neglected by occupants and owners of buildings.

A joint effort towards ventilation systems, user behavior, source control and maintenance is required to reduce dampness problems.

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