

INDOOR CLIMATE PROBLEMS IN DANISH DWELLINGS. COMPLAINTS AND DISEASES REFERRED TO THE TYPE AND MATERIALS OF DWELLINGS AND THE LIVING HABITS

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ABSTRACT

Questionnaires from 240 Danish dwellings, where indoor climate problems occur, have been worked up in order to find any connections between the complaints and the building materials, the living habits or the design of the dwelling.

The frequency of complaints is tabulated. Headache, eye irritation and dry upper airways had the highest score.

Tendencies showing connections between eye irritation, respectively airway irritation and emulsion paint on inner walls have been found.

Tendencies showing connections between dry upper airways and concrete as well as newly restored dwellings have been found.

In dwellings where headache and airway irritation occur, three or more airings are being used significantly more frequent.

Dwellings where eye irritation occurs are significantly more frequent only 0-4 years old.

KEYWORDS

Indoor climate; dwellings; complaints; diseases; energy conservation problems.

INTRODUCTION

Energy conservation in buildings causes profound changes in the indoor climate. The better insulation creates better thermal climate and reduces risk of condensation on exterior walls and windows. The reduced infiltration and ventilation caused by tightening of the construction and by fewer window openings raise the interior air humidity as well as the content of vapours and gases from building materials, human beings, and from processes such as cooking, tobacco smoking, etc.

Many materials, as for example floor coverings and organic coatings giving off gases and vapours, are being introduced into the houses to a greater extent so that new houses have a higher concentration of organic gases and several more different

gases than older houses. These assertions on the change in air quality have been proved by Mølhav and Møller (1979).

The public discussion on indoor climate has in the last years dealt with assertions such as: that houses built of concrete are unhealthy, that the air humidity is too low (it varies from approximately 30 % RH to 65 % RH during the year in Danish dwellings), and that use of "modern", e.g. synthetic, materials causes an unpleasant climate.

The discussion on the radioactive gas, radon, coming among others from the building materials has forced the uncertainty. The formaldehyde from chipboards which has caused serious irritations in airways, and probably health effects too, has proved the necessity of demands to the building materials as well as to the ventilation. The Ministry of Building has supplied the building code with norms for formaldehyde offgassing from chipboards. The code intends to have indoor concentrations of formaldehyde not higher than 0.15 mg/m³.

INVESTIGATION ON HEALTH AND QUALITY OF THE DWELLINGS

A few investigations on the health standard in Denmark, where the quality of the dwelling is one of the parameters, have been carried out. Vagn Christensen (1956) found by comparing two housing areas, the one with old, small dwellings (slum), the other with good-standard dwellings in the outskirts of the city, that children have from 2 to 8 times higher morbidity in the slum than in the other dwellings depending on the size (number of rooms). The slum dwellings had usually more than 2 persons per room.

The latest investigation is "Health in modern flats", Ib Andersen et al (1977). In this investigation, which included 412 families, the purpose was to compare the health and comfort of inhabitants in modern flats built of bricks with inhabitants in similar flats of concrete. All dwellings were built after 1960. Temperature and humidity were measured. The investigation showed a little lower incidence at the mother and the youngest child of common diseases and of complaints about indoor climate in the buildings made of bricks. Ventilation rate was not taken into account, nor the other building and interior materials. An important result is that the morbidity was drastically lower than even in the best area in the earlier mentioned investigation by Christensen (1956).

INDOOR CLIMATE SECRETARIATE

In 1978, the Danish Building Research Institute organized a secretariate with the purpose of

- assembling information of complaints and diseases referred to the indoor climate, and systematically referring these to the building materials, construction and living habits in the houses
- informing the users (public), consulting engineers, architects and medical practitioners of results from research projects
- formulating the experiences into research or information projects.

A questionnaire was developed and through interviews in the papers, the TV and the radio the public were invited to contact the secretariate when having complaints, or problems with the health which they assumed to have connection with their dwelling.

9 different pamphlets giving answer to common questions was produced. The titles are: Temperature in dwellings, Air humidity, Allergizing components in the dwelling, Ions, Static electricity, Radioactivity, Why irritated eyes?, Condensation on windows and walls, and Noise.

16.000 pamphlets have been distributed by post or at meetings and exhibitions. At the end of 1979 approximately 1100 calls were registered. Many of these received pamphlets and/or direct advices. 424 families also received the questionnaire, which was returned by 240 families. The questionnaire contains more than 100 questions. The questions deal with the persons' living in the dwelling, their age, profession, health and smoking habits, as well as complaints related to the dwelling and the year when the complaints started. The dwelling is described by type, age, material of outer walls, interior walls, ceiling and floor as well as the coverings on floor and walls. There are questions on ventilating habits, cleaning habits, and the laundry-drying habits. Finally, the persons are asked directly of their view on noise, dust, odour, temperature, draft, humidity, static electricity and vibrations.

RESULTS

From the 1100 calls a frequency analysis gives the result seen in table 1, where the reason for calling the institute is given. Some of these calls concerned working sites representing more than one person (family), but they are registered as one case.

TABLE 1. Frequency of Reasons for Calling the Indoor Climate Secretariate. Total 1100 Calls.

Reasons for calling	%	Reasons for calling	%
General questions about indoor climate	21	Other gases from building materials	6
Allergy/asthma	13	Headache	5
Static electricity	11	Thirst	4
Humidity	8	Odours	2
Eye irritation	7	Noise	2
Airway irritation/dry upper airways	7	Eczema, dry skin	1
Formaldehyde	6	High temperature	1
		Low temperature	1
		Dust	1

The Dwellings

The following results are based on 240 questionnaires received from September 1978 to January 1980 from all parts of the country.

50 % of the dwellings represented by the 240 questionnaires are built later than 1970 and 68 % later than 1960. Compared to the distribution for the whole country the dwellings are not representative as only approximately 17 % live in houses built later than 1970 and approximately 35 % in houses built later than 1960.

62 % of the dwellings are single-family houses while less than 57 % of all Danish dwellings are single-family houses. Due to this the dwellings have generally more rooms as approximately 58 % have 4 rooms or more against normally 50 %.

The dwellings have totally 627 occupants. The average number of occupants per dwelling is 2.6 which is equal to the average for the whole country. Per room the average number is 0.66 against normally 0.76. Females and males are represented equally.

Housewives/-men, pensioners, and salaried-employed are represented by a higher percentage than normally while skilled and unskilled workers are underrepresented.

Taking this information into account it is obvious that there must be a tendency towards a lower representation of flats than of single-family houses, simply due to the fact that salaried-employed more frequently live in single-family houses than skilled and unskilled workers.

Complaints

Table 2 indicates the frequency of complaints from the occupants in the 240 dwellings. The complaints are answers to the question: "Which are the indoor climate problems?".

Headache, dry upper airways and eye irritation are the three most common complaints. The paper is mainly dealing with these and with airway irritation.

The data from the questionnaires have been tested in order to see, if dwellings where a specific complaint occurs, have another frequency of age, materials used or airings done than dwellings without this specific complaint. Table 4 gives a survey of the tests which have been done and the tendencies found.

TABLE 2. Frequency of Complaints from totally 627 Occupants living in 240 Dwellings.

Complaint	%	Complaint	%
Headache	24	Asthma	4,5
Dry upper airways	16	Humidity	4
Eye irritation	15	Static electricity	3,5
Tiredness	13,5	Itch	3,5
Colds	12	Dryness	3
Coughs	9	Giddiness	3
Airway irritation	8,5	Loss of concentration	2,5
Eczema	7	Odour	2
Difficulty in breathing	6,5	Low temperature	2
Allergy	5,5	High temperature	2
Depressions	5		

Questions have been made on several climatic parameters and the results are shown in table 3.

The frequency of some diseases is mentioned in the text.

TABLE 3. Evaluation of Climatic Parameters in 240 Dwellings with Indoor Climate Problems.

Parameter	Percentage annoyed	General evaluation
Noise	21	15 % dissatisfied with sound insulation from outside. 24 % dissatisfied with sound insulation inside the dwelling.
Odour	18	
Dust	18	
Glare	6	
Vibrations	8	
Draft	30.5	
"Cold feet"	winter 35.5 summer 15	
Static electricity	winter 36.5 summer 21	
Heat	26	
Air temperature	winter summer	14 % feel temperature warm and 14 % cold 40.5 % feel temperature warm and 2 % cold
Humidity	winter summer	53 % feel the air dry and 7 % humid 35 % feel the air dry and 4 % humid

Headache

24 % of all persons indicate that their headache might have connection to the dwelling. These persons represent 81 dwellings. 30 % of all persons take drugs against headache at least one day per month. 15 % take drugs more than 7 days per month. It is the double amount of that indicated for grown-up persons in the latest Danish investigations (Andersen 1977). On the contrary an investigation (Nørrelund, Hollnagel 1979) among 40 years old men and women indicated that 50 % suffered from moderate or hard headache. Headache seems to be common. In dwellings headache could be caused by high temperature or by organic or other gases from paints, etc. or from carbon dioxide in badly ventilated rooms (from tobacco smoke or the expiration).

The air temperature in dwellings where at least one person suffered from headache did not differ from the one in all other buildings. The average temperature was calculated to 21 °C, and the preferred temperature was 21.5 °C with a minimum and maximum temperature of respectively 18 °C and 25 °C.

The tests showed that in dwellings where headache occurs 51.1 % did use three or more airings per day compared to 36.4 % in other dwellings, and in 28.2 % of the dwellings the airing time was more than 1 hour compared to 15.8 % in other dwellings. This is significant ($p > 97.5 \%$ and $p > 99.5 \%$).

TABLE 4. Analyses done and Tendencies found in the Investigation.

	Headache	Eye irritation	Dry upper airways	Airway irritation
Number of dwellings	81	64	61	34
<u>Parameters tested</u>				
Air temperature	0			
Outer wall material			concrete walls, higher frequency (fig. 2)	0
Interior wall finish		emulsion paint, higher frequency (fig. 1)	0	emulsion paint, higher frequency (fig. 4)
Ceiling material	0	0	concrete, higher frequency (fig. 3)	0
Floor covering	0	0	0	0
Number of airings per day	≥ 3 , signific. higher freq.		≥ 3 , higher frequency	≥ 3 , signific. higher freq.
Airing time	> 1 h, signific. higher frequency		0	0
Time since last restoration (painting, etc.)			$< \frac{1}{2}$ year, higher frequency	0

"Higher frequency": 1.4 times higher percentage of the specific material is used in dwellings with a given complaint.

(0) : No tendency or less than 1.4 higher frequency found.

No text : No analyses has been done.

Eye Irritation

Eye irritation occurs among 15 % of the persons. These persons represent 64 dwellings.

Eye irritation is a typical reaction for persons with hayfever or allergic diseases as well as a reaction to formaldehyde and tobacco smoke. Among dwellings where eye irritation occurs 22 % are only 1-2 years old and 33 % 1-4 years old against respectively 12.5 % and 20 % for dwellings without this specific complaint. This is significant ($p > 99.5 \%$). There is also a tendency to have more frequently emulsion painted walls in dwellings where eye irritation occurs (fig. 1).

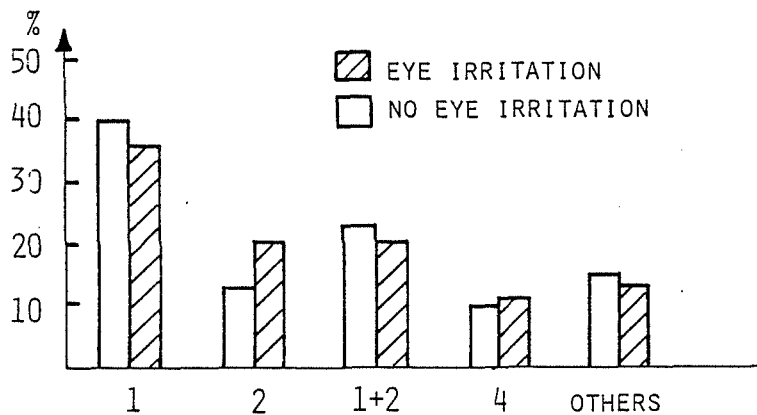


Fig. 1. Type of inner wall finish in dwellings with (64 dw) and without (175 dw) complaints from eye irritation. 1. wall paper, 2. emulsion paint, 1+2. emulsion paint on wall paper, 4. canvas tapestry.

This experience supports the assumption that a higher gas concentration might provoke reactions to people with a low tolerance to airborne irritants. It should be tested, if many allergic persons are among the group with eye irritants.

Totally, the questionnaire shows a high degree of eye inflammation compared to Andersen (1977), as 8 % in our investigation have more than 3 cases per year against less than 1 % in the reference.

Dry Upper Airways

Dry upper airways occur among 16 % of the persons. These persons represent 61 dwellings.

Dry upper airways is a typical complaint not only reported in dwellings but also in schools among teachers and in offices.

Dry upper airways can be caused by stress, medicine, and irritation of the nasal mucous membrane nerve from gases, dust, etc. The complaint has been tested and some tendencies found. There are more frequently concrete walls and concrete ceilings in these dwellings (fig. 2 and 3).

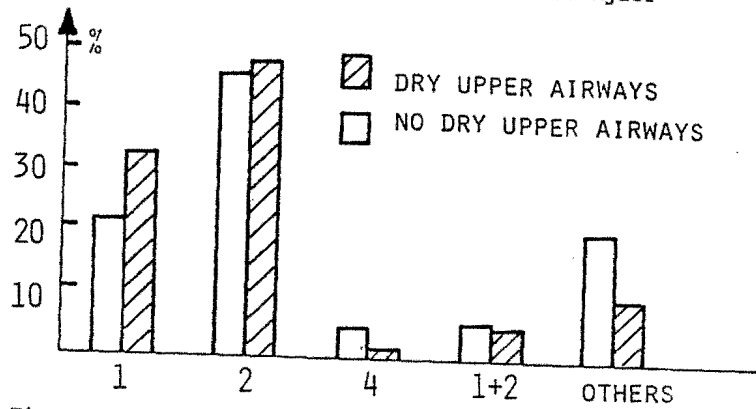


Fig. 2. Type of outer wall material used in dwellings with (61 dw) and without (176 dw) dry upper airways. 1. concrete, 2. bricks, 1+2. concrete and bricks, 4. lightweight concrete.

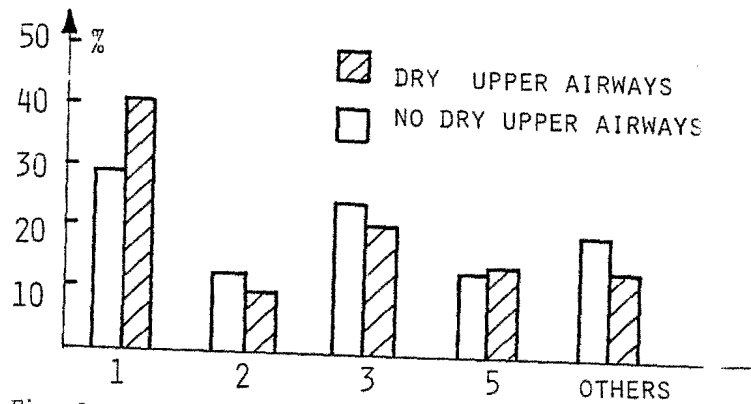


Fig. 3. Type of ceiling material used in dwellings with (61 dw) and without (176 dw) dry upper airways. 1. concrete, 2. gypsum boards, 3. wood/fibre wood, 5. plaster.

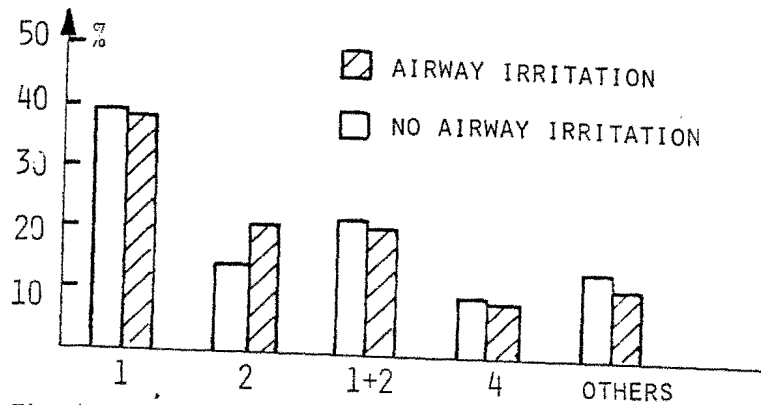


Fig. 4. Type of inner wall finish in dwellings with (34 dw) and without (203 dw) airway irritation. 1. wall paper, 2. emulsion paint, 1+2. emulsion paint on wall paper, 3. canvas tapestry.

More frequently it is only half a year since the dwellings have last been restored. The age of the dwellings does not show any influence.

Airway Irritation

Airway irritation occurs among 8.5 % of the persons. These represent 34 dwellings.

In dwellings where airway irritation occurs the interior wall finish is more frequently emulsion painted (fig. 4). No other of the materials tested are more frequently used. The number of airings were three or more in 61.8 % of the dwellings compared to 37.7 % in other dwellings. This is significant ($p > 99.5 \%$).

Complaints in "Healthy" and "Unhealthy" Dwellings

As a consequence of the hypothesis about the influence of gases, odours, and humidity on well-being we have tried to separate supposed "unhealthy" dwellings which are small, newly built or newly restored and have only few airings, in order to compare the complaints in these dwellings with the complaints in "healthy" dwellings which are large, older or restored several years ago and have many airings per day. Only 16 dwellings (with 38 occupants) of the first type and 30 dwellings (with 93 occupants) of the last type fulfilled the criteria.

In this small number of dwellings actually the opposite tendency from the one expected did appear. There were less complaints in the "unhealthy" dwellings.

Asthma, Allergy and Hayfever

Many of the registered symptoms, except headache, are allergic symptoms. It is well-known that allergic persons react to irritants, as for instance organic gases, and to other physical stress factors as well. Among the persons in this investigation there are 12 % suffering from hayfever or allergy and 12 % from asthma. It is the double of the cases found by Andersen (1977). The living habits are essential to this group. The knowledge of these habits can hardly be achieved by a questionnaire alone.

Ventilation

A typical Danish dwelling has a natural ventilation equivalent to approximately 0.6 air changes per hour. It can vary from 0.3 or less to 0.9 or more. It means that a tight dwelling without or with few airings might have up to 3 times higher concentration of gases and vapours than another untight dwelling. This important factor is not known for the 240 dwellings.

It has been seen (table 4) that in dwellings where headache, dry upper airways and airway irritations occur there are a tendency to have more frequently 3 or more airings per day. It might be an indication of the need of ventilation, for instance caused by an extraordinary air tight or extraordinary contaminated dwelling.

An investigation in a restored, extra-insulated and tightened building with 24 flats showed that the occupants did use more airings as measurements proved that they afterwards had the same humidity. There were several complaining from trouble with the upper airways and headache.

DISCUSSION AND PROPOSALS

The number of dwellings in this investigation was limited and more dwellings should be included before making further analyses. However, some tendencies which support the public opinion of the influence of some building materials have been found.

The questionnaire used in this investigation is used in the daily work as basis for a dialogue with the occupants. In some cases measurements have been done, or just visual investigations. Only with the last steps a safe diagnosis can be set up.

Example: A family with 3 persons living in a 82 m² flat built in 1965 suffered since they moved in from eye irritation, colds and coughs. The walls were reported very humid and had growth of moulds near the ceiling. It was more than 3 years since any painting or restoration had been done. 3 or more airings per day was done. The insulation standard in 1965 should normally secure against condensation on walls.

The diagnosis could have been: Extraordinary tight dwelling with high water evaporation. Advice: More airings!

Measurements and a visual inspection proved that the humidity was not very high and that the mould was caused by an extraordinary cold wall. The walls passed the insulation into the cold ventilated room under the roof and were also cooled by cold air passing into the dwelling through the joint between ceiling and wall. This diagnosis could only be found by visual investigation.

It is our opinion that the best result of investigations on dwellings, living habits and health will be achieved by using questionnaires as well as visits and measurements. From the questionnaires dwellings with specific complaints can be elected for visits and measurements. It seems to be an advantage to invite people having problems to take part in the investigation, as the motivation for answering all questions in the questionnaire will be great.

In an extended investigation as proposed it is of great importance that the staff includes building technicians, medical expertise and possibly psychological and sociological expertise.

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