Indoor Environmental Factors and its Associations with Asthma and Allergy Among Swedish Pre-School Children

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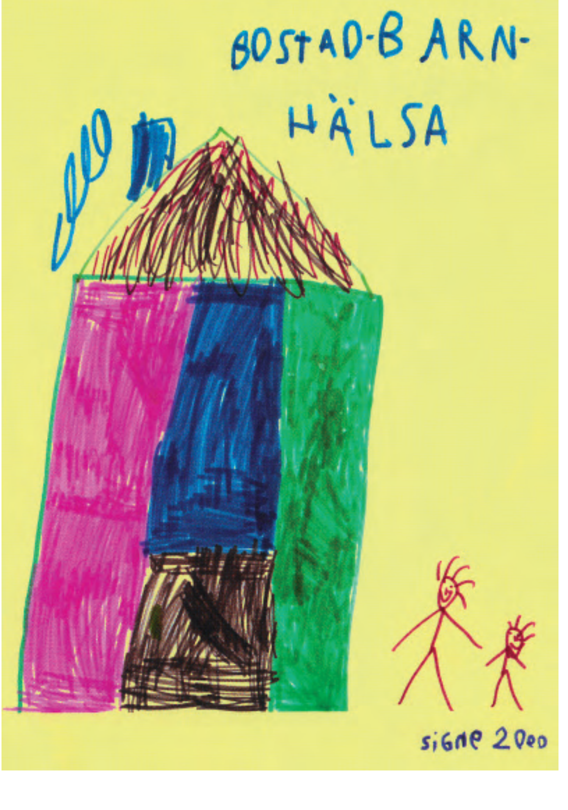
Doctoral Thesis



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To Edvin

Abstract

It has been shown in a large number of scientific studies that living or working in a building with mould and moisture damage increases the risk for asthmatic and allergic symptoms. However, there is a need to establish more valid methods to obtain a more nuanced picture of the wide range of different types of moisture related problems. Furthermore, the causal relationships and the biological mechanisms between moisture damage and health have to be shown.

The study Dampness in Buildings and Health (DBH) was started in the year 2000. Results from the first two phases of the study (a cross sectional questionnaire study on 10,851 children and a nested case control study on 198+202 children) are included in the thesis The overall aim of this work has been to study the impact of moisture related problems in homes on asthmatic and allergic diseases among children.

A dose response relationship was observed, in the case control study, between doctor diagnosed asthma/allergy among the children and inspectors' perception of a mouldy odour along the skirting board i.e. a probably sign of hidden mould damage inside the building structure. Inspectors' observations of visible damp stains or mould odour in a room were not associated with studied health effects.

The ventilation rate in more than 80% of the single family houses and around 60% of the multi family houses did not fulfil the Swedish building code requirement. It was found that children with asthma and allergy more often lived in homes with a low ventilation rate and a dose response relationship was indicated for this association in single family houses.

Validation of the used questionnaire showed that parental reports were in good agreement with the inspectors' observations regarding building characteristics, such as type of house and type of foundation and to a lower degree for type of ventilation system and flooring material. However, the concordance for mould odour and visible signs of dampness was poor. Day care attendance was shown to increase the risk for infectious diseases e.g. common colds, as expected, but also for asthmatic and allergic symptoms among children.

In conclusion, "dampness" in buildings is a major risk factor for health effects among children, such as asthma and allergies. Parental questionnaire reports on "dampness" were more valid from a health point of view than observations from inspectors.

Sammanfattning på svenska

En mängd epidemiologiska studier har visat att fuktskador i bostaden eller på arbetsplatsen ökar risken för olika typer av hälsobesvär, t.ex. astmatiska och allergiska besvär. Exakt vad som emitteras och orsakar dessa symptom i fuktskadade byggnader är inte känt, men både kemiska och mikrobiologiska agens är misstänkta. Vidare finns behov av bättre metoder för att identifiera hälsorelevanta fuktproblem i byggnader.

År 2000 startade den epidemiologiska studien Bostad-Barn-Hälsa, (Dampness in Buildings and Health, DBH). I den första fasen genomfördes en enkätundersökning där hälsa och bostadsmiljö kartlades för alla barn mellan ett och sex år i Värmland, (n=14 077). I den andra fasen fördjupades undersökningarna i en fall-kontroll studie där 198 barn med allergiska besvär och 202 friska kontroller ingick. Barnen läkarundersöktes och tekniska mätningar och besiktningar genomfördes i deras bostäder.

Resultat från fall-kontroll studien visade att i hus där inspektörerna observerade en mögellukt i golvvinkeln i något rum, var risken för astma och allergiska besvär hos barnen större. Ju starkare lukt desto större risk för besvär av typen rinit och eksem. Mögellukt i golvvinkeln kan vara ett tecken på en fukt- och mögelskada inuti konstruktionen, t.ex. i grunden eller i ytterväggen. Hus byggda mellan 1960-1983, småhus med betongplatta på mark samt hus med frånluftssystem hade i högre grad mögellukt i golvvinkeln än andra. Andra fuktindikationer som observerades av inspektörerna var inte associerade till hälsobesvär hos barnen.

Mer än 80 % av småhusen och runt 60 % av lägenheterna i flerbostadshusen hade en lägre ventilationsgrad än vad som föreskrivs i den svenska byggnormen. Vidare visade det sig att barn med besvär hade lägre ventilation hemma än friska barn.

För att validera enkäten jämfördes föräldrarnas enkätsvar med observationer från besiktningen. Det var mycket god överensstämmelse för olika byggnadstekniska parametrar som exempelvis typ av hus eller typ av grundläggning, och relativt god för typ av ventilationssystem och golvmaterial. Däremot stämde föräldrarnas rapportering av olika typer av fuktindikationer och mögellukt dåligt överens med inspektörernas uppfattning.

Slutligen visades att daghemsvistelse innebär en ökad risk för luftvägsinfektioner, vilket var väntat, men även att risken för astmatiska och allergiska symptom var större.

Sammanfattningsvis visade undersökningarna att fuktskador i byggnaden är en riskfaktor för hälsobesvär såsom astma och allergi bland barn.

Fuktindikationer som rapporterades av föräldrarna var i större utsträckning associerade till astma och allergiska besvär hos barnen, jämfört med de observationer som gjordes vid besiktningen.

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List of papers

This thesis is based on the following original publications, referred to in the text by their Roman numerals in bold (I-V).

I Hägerhed-Engman L, Sigsgaard T, Samuelson I, Bornehag CG, Sundell J.
Observed dampness and mouldy odour indoor and its association with asthma and allergy among 400 children. A nested case control study.

Submitted to Building and Environment

II Hägerhed-Engman L, Bornehag CG, Sundell J.
How valid are parents questionnaire responses regarding building characteristics, mouldy odour and signs of moisture problems in Swedish homes?

Submitted to Scandinavian Journal of Public Health

III Bornehag CG, Sundell J, Hägerhed-Engman L, Sigsgaard T.
Association between ventilation rates in 390 Swedish homes and allergic symptoms in children.

Indoor Air 2005: 15(4): 275-80

IV Hägerhed-Engman L, Sundell J, Bornehag CG.
Building characteristics associated with moisture related problems in 8,981 Swedish dwellings.

Submitted to Indoor Air

V Hägerhed-Engman L, Bornehag CG, Sundell J, Åberg N.
Day-care attendance and increased risk for respiratory and allergic symptoms in preschool age.

Allergy 2006: 61: 447-453

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Abbreviations

ach	Air changes per hour
adjuvant	Non-allergenic factor that can increase the risk for sensitization
AOR	Adjusted odds ratio
CI	Confidence Interval
ETS	Environmental tobacco smoke, i.e. passive smoking
EU	European Union
HDM	House dust mites
IAQ	Indoor air quality
IgE	Immunoglobulin E
IRR	Incidence rate ratio
kappa	Chance corrected agreement (κ)
OR	Odds ratio
p-trend	Trends in data tested by linear by linear association.
RAST	Radioallergosorbent test
RH	Relative humidity
RR	Relative risk
SBS	Sick building syndrome
TVOC	Total volatile organic compounds
WHO	World Health Organization

Introduction

Background

People do survive in sub-arctic and artic climates, in spite of the fact that the human body was developed for life in a tropical or subtropical climate. This was made possible due to the use of clothing, control of fire and the use of shelters (e.g. caves and buildings). The main aim of a building is to protect us from the outdoor climate in terms of rain, snow, wind, heat and cold etc.

In countries with a western society style of life people spend more than 90% of their time indoors according to studies from Germany (Brasche and Bischof 2005), United States and Canada, (Leech et al. 2002), figure 1. Pre-school children spend a longer time in the home compared with adults (73.3% vs.65.4%) (Brasche and Bischof 2005). Older children come into contact with other important indoor environments besides the home, such as day care centres and school buildings.

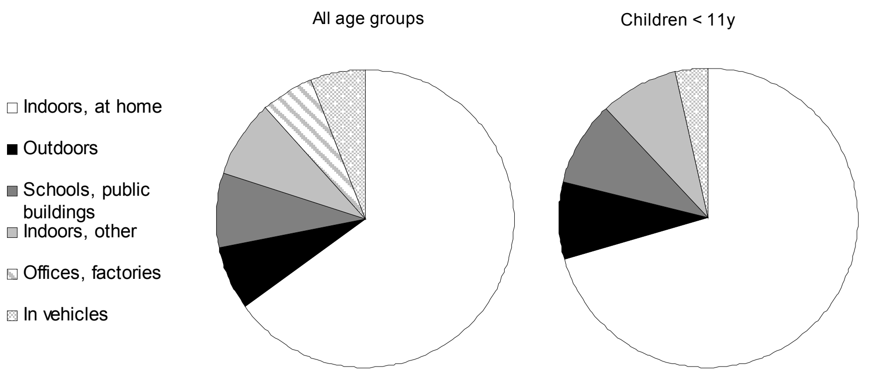

Figure 1. Time spent in different locations (%) for 9,386 persons in USA for all age groups and for a subgroup of 1,126 children younger than 11 years of age, (Leech et al. 2002).

There are a number of demands on buildings from the users, the builder and from the owner. Examples are an esthetical design, a profitable investment, a safe and healthy indoor environment, energy efficiency etc. Focusing on just one of these parameters might cause others to fail. For example, an attempt to reduce heat loss through the attic by the use of extra insulation, can lead to a decrease in temperature and an increase in relative humidity, thus increasing the risk for mould problems in the attic space. Hence, the challenge is to satisfy all the requirements, and in doing so making sure that the building fulfils the primary aim, to protect people from the outdoor climate extremes. The right to a healthy indoor air environment has been stated by several institutions such as the World Health Organization (WHO) (WHO 2000), EU (Directive 89/106/EWG) and the Swedish government (Sweden's environmental objectives 2005).

Health and comfort problems associated with indoor environment

Draughts and too high or low temperatures (poor thermal comfort) are typical comfort problems associated with indoor environments. Other complaints/problems are associated with unpleasant odours, perception of dry air, traffic noise, noisy neighbours, noisy equipment and poor lighting.

Beside comfort problems, a number of health disorders can be attributed to the indoor environment. In some cases the causes and mechanisms are well understood, but for other diseases and symptoms, the biological mechanisms are still unknown.

Sick building syndrome

A number of symptoms and complaints experienced in certain buildings or specific rooms were summarized in 1983 by WHO as Sick Building Syndrome (SBS), (WHO 1983). SBS symptoms can be grouped into the following:

- *general symptoms:* for example headache, fatigue, heavy head feeling and difficulty in concentrating.
- *symptoms of the mucous membranes:* for example eye, throat and nose irritations or coughing.
- *skin symptoms*: for example on the face, hands or scalp.

Typically SBS-symptoms disappear soon after leaving the building. In a report from 1986 it was supposed that up to 30% of new or rebuilt buildings had higher rates of SBS-symptoms than what was regarded as normal (Akimenko et al. 1986). SBS symptoms have been associated with buildings that have moisture problems (Bornehag et al. 2001, Engvall et al. 2002), a low ventilation rate (Sundell et al. 1994, Engvall et al. 2005) and with the presence of photo-copiers (Stenberg et al. 1994). Individual risk factors for SBS appear to be female sex (Brasche et al. 2001), personality (Berglund and Gunnarsson 2000, Runeson et al. 2004), atopy, anxiety, depression (Björnsson et al. 1998) and dissatisfaction with the psychosocial environment in the workplace (Wallace et al. 1993).

Asthma and allergy

The strongest individual risk factor for asthma and allergies in children is heredity, i.e. if one or both parents are suffering from asthma or allergies (Åberg 1993). The prevalence of asthma is higher among boys, but is equalized between the genders during puberty and then switches to a female predominance in adulthood (Björnson and Mitchell 2000). The first period of life appear to play a significant role for future risks for asthma and allergy. For example, breastfeeding has been shown to be a protective factor for early development of asthma and allergy (van Odijk et al. 2003, Kull et al. 2005). A study of over one million Swedish men born between 1952 and 1977 showed that the role of social economic status in relation to asthma and allergic rhinitis have changed over time i.e. a low socioeconomic status was associated to a lower risk in the earlier cohort and vice versa for the more recent group of men (Bråbäck et al. 2005).

Asthma and allergy belong to the group of disorders termed hypersensitivity. This is defined by objectively reproducible symptoms initiated by an exposure to a dose that is tolerated by a normal person (Johansson et al. 2004). Typical symptoms of allergic disease in childhood are itching recurrent eczema (dermatitis) and nettle rash (urticaria), hay fever with blocked nose and/or runny eyes (rhinitis and/or conjunctivitis), and asthma with symptoms like wheezing, coughing and sometimes difficulties with breathing. Hypersensitivity can either be allergic or non-allergic depending on whether specific immunologic mechanisms are initiating the reaction or not (Johansson et al. 2004).
Allergens are proteins that can cause sensitization and allergic or asthmatic symptoms among sensitized individuals. Examples of common indoor related sources of allergens are from furred pets, birds, house dust mites (HDM) and mould. However, sensitization to moulds is not particularly common in Scandinavian countries, compared to countries in warmer climates (Boulet et al. 1997, Hasselgren 2005). Cat-allergens are ubiquitously present in almost all indoor environments (Almqvist et al. 1999).

Other indoor air exposures that are associated with either sensitization or symptoms of asthma and allergies are e.g. tobacco smoke (both prenatal and postnatal exposure), combustion particles, NO_2, SO_2, ozone and chemical compounds in consumer products and building materials (Björksten 1999, Hirsch et al. 1999, Gilliland et al. 2000, Bornehag et al. 2004c, DiFranza et al. 2004, Penard-Morand et al. 2005). These compounds are not allergens themselves, but so-called adjuvant factors which enhance or modify the immune response to an antigen. Phthalates from soft PVC products (and from many other consumer products) have been shown to act as an adjuvant factor for allergic disease and sensitization (Öie et al. 1997, Jaakkola et al. 1999, Larsen et al. 2002, Bornehag et al. 2004c, Bornehag et al. 2005a).

Asthma and allergic diseases are some of the most prevalent chronic diseases, especially among children, and are therefore a large public health issue (SOU 1996). According to a recent report from the Swedish National Board of Health and Welfare (Socialstyrelsen 2005), more than a quarter of the Swedish children aged between 4 and 12 years suffer from serious asthma or allergy symptoms, and about 5% of all the children have asthma that has been diagnosed by a doctor. Allergic reactions to food, eczema and asthma triggered by colds are most prevalent among younger children while allergic rhinitis, doctor diagnosed asthma and contact dermatitis are more common among older children. The costs to society are high in terms of reduced life quality for the patients and their families, absence from work, disability pension, medications, and hospitalization (Dalheim-Englund et al. 2004, Rydström et al. 2005). A recent report showed that the cost for asthma in Sweden is 3.7 billion SEK per year for adults (25-56 years of age) and for the whole population around six billion SEK per year in total (Dagens Nyheter 2006, Jansson et al. 2006).

World-wide variation

There is a worldwide variation in the prevalence of asthma and allergic diseases. The ISAAC-study (the International Study of Asthma and Allergies in childhood) of nearly half a million children (13-14 years of age) in 56 countries found a 20- to 60-fold difference in the prevalence of asthma, allergic rhino conjunctivitis and atopic eczema between the included centres (ISAAC 1998). The highest prevalence of asthma (in the last 12 months) was reported from UK, Australia, New Zealand and Ireland, while the lowest prevalence was reported from Indonesia, Albania, Romania, Georgia and Greece.

The ECRHS-study (European Community Respiratory Health Survey) of adults in 22 countries, most in the western part of Europe, reported a wide variation in the prevalence of respiratory symptoms as well (Burney 1996). The highest prevalence was found in English-spoken countries which were explained by a possible cultural variable, associated with some unidentified environmental determinants of asthma. A weak but positive association between socioeconomic wellbeing, expressed in gross national product (GNP) per capita, and atopic diseases was found in one of the ISAAC studies (ISAAC

1998). However, variations in the cultural and factual environment might not explain all these differences in prevalence. Peru, for example, has a rather low GNP, but a high prevalence of asthma. It has been suggested that some of the differences between high- and low prevalence countries might be attributable to underestimations according to a recent study that have reported a similar prevalence of asthma in Estonia as in “western” countries (Meren et al. 2005).

Increased prevalence of asthma and allergy in the world

The prevalence of asthma and allergy has increased dramatically during the past decades and the incidence is highest among the younger children (Åberg 1989, Åberg et al. 1995, Downs et al. 2001, Beasley et al. 2003, Maziak et al. 2003, Anderson et al. 2004, Ellwood et al. 2005, Sennhauser et al. 2005, Carlsen et al. 2006). However, a few studies have reported that the increase of asthma may have stopped and that the prevalence has reached a peak level (Devenny et al. 2004, Robertson et al. 2004, Grize et al. 2006). However, the study by Grize et al. showed that symptoms of eczema were still on rise (Grize et al. 2006).
According to a British study, the prevalence of asthma in school-children has increased from 5.5% in 1973 to 12.0% in 1988 and up to 27.3% in 2003 (Burr et al. 2006). A Swedish study of 7-year old children between 1979 and 1991 showed an increase from 1.9% to 5.7% in the prevalence of doctor diagnosed asthma (Åberg et al. 1995). The incidence among children is around 1-2 children per 100 during one year, and for adults around ten times lower (Jaakkola et al. 2005, Kujala et al. 2005). In contrast to the well documented increase in the prevalence of asthma, data on possible changes in the incidence of asthma appears to be lacking. However, data from an American study showed that the incidence rates between 1964 and 1983 had increased for children and adolescents, but not for infants less than 1 year, or for adults (Yunginger et al. 1992).

The increased prevalence of asthma and allergies has been well documented in countries with a western society lifestyle, but also other parts of the world are experiencing an increased prevalence of asthma and allergy e.g. Kenya (Esamai et al. 2002), Qatar (Janahi et al. 2006), Thailand (Vichyanond et al. 2002), Turkey (Demir et al. 2005) and Maori and Pacific children in New Zeeland (Pattemore et al. 2004). There is a conception that the prevalence of asthma seems to increase as communities adopt a Western lifestyle and become urbanised, but the actual causes are unknown and are intensely debated (Nicolaou et al. 2005).

Why are asthma and allergies increasing?

Although genetic factors are important for the onset of asthma and allergies, the dramatic increase of asthma and allergies during the past 30-40 years has been far too rapid to be explained solely by genetic changes. Environmental exposures and life style factors have consequently been proposed as causes. There is a continuing effort to identify such causative environmental factors responsible for the overall trend of increased asthma and allergy prevalence. The explanation models for the world wide increase of asthma and allergy follow two main routes. First, the more traditional hypothesis of a dose-response relationship between exposure (i.e. allergens and adjuvant factors) and disease (Peat 1996, Beasley 1998, D'Amato et al. 2005) and secondly, the so called hygiene hypothesis, which suggests that the increase in asthma and allergy is caused by a lack of exposure, and thus dysfunctions in the immune system (Strachan 1989, Bach 2002).

The "dose-response" hypothesis suggests that the exposure of allergens and/or adjuvant factors has increased in our environment. However, the increase of asthma and allergy can not be explained by a higher amount of allergens or more pets in our homes, even if the amount of house dust mites in some indoor environments and to some extent pollen have increased during the last decades (Sundell 1994, Beggs and Bambrick 2005). The modern man has obviously become more sensitive to compounds that have been a natural part of our daily life for thousands of years. However, the increase of adjuvant factors, like the dramatic increase in air pollutants both indoors and outdoors from e.g. traffic and combustion, and a considerable increase in the use of chemicals, may play a more important role in the riddle about what could have caused the increase in allergies. In other words, the exposure to "chemicals" (adjuvant factors) rather than allergens, might explain the rapid increase in asthma and allergic diseases.

The "hygiene hypothesis" was initiated in 1989 when a group of scientists observed that children having a greater number of siblings, especially older siblings, had a reduced prevalence of hay fever and eczema, which was suggested to be a result of more cross-infections in large families (Strachan 1989). The decreased incidence of many infectious and viral diseases in developed countries as a result of antibiotics, vaccination and improved hygiene are proposed to be main factors responsible for the increase of autoimmune diseases like allergies (Bach 2002). More recent studies have turned the focus towards the microbial exposure in infancy and the intestinal microflora, which has been shown to differ between healthy and allergic infants and also between countries with high and low prevalence of allergies

(Björksten 2005). A number of recent studies have supported these theories. Less allergies have been reported among children growing up on farms with animals (Braun-Fahrländer 2000), in families with an anthroposophic life style e.g. less use of antibiotics and vaccinations (Flöistrup H et al. 2006), children who start day care centre care before the age of 12 months (Krämer et al. 1999) and children who grow up in a large family with many (older) siblings (Marshall et al. 2002).

However, some of the findings supporting the hygiene hypothesis have been questioned due to selection bias problems (Bornehag et al. 2003, Waser et al. 2005) and results to the contrary regarding for example day care attendance (Nafstad et al. 1999, Nystad et al. 1999, Brims and Chauhan 2005) and early life infections (Bager et al. 2002) have been reported. According to an article by Platts-Mills et al. the original hygiene hypothesis based on infections exposure is not an adequate explanation and a broader thinking including life style factors e.g. less physical activity and dietary changes is needed to combat the rising incidence of allergic disease (Platts-Mills et al. 2005).

Association between moisture problems in buildings and asthmatic and allergic symptoms

In reviews of hundreds of scientific articles, it has been concluded that one of the strongest and most consistent risk factors indoor for health disorders such as SBS, asthmatic and allergic symptoms is moisture problems in buildings (Peat et al. 1998, Bornehag et al. 2001, Institute of Medicine 2004, Bornehag et al. 2004a). Despite a wide variation of the definition of "dampness" in the literature and large frequency differences throughout the world , the odds ratios for airway problems such as asthma, wheeze and cough in such buildings are in the range of 1.4-2.2 (Bornehag et al. 2001, Bornehag et al. 2004a, Zuraimi et al. 2006a).

A number of chemical and biological agens are suspected to cause asthmatic and allergic symptoms in buildings with moisture problems e.g. microbes and its metabolites (Nevalainen and Seuri 2005), chemical emissions from surface material (Norbäck et al. 2000, Bornehag et al. 2004c), viruses (Hersoug 2005), house dust mites (Wickman et al. 1991, Richardson et al. 2005), but the biological mechanisms and causative agens are still mainly unknown. Sensitisation to house dust mites is proposed to play a major role in the explanation of the association between dampness and health, but it does not explain all associations. For example, in the north of Sweden, few houses have mite-infestations, and the prevalence of asthma is higher there than in the south of Sweden, where mites are more common (Munir et al. 1995).

In a follow-up study of 16190 adults included in the ECRHS study it was shown that home dampness was a significant risk factor for onset of respiratory symptoms, but not for asthma (Gunnbjörnsdottir et al. 2006). Another study on incidence reported that homes with reported mould odour at the baseline was a significant predictor for development of asthma among children (adjusted IRR 2.44 95% CI 1.07-5.60), but that other exposure indicators such as history of water damage, spots of surface moisture or visible mould were not (Jaakkola et al. 2005).

Definition of dampness and moisture problems in epidemiological studies on health effects

In epidemiological studies on the association between moisture problems in buildings and health, there is a wide variation in the definition of the term "dampness". Indications of moisture problems that can be seen without destructive methods, dominate in epidemiological studies, since destructive methods are expensive, require professional personnel and are obviously not always permitted by the owner of the building. The following indications have often been used in questionnaire studies (Bornehag et al. 2001).

Visible mould on indoor surfaces is the most common definition of dampness in international studies. Visible mould on indoor surfaces is commonly reported in tropical and subtropical climates. This type of moisture problem, owing to a high relative humidity indoors and condensation on walls, may also occur in colder climates if the outer walls are poorly insulated. *Mouldy odour* is an indicator of a microbiological growth but the source of the odour is sometimes difficult to explore. Hidden mould problems inside the building structure can sometimes be detected by sniffing near the suspected spot, or close to gap/ imperfections in the building envelope. A perception of *"dry air"* is commonly reported in buildings with mould and moisture problems (Sundell and Lindvall 1993). *Damp stains* can be due to condensation or to leakages from e.g. pipes or rain, while the latter is more often described as discoloured stains. Discoloured stains can be a sign of a moisture problem in the building structure behind the surface, but are sometimes simply an esthetical problem thanks to a quick dry out after a light temporary wetting. Another common indication of "dampness" is *condensation on the inside of the window pane*, which is a sign of a "high" relative humidity indoors and/or of insufficient ventilation and/or bad insulated windows (single glass windows).

Moisture problems in Scandinavian buildings

According to a Swedish report, at least 10% of the Swedish building stock had serious moisture damage from excess moisture, mould or rot that needed immediate repair (Tolstoy et al. 1993). A Finnish study of 450 houses found signs of current or previous moisture defects in 80% of the buildings, and 55% were assessed to be in need of repair or a more comprehensive inspection (Nevalainen et al. 1998).

Principal sources of moisture in buildings are rain, snow, initial construction dampness, soil moisture, indoor and outdoor air humidity and leakages from technical installations (Nevander and Elmarsson 1994). The moisture can be transported by convection, diffusion or liquid transfer into or within the building and cause microbiological growth and chemical emissions. The indoor air quality is in general terms a result of the concentration of different pollutants from humans, activities, and emissions from the building material inclusive possible moisture damages diluted with the efficiency and rate of ventilation. A distinguish can be made between moisture in the indoor air and moisture in materials and in the building structure.

Moisture in the air

Elevated moisture content in the indoor air increases the risk of surface condensation on cold surfaces like windows or the inside of poorly insulated outer walls. A high relative humidity at the surface will increase the risk for microbiological activity resulting in mould growth (Pasanen et al. 2000). Visible mould and condensation on interior walls are rare in modern Scandinavian houses, due to a dry indoor climate and the fact that most structures are well insulated (Pirhonen et al. 1996, Bornehag et al. 2005b, Jaakkola et al. 2005). However, in sub-tropical and tropical climates, visible mould growth on indoor surfaces is more common (23-79% of the dwellings) (Bornehag et al. 2001). For example, in an Australian study of 80 houses, 92% had surface condensation and 60% removed mould growth from the interior on a regular basis (Garrett et al. 1998). In a study of over 35,000 children in Taiwan, 24% had visible mould on at least one wall in the home (Lee et al. 2003). Furthermore, humid indoor air increases the risk for mite infestation (Munir et al. 1995).

In well-insulated buildings in colder climates, high moisture content in the indoor air can cause serious moisture damage. If humid indoor air is transported by convective forces to colder parts of the construction, such as the attic or the outer wall structure, then condensation can occur. The risk for such moisture problems can be reduced or eliminated by making the structure more air-tight or having indoor air under pressure. An air-tight structure will also decrease the heat losses and noise transfer through the construction.

Moisture in the building structure

Elevated moisture content in the building structure may cause both microbiological and chemical processes. This can lead to emissions of odours and irritants from the affected building materials e.g. mould growth on timber in the structure and degradation of glued vinyl floor coverings (Wengholt Johnsson 1995, Pasanen et al. 2000).

In a Swedish report, statistics from 465 different investigations, performed between 1978-1984 in buildings (mainly single family houses) with mould and moisture problems were summarized (Samuelson 1985). Sources of moisture, damaged building structure and year of construction were listed. The dominating building structures with mould problems were wooden-framed flooring construction on a concrete slab on the ground foundation with insulation on the top of the concrete, crawlspaces and basements i.e. different types of foundations. The majority of the investigations of mould and moisture problems were performed in houses built in the 1970's. The four most frequent causes of damage were moisture from the ground, leakages, built in moisture and poor ventilation.

Until the 1970's, the research about moisture in buildings had mainly been focused on decreasing the risk of reduced structural strength, indoor surface condensation and decreased insulation capacity. In a Swedish review and research program published 1970, the consequences of moisture in buildings were listed (Adamson et al. 1970). Movements and deformations of building material, durability, structural strength, corrosion, frost erosion, decreased insulating capacity and biological degradation by rot fungi were mentioned. In the mid 70's, the first reports of mouldy odour in recently constructed houses were presented. One of the first Swedish reports about mould odour and fungal contamination in crawlspaces was published in 1974 (Carlsson 1974), and somewhat later, mould odour in houses with a slab on the ground was described (Nilsson 1977, Samuelson 1981). It was not until the 1980's that different health effects associated with houses that had mould and moisture problems became frequently discussed (Akimenko et al. 1986, Strachan and Elton 1986).

Buildings, constructions and materials have undergone a number of changes during the last decades, with the ambition to improve the thermal comfort indoors, to save energy, to speed up the building process and production time, and to build cheaper dwellings etc. These actions have often lead to an improved indoor environment. However, in many cases, mistakes have been made that have caused mould and moisture problems also in the modern buildings.

In the late 1960's, well insulated multi layer construction was introduced. They had a higher insulation capacity in comparison with more homogenous constructions of e.g. wood, aerated concrete or brick-wall constructions (Björk et al. 1984). In a well-insulated multi layer construction, different materials have a specific task of their own e.g. façade material, wind protection layer, load bearing capacity, thermal insulation and vapour barrier etc. compared to the homogenous structure where one material is required to perform all these tasks. If one of these components in the multi-layer structure gets damaged or even destroyed, the whole construction can be affected. Mould damage inside this type of construction is not visible on the surface, but can give rise to a mouldy odour. Dismantling of the structure is therefore needed to investigate moisture damage in such cases. In conclusion, the use of well insulated multi layer building structures does not tolerate many (or any) mistakes.

In 1973, the energy crises lead to a number of actions to decrease the energy use in the buildings. In many cases, actions of improved insulation, and air-tightening and decreased ventilation rate led to a decrease in indoor air quality and to mould and moisture problems in the structure. In these cases, the effects of for example improved insulation on the physics of the building were not always taken into consideration.

Ventilation

The purpose of ventilation is to dilute and remove contaminants generated in the room by persons, building materials and activities and bring in fresh air in order to achieve an acceptable indoor air quality. The word ´ventilation´ comes from the Latin word "*ventilare"* which means "exposed to the wind". As discussed above, there is a conflict between a high ventilation rate and energy costs, but technical solutions using for example heat recovery systems, can decrease the cost without reducing the ventilation.

In a review on ventilation, health and productivity, "EUROVEN", it was concluded that a low ventilation rate was associated with health effects and decreased performance in offices (Wargocki et al. 2002). However, only a few studies have been performed regarding ventilation rate in homes. It was concluded that a rate below 0.5 air changes per hour (ach) in dwellings increase the risk for house dust mite infestation in Scandinavian climate and consequently an increased risk for sensitization and allergic symptoms. The conclusions in EUROVEN were supported in another review by Seppänen and Fisk (Seppanen and Fisk 2004). However, two studies from Sweden and Norway, have shown no association between ventilation rate in residences and asthmatic or allergic symptoms (Öie et al. 1999, Emenius et al. 2004), but it was suggested that a low ventilation rate could strengthen the effect of other pollutants and therefore indirectly increase the risk of symptoms (Öie et al. 1999).

A low ventilation rate has been associated with natural ventilation and with buildings built in the 1960's and 70's (Sundell 1994, Emenius et al. 1998, Öie et al. 1999). Swedish studies have shown that a low ventilation rate is associated with increased infestation of house dust mites and sensitization to HDM (Wickman et al. 1991, Sundell et al. 1995, Emenius et al. 1998). After the SARS-epidemic in 2003, there is a current concern of the relationship between ventilation, air movements in buildings and the spread of infections in indoor environments (Li et al. 2006).

To summarize, there is a need to establish valid and less subjective methods to obtain a more nuanced picture of the wide range of different types of moisture related damages in indoor environments. The next challenge is to identify what causative agents (both microbiological and chemical exposures) and biological mechanisms that are responsible for the association between "dampness" and health. If the goals for healthy indoor environments stated by WHO, EU and the Swedish government are to be achieved, these issues have to be prioritised both in the building industry and in research.

Aim and objectives

The main aim of this work has been to study the impact of moisture related problems in home environments on asthmatic and allergic symptoms among children. In addition, the aim has been to identify building characteristics that are associated with signs of moisture problems and odours.

In the included articles, the objectives have more specifically been:

I to study the association between inspectors observations of mouldy odour and other signs of moisture problems and asthma and allergy among children.

II to validate the questionnaire by comparing parental reports on building characteristics, mouldy odour and moisture problems with inspectors observations.

III to investigate if low ventilation rate at home is associated with asthma and allergy symptoms among children.

IV to investigate the association between parents reports of moisture related problems in the home including bad indoor air quality and building characteristics of the dwellings.

V to study the association between day care attendance and asthmatic and allergic symptoms among children.

Material and methods

The study Dampness in Buildings and Health (DBH) has been conducted in different phases as shown in figure 2. The overall idea with this design is that findings identified in an earlier phase can be tested in a later phase. Studies within the first two phases are included in this thesis.

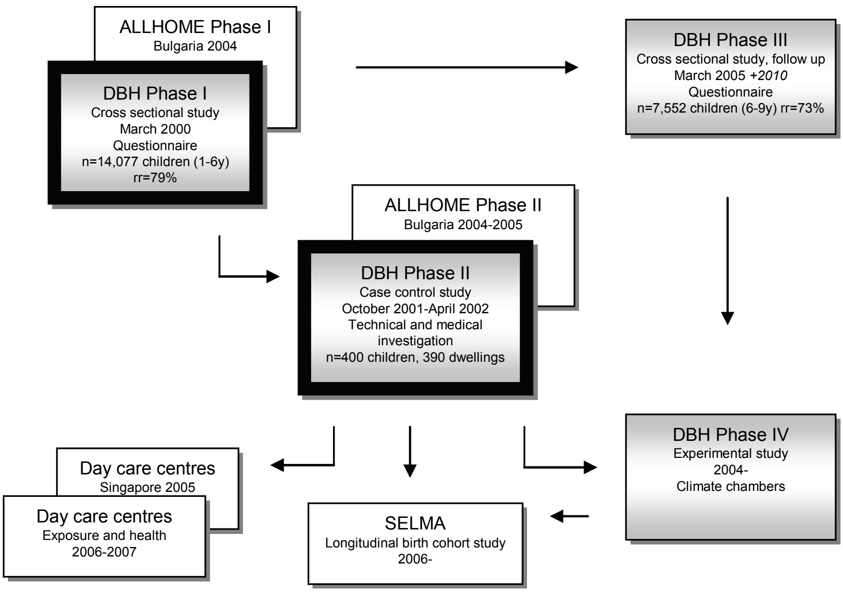

Figure 2. General structure of the DBH Phase I to IV and other studies generated from DBH. Results from DBH phase I and II are included in this thesis.

First, a cross sectional questionnaire survey in 2000 (DBH-I) was carried out, followed by a nested case control study in 2001 (DBH-II), a follow-up questionnaire in 2005 (DBH-III) and experimental studies in climate chambers in 2004 (DBH-IV). An overview of obtained results is reported elsewhere (Bornehag et al. 2004b). Moreover, results and hypotheses in DBH have generated new studies – using the same approach e.g. questionnaire, protocols etc. – both in Sweden, and in other countries. The first two phases of the DBH-study have been performed in Sofia and Bourgas in Bulgaria, the ALLHOME study (Naydenov et al. 2005). In Singapore, Taiwan, China and Greenland studies using the DBH design have been initiated. In Singapore, a study on day care centres has been commenced as well (Zuraimi et al. 2006b). In Sweden, a study on the indoor environment in day care centres and health among the children is being commenced. Additionally, a longitudinal birth cohort study (Selma) will start during 2006 where families and children will be followed from pregnancy, over birth, and up in school age. Earlier findings from the DBH study will be tested with in this study in a longitudinal way.

DBH phase I (presented in paper II, IV, V)

The first step was carried out in March 2000 as a cross-sectional study. A questionnaire (baseline questionnaire) was distributed to the parents of all children between the ages of 1-6 years in the Swedish county of Värmland, with about 280,000 inhabitants. Of the 14,077 included children, 100 had earlier participated in a pilot study where the questionnaire was tested and improved, and 195 could not be found by post. In total, we sent out three postal reminders in the form of two postcards and one letter including a new questionnaire. The parents of 10,851 children returned the questionnaire (out of 13,782), corresponding to a response rate of 79%. These children were representing 8,918 families (homes) since all siblings 1-6 years of age in the family were included.

The questionnaire included 84 questions with sub-questions about the child and its family. Validated questions from the ISAAC study (Pearce et al. 1993) were used for asthmatic and allergic symptoms among the children. Furthermore, there were questions about the dwelling e.g. type of house, surroundings, type of construction, installation systems, surface material on walls and floors plus different indications of moisture problems and odours. Moreover, information regarding day care centre attendance, SBS symptoms of one parent, pet-keeping, cleaning frequency, parental smoking and food habits were collected.
The answers to the single questions of visible mould, damp stains, suspected (but not visible) dampness problems and bubbly, loosening or discoloured floor coverings could be answered by “yes”, “no” or “don’t know” for the child’s room, the parents bedroom, other room or bathroom. Water damages were specified in the kitchen as well, including a question on when the damage occurred (last year or earlier). Condensation on the inside of the windowpanes during wintertime in the child’s or parents bedroom or in the living room was specified in intervals 0, 0-5 cm, 5-25 and more than 25cm (measured up from the window sill). Odours were listed as stuffy, pungent, unpleasant, mouldy, and perception of dry air which could be answered by “yes, often, (every week)”, “yes, sometimes” or “no, never”. Indexes of these questions have been constructed and are specified in each paper **(paper II, IV)**. The questionnaire is attached in Appendix A (in Swedish).

DBH phase II (presented in paper I, II, III)

The second step (DBH phase II) was a nested case-control study including 400 children (198 cases and 202 healthy controls) from the baseline questionnaire. In this study, more expensive medical and technical investigations were made in order to identify risk factors for health in the home environment compared to the cross sectional study. The required number of cases and controls was obtained by a power calculation (power 0.80, $p<0.05$, OR 2.0).

The selection procedure for the recruitment of cases and controls started in September 2001, eighteen months after the baseline questionnaire. In total, 2,156 children (1,056 potential cases and 1,100 controls) were then invited to participate in the case control study. The families received a follow-up questionnaire and they were informed about the study in general and more specifically about the health examination of their child, and the environmental investigations of their home. Cases and controls were then selected according to the following inclusion criteria's:

Inclusion criteria for cases were:

1) reports of at least two symptoms of the following in the baseline questionnaire:

- wheezing last 12 months without a cold
- rhinitis last 12 months without a cold
- eczema last 12 months.

In the follow-up questionnaire they should:

2) accept to co-operate in the case-control study,

3) report at least two of the three listed symptoms,

4) have not carried out any renovation work due to moisture and mould problems,

5) have not moved house since the baseline questionnaire.

All children with at least two symptoms at the baseline questionnaire were invited, (n=1056 corresponding to 9.7% of the total population).

Inclusion criteria for controls were:

1) no symptoms at all in the baseline questionnaire (eleven symptoms included).

In the follow-up questionnaire they should:

2) accept to co-operate in the case control study,

3) report no symptoms of the three listed symptoms,

4) have not carried out any renovation work due to moisture and mould problems,

5) have not moved house since the baseline questionnaire.

In the baseline questionnaire 5,303 (48.9%) children fulfilled the first criteria. Of these, 1,100 children were randomly selected (20.7% of the 5,303 children), and were invited to participate in DBH phase II.

In the final case-control study, 198 cases with persistent allergic symptoms and 202 healthy children (non-cases) were included. Among the 400 children there were ten pairs of siblings, which meant that 390 families/homes were included.
Between October 2001 and April 2002, a medical examination of the 400 children and a technical investigation of their 390 homes were performed. The technical investigation was in general carried out within a week after the medical examination of the children. The medical examination was not performed if the child had a current infection. In such cases, the families received new appointments for both the medical examination and the technical home visit.

The families were given written information in which they were asked not to clean the floor or shelves in the child's room and living room for at least 3-4 days before the technical investigation, nor to change the linen in the child's bed the week before. This was in order to facilitate the dust collections. Also, for the duration of the technical visit, the families were asked not to use the shower, the washing machine, cook odorous food or open the windows.

Technical inspection and measurements in the 390 homes

The aim of the technical inspection and measurements in the dwellings was to measure the ventilation rate, to take samples of dust and air and to perform an ocular inspection and odour assessment to identify possible moisture problems.
Firstly all inspectors performed the inspection and measurements in the first home collectively. Secondly, pairs of inspectors visited the two next homes together and after that one inspector alone visited two houses per day. The inspectors had no information about the health status of the child and the family at the time of the inspections, and were told not to discuss such issues with the family. A questionnaire for the parents, a room-by-room protocol, and a protocol for the measurements and sampling procedures were used (Appendix B, in Swedish).

The inspector informed the family about the measurements and delivered the questionnaire. Moreover, he/she performed measurements of temperature, relative humidity and ventilation, collected dust and air samples and performed an ocular inspection.

Temperature and relative humidity were momentary measured indoors and outdoors at the visit and continuously measurements indoors were logged every hour for one week. Continuous data on the outdoor climate was obtained from the nearest gauging station of Swedish Meteorological and Hydrological Institute (SMHI).

The ventilation rate was measured for one week using a passive tracer gas method (perfluorocarbon, PFT), called Homogenous Emission Technique, which measures the "mean age" of the air, NT VVS 118 (Stymne and Eliasson 1991, Nordtest 1997). After one week, the equipment was sent by post to the laboratory by the families themselves.

Furthermore dust and air samples were collected from floor, bed and shelves in the child's´ room and in the living room, and passive dust collectors were set up in position. The microbiological and chemical content of the dust and air samples have been further analysed. However, the results from these samples are not included in this thesis.

The 390 dwellings were ocular inspected without any destructive methods or structural dismantling. A standardized room-by-room protocol was used in each house for observations on type of construction, surface materials and type of installation systems etc. The inspector noted his/her observation on visible signs of dampness and assessment of odours e.g. stuffy, mouldy, etc. (including mouldy odour along the skirting board) in the protocol.

Due to time limits crawlspaces and cold attics were not inspected. The inspector used a subjective scale to asses the severity of the observations on dampness and odour at different places in the home:

- Grade 0 for “no remarks”, i.e. the inspector did not find any visible sign of moisture damage or did not perceive an e.g. mouldy odour.

- Grade 1 for “a possible smell or a visible indication of moisture problems, but no suspected effect on the IAQ”.

- Grade 2 for “a slight odour or a visible moisture damage that might affect the IAQ”.

- Grade 3 for “a clear and strong odour or obvious moisture damage with extensive effect on the IAQ”.

In the analyses, indexes have been constructed from the data collected by the inspectors. The specific definition of each index has been described in the papers **(paper I, II)**.

Medical examinations and tests

The first aim with the medical examination was to diagnose children regarding asthma, rhinitis and eczema, and to collect biological samples. The clinical samples of nasal secret (Nasal Lavage, NAL) and condensed breath (CB) and the analyses of inflammation markers, cytokines etc. were used in with a more experimental objective compared to the established measure of IgE in the blood.

The medical team consisted of four paediatric physicians and two experienced child health nurses. During the study-period (October 2001-April 2002), the team used four different health care facilities geographically spread over the county of Värmland, and the families travelled to the nearest one. The doctor reviewed the medical history of the child and made a standardized medical examination for diagnoses of eczema, asthma and rhinitis. Serum (blood) samples were drawn from 387 children and screened for sensitization (IgE) to a mix of common allergens (Hasselgren 2005).

Statistical methods

Differences in frequencies and prevalence have been tested with Chi-square test (χ^2) and trends in data have been tested with linear by linear associations. Differences in continuous variables were tested with parametric (Student´s t-test) and non-parametric tests (Mann-Whitney *U*). Associations between building related factors and symptoms have been tested with logistic regression models. In multiple logistic regression models, adjustments have been made. The specific adjustment variables used in each analysis are further described in each paper, but commonly used potential confounders were sex, age, smoking parent, parental atopy, type of building (home) and construction period of the building. Logistic regression models were used to estimate odds ratio (OR) and the 95% confidence interval.

The agreement between inspector's observation and the family's report on building characteristics, odour and signs of moisture problems was tested with their kappa value (κ). Cohen´s kappa is a measure of agreement between two binary variables that measure the same thing. Kappa of 1 implies perfect agreement; negative kappa means that the agreement is lower than by chance. Often used interpretations of the score of kappa; poor agreement <0.20, fair agreement 0.20-0.40, moderate agreement 0.40-0.60, good agreement 0.60-0.80 and very good agreement 0.80-1.00 (Landis and Koch 1977). In addition to the kappa value, the observed and proportional agreements (positive and negative) have been calculated (Cicchetti and Feinstein 1990).

All analyses were considered to be statistically significant when the p-value was less than 0.05.

Statistical analyses were performed using the computer program Statistical Package for Social Sciences (SPSS, 11.5).

Ethics

All accomplished studies have been approved separately by ethical committees.

Results and discussion

Cross sectional data (DBH phase I) from 10,851 children was collected by a questionnaire, corresponding with a response rate of 79%. The children were between the ages 1-6 years, and lived in 8,918 households (dwellings) in the county Värmland, Sweden. The prevalence of symptoms is presented in figure 3. The most frequently reported symptoms were wheezing closely followed by eczema (last 12 months). Almost half of the children were reported to have at least one of the symptoms presented in figure 3. Symptoms of wheezing and nocturnal cough occurred more often among the younger children, whilst the prevalence of asthma and rhinitis diagnosed by a doctor increased with age. The prevalence of symptoms are in accordance with other studies of Swedish pre-school children (Björksten et al. 1998, Socialstyrelsen 2005).

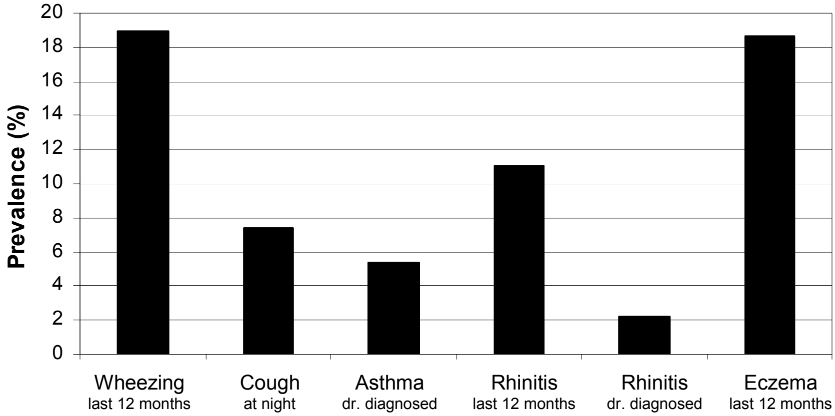

Figure 3. Prevalence of symptoms among 10,851 pre-school children in DBH phase I.

The main part of the dwellings in DBH-phase I were single family houses (70.4%) followed by apartments in multi family houses (18.1%) and terraced houses (8.8%). Almost half of the dwellings were built before 1960, and in general the single family houses tended to be older than the multi family houses. The buildings are described in more detail in **paper IV**. Frequencies of the different types of houses and their construction period are presented in figure 4.

In papers **I** and **III** associations between asthma and allergy (diagnosed by a doctor), moisture problems (observed by inspectors) and ventilation rates have been analyzed. In **paper II**, the questionnaire has been validated by a comparison between parental reports on housing (incl. dampness) and observations made by the inspectors. Associations between building characteristics and parental reports of different moisture problems are presented in **paper IV**. Finally, the association between day care attendance and symptoms among the children has been analysed in **paper V**.

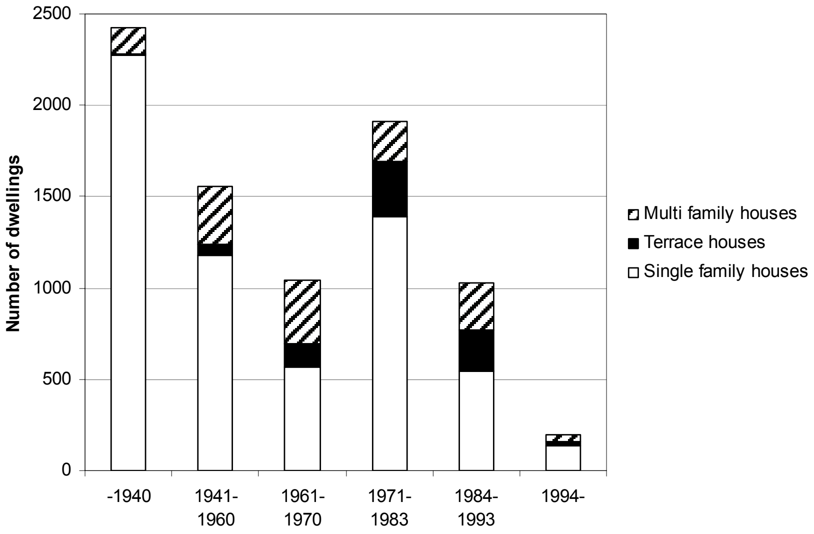

Figure 4. Description of the 8,918 dwellings in DBH phase I

Moisture problems in buildings and asthma/allergy among children

In the first phase of the DBH study, the association between self reported signs of moisture problems in the homes and the health among the children was analysed (Bornehag et al. 2002, Bornehag et al. 2005b). A strong and significant relationship between parental reports of moisture problems (such as visible dampness, water leakage, floor moisture, window pane condensation and bad/mould odour) and symptoms among the children were shown with adjusted odds ratios in the range of 1.23-2.95. The strongest associations were found between visible dampness and rhinitis. These results are in line with many other studies on moisture damage and asthmatic and allergic symptoms (Peat et al. 1998, Bornehag et al. 2001, Institute of Medicine 2004, Bornehag et al. 2004a).

In the case control study, inspectors' observations of dampness were divided into four indexes:

- mould odour along the skirting board
- mould odour from at least one room of the home (bathroom and basement excluded)
- "damp stains" (including visible mould; bathroom and basements excluded) and
- signs of floor dampness (bubbly, loose or discoloured vinyl floor covering or blackened parquet).

For definitions of the different indexes, see method section in **paper I**.

Moisture problems observed by the inspectors (including mouldy odour in at least one room, "damp stains" and "floor dampness") were not associated with asthma and allergy amongst the children. However, a strong dose-response relationship was found between the inspector perception of a mouldy odour along the skirting board and asthma and allergy (diagnosed by a doctor) amongst the children, see figure 5. A more severe odour led to a higher risk for rhinitis and eczema, and to a lesser extent asthma. An indication of a relationship between mouldy odour along the skirting board and sensitization amongst the children was found. A severe mouldy odour along the skirting board was observed in 16.2% of the dwellings (17.3% single family houses, 6.8% multi family houses) and a weak odour was found in 31.3% of the homes.

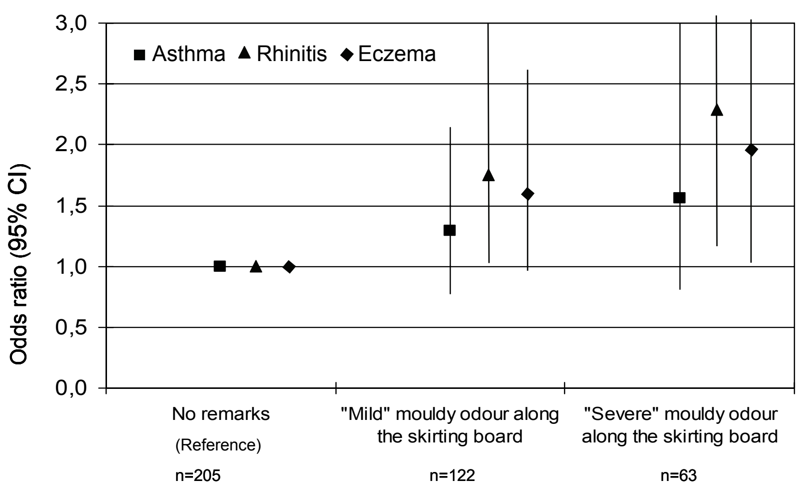

Figure 5. Associations between inspectors' perceptions of mouldy odour along the skirting board and asthma, rhinitis and eczema (diagnosed by a doctor) among the children.

A mouldy odour from the area along the skirting board is an indication of hidden mould and moisture problems inside the building wall or foundation structure. At floor level, the indoor air pressure is often negative and odour from mould growth within the building structure can be transported to the indoor air by convection. This finding is supported by several investigations in Sweden, which show that the majority of the moisture damages can be associated with the foundation structure of the building (Samuelson 1985, Samuelson 1987, Björk and Mattson 2002).

A mouldy odour in the indoor air (in at least on room) was perceived by the inspectors in almost 40% of the dwellings, and a severe mouldy odour in 17.3%. Surprisingly, such an odour was not associated with health effects whilst a mouldy odour coming from the skirting board area was strongly associated with allergic symptoms. This may be due to the fact that mouldy odour at the skirting board level is less affected by other smells in the room. An indoor mouldy odour can come from several other sources than moisture damage for example pot plants, dirt, food, human activities, etc. This means that the odour in the room is less specific than mouldy odour coming from specific spots.

"Damp stains" were observed by the inspectors in 24.6% of the 390 dwellings, but in only 3.8% were they deemed to be a sign of a severe moisture problem. Visible moulds on indoor surfaces (bathroom and basements excluded) were found in only 6 out of 390 homes and are included in the index of "damp stains". A low ventilation rate was associated with mould odour, but not with "damp stains" **(paper I)**. This indicates that the observed "damp stains" are primarily due to leakage from pipes, rain, accidental leakages or moisture convection, and not condensation on cold indoor surfaces. Without dismantling the structure, it is very difficult to obtain any information regarding the state of the construction inside the walls, not to mention the extent and severity of such moisture damage.

In other parts of the world, visible mould on indoor surfaces is more common. In an Australian study of 80 households, visible mould growth was present in every house and 92% had evidence of condensation (Garrett et al. 1998). According to the NORDDAMP-review, it was summarized that visible mould in tropic and sub tropic climates normally are found in 23-79% of the buildings, whilst, 4-25% of the buildings in colder climates had visible signs of dampness. Furthermore, odour were more frequently reported inside these buildings (Bornehag et al. 2001). The low frequency of visible mould on indoor surfaces in Swedish buildings is due to a combination of cold winters and a with well insulated building envelope which decreases the risk for surface condensation on the inside of the outer walls. In Sweden, the relative humidity indoors during the winter season is very low (<30%) (Nevander and Elmarsson 1994).

"Floor dampness" was only observed in 7.4% of the homes, and only in 4 of these homes (1%), was it regarded as a severe sign of a moisture problem. Such a low frequency makes any analyses on associations with health effects difficult, which could be an explanation that there was no association between "floor dampness" and health.

Validation of the used questionnaire

The associations between moisture problems in the homes and asthma and allergies among children were different for parental reported data and observations made by the inspectors. These discrepancies could be due to several causes.

In questionnaire studies where exposure and health are reported by the same person, (and at the same time) there is a risk for recall bias. This means that parents to symptomatic children report more moisture problems and/or that parents living in homes with visible signs of dampness over-report symptoms among their children (Strachan and Elton 1986). Thus, recall bias could be an explanation for the strong association between dampness and health found in questionnaire data. There is a general opinion in Sweden that mould and moisture damages are risk factors associated with asthma and allergy, which may have influenced the parental reports. However, associations between self-reported "dampness" and health effects has been reported since the 1980's, i.e. at a time when the general population was less aware of this problem. Furthermore, there are longitudinal studies on incidence of asthma/allergy showing associations between self reported dampness and health, i.e. studies with a low risk for recall bias (Belanger et al. 2003, Jaakkola et al. 2005, Gunnbjörnsdottir et al. 2006). In the study by Jaakkola et al. (2005) children from families with parental reports of mould odour at baseline (i.e. when the children were free from asthma) had more than double the risk of developing asthma during the six following years. This points towards that parental reports of mouldy odour is relevant to health.

Another possible explanation is a low validity of the questionnaire. Validation of the current questionnaire showed a very good agreement between self-reported symptoms and physician diagnoses, (Hasselgren 2005). Regarding housing characteristics there was a good agreement between parental reports and inspectors' observations for type of house and type of foundation for single family houses, and a lower agreement for flooring material (vinyl or linoleum) and type of ventilation system. However, the agreement between parental reports regarding signs of moisture problems and inspector's observations was very low (κ=-0.04-0.11). This agreement was improved if only the buildings with the most severe mouldy odour were included in the analysis (κ=0.23) **(paper II)**.

In several studies comparisons have been made between questionnaire reports of mould and moisture problems and observations by inspectors with divergent results. Rather low agreement have been reported in some studies (κ=0.2-0.4), (Williamson et al. 1997, Nevalainen et al. 1998, Frank et al. 1999, Norbäck et al. 1999, Mahooti-Brooks et al. 2004, Haverinen-Shaughnessy et al. 2005), whilst two studies found high levels of agreement for visible mould (κ=0.7-0.8), (Verhoeff et al. 1995, Dharmage et al. 1999). It is reasonable to see that studies in countries with high frequencies of visible mould on indoor surfaces have a higher level of agreement between questionnaire reports on "dampness" and observations made by inspectors, compared to studies in countries with a higher degree of hidden mould problems. There is a weak tendency that this is true since more studies in Scandinavia have reported a low agreement for "dampness" **(paper II)**, (Nevalainen et al. 1998, Norbäck et al. 1999, Haverinen-Shaughnessy et al. 2005) compared to studies from the Netherlands and Australia where the frequency of visible mould is higher (Verhoeff et al. 1995, Dharmage et al. 1999).

Inspectors' observations are often used in epidemiological studies to increase the validity of mould and moisture data. i.e. the inspectors' observations are often considered a "golden standard". Determination of technical parameters of the building, (e.g. type of building, type of building material, type of building construction and installation systems) ought to be more reliable when observed by a trained inspector. For example, one third of the occupants in multi family buildings in our study had not answered the question about ventilation system, which indicates that such questions are less valid when used in questionnaire studies. In another Swedish study of 34 homes where inspectors observations and questionnaire reports were compared, it was concluded that the occupants had difficulties to answer questions about the construction and the material of the house (Andrae et al. 1988).

However, the inspectors' observations as "golden standard" for the assessment of health relevant mouldy odour and visible signs of moisture problems on indoor surfaces are not clear. In a Dutch study, the agreement was better between questionnaire reports on mould and dampness with measured concentrations of fungal compounds in dust than for the inspectors observations (Douwes et al. 1999). It was concluded that occupant reports were a more reliable estimate of dampness than observations of inspectors. A low validity of inspectors' assessment of mould and moisture damages may be due to that inspections often have been ocular and short. A complete investigation of moisture damage requires often destructive methods involving dismantling of the building structure to perform moisture content measurements of the building materials and to take samples for microbiological analysis. Such an investigation would increase the validity of inspectors' observations.

Inspectors' perceptions of a mouldy odour and visible signs of dampness were considerably more common than what parents reported. The inspectors perceived for example a mouldy odour in 133 of the dwellings compared to the occupants reports of mouldy odour in 20 dwellings. This has also been reported from a number of other studies (Pirhonen et al. 1996, Nevalainen et al. 1998, Frank et al. 1999, Mahooti-Brooks et al. 2004, Haverinen-Shaughnessy et al. 2005). This difference can have several explanations.

The inspectors might observe more "dampness" compared to the parents due to their knowledge and experience about where such damage often occurs. This was also the conclusion from a Finnish study, where they explained the higher frequency of inspectors "dampness" observations in comparison with that of the occupants, was most likely due to the inspectors knowledge of the weak points in a building in combination with an understanding of the importance of their observations (Nevalainen et al. 1998). A trained inspector may also be more sensitive to weak mouldy odours compared to the occupants. Another possible explanation is that people living in dwellings with a mould odour will get used to the smell and therefore not consider their house to be affected by mould damage. Furthermore, people will often be less willing to accept that the house, which for most people is one of the largest investments in life, has moisture damage. Haverinen-Shaughnessy discussed this as a feasible effect of the occupants' personal relationship with the house compared to an inspector (Haverinen-Shaughnessy et al. 2005). In another Finnish study, a possible under-estimation by the occupants of mould odour in the house was discussed to be due to that people might feel ashamed of a mould problem in their house (Pirhonen et al. 1996). To conclude, there are several possible explanations as to why the inspectors' perceive more of mould odour than the parents. On the contrary, some other studies have reported a higher frequency of occupant reports of "dampness" compared with inspectors' observations (Verhoeff et al. 1995, Williamson et al. 1997, Nafstad et al. 1998). This was explained by the relatively short visit by the inspector compared to the occupants longer association with the building (Verhoeff et al. 1995, Bornehag et al. 2001).

In summary, even though the inspectors noticed more mould odour and “damp stains” in the dwellings, there were no associations between such reports and health effects among the children, in contrast with such signs that were reported by the parents. There was no association between inspectors' observations of ”damp stains” and health. This is probably due to that such discoloured stains in reality are not health relevant, and are therefore not a valid sign of a health relevant moisture problem in Swedish buildings. The finding that a perceived mouldy odour in a room by the inspectors was not health relevant, in contrast to a mouldy odour along the skirting board, is not easy to quantify. One possible explanation is that a general mouldy odour in the room is much less specific than mouldy odour along the skirting board.

Ventilation rate and health

One of the main findings from the case-control study was an association between a low ventilation rate and the health of the children living in single-family houses **(paper III)**. When the ventilation rates were divided into quartiles a dose response relationship was indicated, figure 6. No associations were found between low ventilation rate and sensitization.

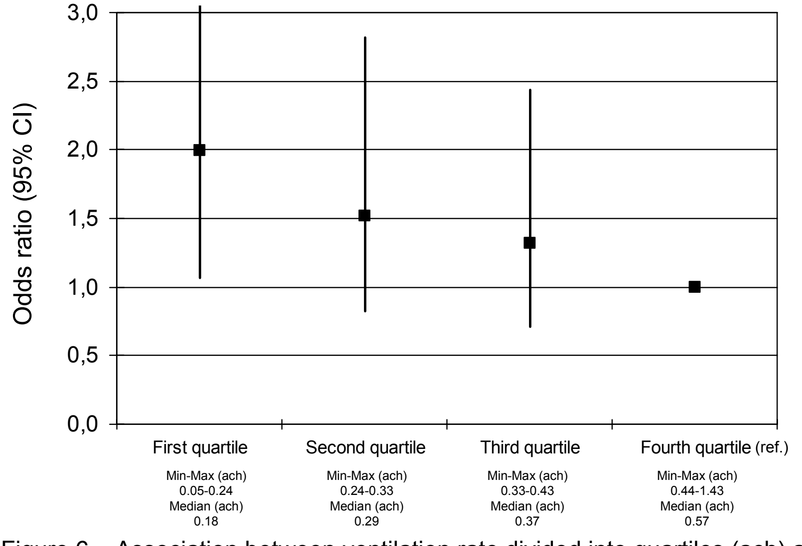

Figure 6. Association between ventilation rate divided into quartiles (ach) and case status in 349 single family houses.

Another finding was that about 80% of the single family houses and 60% of the multi family houses did not meet the Swedish building code requirement for 0.5 ach. Earlier studies from the 1990's have also shown that a majority of Swedish homes have a lower ventilation rate than that required in the building codes (Stymne et al. 1994, Norlén and Andersson 1995).

In two other Scandinavian studies on the home environment and respiratory symptoms among children, there were no associations found between the ventilation rate and airway symptoms among children (Öie et al. 1999, Emenius et al. 2004). However, this might be due to the fact that the mean ventilation rate was higher in these studies compared to ours, probably as a consequence of their higher number of multi family houses. The mean ventilation rate in the Swedish study by Emenius et al. was 0.68 ach and around the same in the Norwegian study, see figure 7.

A low ventilation rate is in general coupled to a lower indoor air quality in many ways, for example more pollutants, increased indoor air humidity, increased number of house dust mite allergens, etc. (Wickman et al. 1991, Sundell et al. 1995, Emenius et al. 1998, Munir 1998, Gustavsson et al. 2004). House dust mites are a major factor in the association between a low ventilation rate in homes and health. However, mite allergen cannot explain our findings between low ventilation rate and health, since only 15 children out of 198 cases were sensitized to house dust mites (Hasselgren et al. 2005). In the Norwegian study, residential mould and moisture damages was associated with bronchial obstruction in the children, independent of whether there were mites in their bed or not (Nafstad et al. 1998).

When a mouldy odour along the skirting board was combined with a low ventilation rate (lower than median), the association with rhinitis and eczema became significantly greater (than reported in figure 5) **(paper I)**. This indicates that a low ventilation rate increases the effect of health relevant indoor pollutants, i.e. ventilation rate could be seen as an effect modifier. This effect has earlier been reported in the Norwegian study where they found that a low ventilation rate increased the association between bronchial obstruction and moisture problems (Öie et al. 1999).

There was a significant lower air change rate in the houses built in the 1960's and 1970's compared to other construction periods. The same pattern was also seen in the Norwegian study (Öie et al. 1998) figure 7.

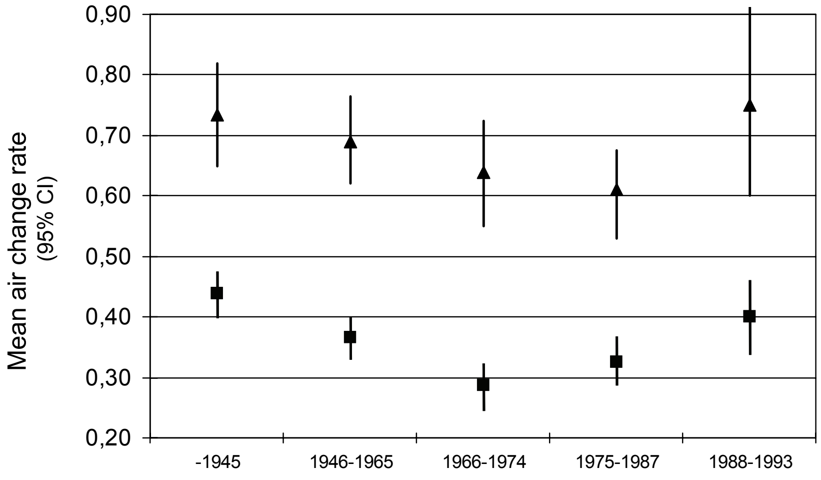

Figure 7. Mean air change and 95% confidence intervals for different construction periods. "■" represents the DBH-data and "▲" corresponds to the Norwegian data by Öie et al. (1998).

Health relevant moisture problems and building characteristics

In the case control study (DBH phase II); a mouldy odour along the skirting board observed by the inspectors was significant associated with asthma and allergy among the children **(paper I)**. Such odour was more often observed in single family houses, in dwellings with exhaust ventilation systems, and in houses built between 1960-1983. Single family houses with a concrete slab on the ground had a higher rate of "severe" mouldy odour along the skirting board, and houses with a crawlspace had the highest frequency of a "mild" odour.

These findings are reasonable, since single family houses have a larger area in contact with the ground and precipitation, compared to apartments in multi family houses. Exhaust ventilation systems increase the negative air pressure in the home and may facilitate odour transport from the ground or building construction. Houses built in the sixties and seventies were in many cases built with technical solutions associated with a high moisture problem risk. In the mid-1970's, demands for energy savings lead to decreased ventilation rates **(paper III)**. Single family houses with a concrete slab on the ground built before 1983 had in general insulation above the concrete (if any), sometimes in combination with wooden joists onto, or partly within, the concrete. Such constructions are well-known risk factors for mould and moisture problems (Samuelson 1985, Björk and Mattson 2002).

In the cross sectional study (DBH-phase I), a number of dampness indicators were associated with asthmatic and allergic symptoms (Bornehag et al. 2005b). Building characteristics for single family houses that was associated with different indexes of “dampness” indexes reported by the parents were: **(paper IV)**

- construction period between 1960-1983
- natural ventilation
- concrete slab on the ground in buildings constructed before 1983
- houses built 1960-1983 with a horizontal roof.

These findings are well in accordance with the inspectors’ observation of mould odour indoor and from the skirting board level. A perception of “dry air” was associated to houses built in the 1960’s and 1970’s. A perception of “dry air” has earlier been associated with buildings that have mould and moisture damage and with sick building syndrome (Sundell and Lindvall 1993). Furthermore, in the study by Sundell and Lindvall, as well as in DBH **(paper IV)**, a sensation of dry air is associated with condensation on windows, which is a sign of low ventilation rate. It was shown that houses built during the 1960’s and 70’s had a lower ventilation rate, more likely to have condensation on the windows, mouldy odour and other moisture damages compared to buildings built in other construction periods **(paper I, III, IV),** (Nevalainen et al. 1998, Engvall et al. 2001). A number of factors led to these problems, as previously described in the introduction. These are for example new types of building constructions and materials, low-cost and fast production, demands on energy savings i.e. decreased ventilation etc. and efforts to protect buildings from rot and free water instead of mould growth and high relative humidity.

A horizontal roof have in many studies been associated to leakages and moisture damage (Nevalainen et al. 1998, Wålinder et al. 2001, Bröms et al. 2006). In the Finnish study by Nevalainen et al. (1998) significant more leakages were found in houses with a horizontal roof compared to buildings with gabled or hip roof. This indicates that horizontal roofs, often built during the 1960’s and 1970’s, are not suitable in the Nordic climates, as concluded in the Finnish study.

Tenants in both single family houses and multi family houses reported more dampness compared to occupants in owned dwellings. This finding is also reported from other studies (Engvall et al. 2001, Macintyre et al. 2003). The higher frequency of dampness related problems that were reported by occupants in multi family houses compared to that for single family houses, may thus be due to tenancy, since the majority of the apartments and less than 10% of the single family houses were rented.

An earlier renovation due to a mould or moisture damage in the dwelling was associated with houses built in the 1960's and 1970's. Such a renovation was further associated with continued complaints on signs of moisture, mouldy odour and dry air. This may be due to that the renovation did not solve the moisture problem, or that occupants who have come into contact with moisture damage are more likely to detect such indications and odours compared to other people.

In summary, building characteristics that had the strongest association with signs of mould and moisture damage in both the questionnaire study and in the case control study were; houses built in the 1960's and 1970's, single family houses with a concrete slab as ground foundation and/or horizontal roof (built before 1983) and houses with indications of low ventilation rate.

Day care attendance and health

Beside the home, day care centres are other important environments for small children, since more than 80% of Swedish pre-school children attend such centres **(paper V)**. We have shown that children in day care were reported to have more asthmatic and allergic symptoms and airway infections compared to children cared for at home. Among the younger children aged between 1-4 years, the association between day care centre attendance and health was greater compared with the group of older children (aged 5-6 years). However, day care attendance was associated with symptoms in both groups.

A number of other studies have shown an increased prevalence of respiratory symptoms and airway infections among children attending day care centres compared to children at home (Louhiala et al. 1995, Nafstad et al. 1999, Bradley 2003). However, the increased occurrence of eczema and food-allergy among children in day care was less expected. The association between day care and symptoms could not be explained by more common airway infections, since day care attendance was associated with asthmatic and allergic symptoms amongst both those children who had few common colds and those who had many colds the last 12 months.

The higher prevalence of symptoms among children in day care centres compared to children at home is probably caused by many factors. Viruses and bacteria are spread not only by direct person to person contact, but are also transmitted when they are airborne in the indoor air. Therefore, ventilation rate and efficiency is of importance when decreasing airborne disease transmissions (Li et al. 2006).

According to a Swedish report from 1994, 25% of the schools and day care centres had moisture and mould problem, and in 80%, there were complaints of poor ventilation and thermal comfort (Arbetarskyddsstyrelsen 1994). In a recent Swedish study, the indoor and outdoor environment of 84 special "allergen avoidance" day care centres sections and 355 ordinary day care centre sections were compared (Bröms et al. 2006). One of the main findings was that there were a reduced number of environmental risk factors in the "allergy avoidance" day care centres compared to the ordinary ones. The ordinary day care centres had a higher frequency of present or past signs of building dampness (39.1% vs. 25.3%, p=0.02), more complaints of odour (other than mould odour) (20.2% vs. 8.3%) and were more often built before 1983 compared with the "allergy avoidance" day care centres. In total, newer day care centres had less mould and moisture problems, while the highest frequencies of "dampness" were found in the centres built 1975-1984 (46.4%) and before 1975 (33.3%). A horizontal roof construction was more common amongst the day care centres with mould and moisture problems. 31.6% of the centres with "dampness" had a horizontal roof. The authors concluded that it is possible to reduce a number of environmental risk factors at day care centres, as the frequencies of such factors were less prevalent in the "allergen avoidance" day care centres compared to the conventional.

A Finnish study compared the prevalence of respiratory and irritative symptoms and days of absence among children attending a day care centre with mould problems and a reference day care centre (Koskinen et al. 1995). They concluded that increased absence and respiratory infections were associated with a serious mould problem, and irritative symptoms associated with a milder mould problem in the day care centre.

The findings by Bröms et al. (2006) and Koskinen et al. (1995) show that moisture related problems are present in around one third of day care centres and that children attending those centres have an increased risk of respiratory infections and other symptoms. Multi disciplinary reviews of the entire literature have shown that moisture and mould problems increase the risk for airway symptoms (Peat et al. 1998, Bornehag et al. 2001, Institute of Medicine 2004). Hence, poor indoor air quality in many day care centres might be one of the causes for the association between day care centre attendance and asthma and allergy reported in this thesis.

Methodological discussion

A non-respondent analysis was made of the baseline questionnaire to investigate potential selection bias between participating and non-participating children (DBH phase I). Of those that had not responded to the questionnaire, 200 were randomly selected and phoned by a nurse. Of these, 116 families participated in the non-respondent analysis, while 67 families could not be reached by phone and 17 families refused to answer any questions. Five questions were asked. These were about the health of the child (wheezing, doctor diagnosed asthma and eczema), type of dwelling and if they suspected any mould or moisture problems in their dwelling. There were no significant differences regarding these parameters between the participating and the non-participating children (Bornehag et al. 2005b). This, in combination with a relatively high response rate (79%) decreases the risk for selection bias in the questionnaire investigation.

Potential selection bias has also been studied in the case control study (Bornehag et al. 2006). The included families more often had a higher socio-economic status, they were more interested in health-related issues and, in the case group, families with more severe sick children were more likely to participate. If the focus of the DBH phase II study tended to concentrate on socio-economic issues, then this bias could introduce severe problems. Stratifications can be used as “best solution” to this problem i.e. compare only (health-exposures) within the same socio-economic strata. However, this study is focused on objectively measured exposures, and objectively measured health outcomes. As was shown, there was no bias found regarding reports of “dampness”, thus exposures due to “dampness” should not be biased.

In the case control study we have compared cases that had persistent symptoms on two occasions 18 months apart, and controls without any asthmatic or allergic symptom at any of these times. Thus, the investigation is more of a case-non case study, that we have compared the healthiest children with the most diseased. This means that among invited case-families, those having children with a more severe illness (e.g. asthma, more antibiotic treatment, pseudo croup and pneumonia) were more inclined to participate. There is no obvious way to handle such selection bias. However, such selection bias results in a greater contrast regarding health status between cases and controls, and hence, a greater possibility to identify differences in health-relevant exposures.

The 390 dwellings were randomly allocated to the six inspectors. There were no major differences in distribution between the inspectors regarding case-status, type of building, construction period or parental reported mould odour at home. However, perceptions of mouldy odour differed greatly between the inspectors, but their observation of "damp stains" and floor dampness were less divergent, see table 1.

Table 1. Distribution of children and building characteristics between the six inspectors in the case-control study.

	Inspector (%)					
	A	B	C	D	E	F
Number of dwellings (n)	70	70	76	55	30	89
Case-status	37.1	51.4	53.9	50.9	60.0	47.2
Type of building (single family houses)	87.1	87.1	73.7	83.6	83.3	83.1
Construction period (1960-1983)	41.4	37.1	42.1	38.2	26.7	46.1
Questionnaire reports of mouldy odour	2.9	6.1	6.8	5.7	3.3	5.7
Inspectors' perceptions of severe mouldy odour in at least one room	17.1	5.7	31.6	7.3	0	22.5
Inspectors' perceptions of severe mouldy odour along the skirting board	8.6	4.3	35.5	9.1	0	24.7
Inspectors' observation of mild/severe 'floor dampness'	12.3	13.5	6.5	0	3.1	5.6
Inspectors' observation of mild/severe 'visible dampness'	34.2	28.4	24.7	12.7	15.6	22.5

To evaluate if the difference between the inspectors reports of mouldy odour and mouldy odour along the skirting board would affect the results, the inspector with the highest frequency of reports of odour (C) and the one with the lowest frequency (E) were excluded in the analyses, one by one. However, the associations expressed in AORs for health effects were only marginally changed, and the agreement values expressed in kappa, remained roughly the same. But it also indicates that professional inspectors are not a "golden standard" with regard to odour sensations.

Conclusions

- The inspectors' perception of a mouldy odour along the skirting board, i.e. a possible proxy for mould and moisture damages in the building structure, was associated with rhinitis and eczema (diagnosed by a doctor) among children, together with an indicated association with sensitization. However, observations of "damp stains" and a general mouldy odour in the houses were surprisingly not associated with asthma or allergy. This indicates that the inspectors' observations of "damp stains" and mould odour in a room cannot be used as health relevant measures indoors in Swedish buildings.

- Inspectors' observations and parental reports showed a good agreement regarding some building characteristics like type of house and type of foundation structure, and to a lower degree type of ventilation and flooring material. However, for mould odour and visible signs of dampness, the agreements were poor.

- The majority of the dwellings had an insufficient ventilation rate. 80% of the single family houses and 60% of the multi family houses did not fulfil the Swedish building code requirements of at least 0.5 ach. A low ventilation rate increased the risk for asthma and allergy among the children, and a dose-response relationship was indicated. However, low ventilation rate was not associated with sensitization. A low ventilation rate was further shown to be an effect modifier.

- Building characteristics that had the strongest association with signs of mould and moisture damage in both the questionnaire study and in the case control study were; houses built in the 1960's and 1970's, single family houses with a concrete slab as ground foundation and/or horizontal roof (built before 1983) and houses with indications of low ventilation rate.

- Day care attendance is associated with an increased risk for airway infections, asthmatic and allergic symptoms among pre-school children. This finding was not explained with a higher prevalence of common colds among children in day care centres. Moisture related problems and insufficient ventilation in day care environments are a possible explanation for this increased risk.

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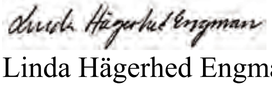
Borås in April 2006



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Observed dampness and mouldy odour indoor and its association with asthma and allergy among 400 children. A nested case-control study.

PAPER I

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Submitted to Building and Environment

Observed dampness and mouldy odour indoor and its association with asthma and allergy among 400 children. A nested case-control study.

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Abstract

There are consistent findings on an association between asthma and allergy and residential moisture and mould and dampness problems in the literature. However, definition of “dampness” is straggling and few studies have tried to estimate mould problems inside the building structure by odour assessments. In a nested case control study of 400 Swedish children (3-8 years), observations and measurements were performed in their home by inspectors and the children were examined by physicians for diagnoses of asthma, eczema and rhinitis. In conclusion, we have found an association between observed mouldy odour along the skirting board and allergic symptoms among children, mainly rhinitis, but no association was found for discoloured stains, “floor dampness” and mould odour in the rooms. A mouldy odour along the skirting board can be a proxy for hidden moisture problem or mould problem inside the outer wall construction or in the foundation construction. There are indications that such dampness problems also increase the risk for sensitization but the interpretation of data in respect of sensitization is difficult since about 80% of the children with rhinitis were sensitized.

Keywords: Dampness, inspection, residence, mouldy odour, asthma and allergy

Introduction

The prevalence of childhood asthma and allergy has increased during the last decades [1, 2]. Since people in western countries spend more than 90% of their time indoors [3] the indoor environment is suspected to play a significant role for the origin of respiratory and allergic disease, especially for children.

It has been reported that dampness and moulds in buildings are associated with asthmatic and allergic symptoms. The causative agents for such health effects are still unknown, but both biological and chemical substances are suspected [4-10].

Two reviews (NORDDAMP and EUROEXPO) of the peer-reviewed scientific literature on dampness in buildings and health concluded that most studies have been of a cross sectional nature with self reported dampness and self reported health. Only few studies have included observed signs of dampness and clinical examination of health effects [5, 11]. In some studies self reported dampness and mould have shown higher odds ratios for health effects [6, 12], and in other dampness observed by inspectors have shown stronger associations to health outcomes [13, 14]. It is discussed whether reporting bias in studies with only self-reported data influences the results [15-19].

The definition of “dampness” varies a lot from e.g. visible mould, specific technical risk solutions to condensation on windows. Often, “dampness” is related to a high relative humidity in the indoor air and consequences such as condensation on walls, visible mould on indoor surfaces and damp stains [5]. In contrast, moisture problems within a construction are often not visible until opening or dismantling the structure. Such damages can be due to leakage, trapped moisture from the building process, moisture from the ground or damages owing to convection of humid indoor air into the construction. And, as Nevalainen et al. (1998) mentions; even small spots of moisture on wall and ceiling surfaces can be a sign of a serious damage underneath the surface covering. Hidden problems within the construction, in crawlspaces and cold attics may give rise to a mouldy smell or spots of discoloration, [8, 20, 21]. However, the reviews NORDDAMP and EUROEXPO [5, 11] concluded that, despite the differences in definition of “dampness” and differences in the frequency of such problems globally (in the range of 4-75%), the risk ratios for health effects like asthma and allergy are mainly the same (OR 1.4-2.2).

The objective of this study has been to evaluate associations between doctor diagnosed asthma and allergic diseases in 400 children and moisture related problems in the children’s homes observed by professional inspectors. Furthermore, an attempt to a more nuanced description of moisture problems with grade of severity and type of observation has been explored.

Method

This study is a part of the DBH-study (DAMPNESS IN BUILDINGS AND HEALTH) on indoor environmental factors in homes and its relation to asthma and allergy among pre-school children and their families in the county of Värmland in Sweden.

The first phase of the DBH-study was carried out in March 2000 as a cross-sectional questionnaire study of 10 852 children [6]. The second phase of the survey, DBH-phase II, was a nested case control study with 198 cases and 202 healthy referent children between 3 and 8 years of age. Potential cases should have at least two of the following symptoms reported in the questionnaire study in the year 2000; “wheezing last 12 months”, “rhinitis last 12 months without a cold” and “eczema last 12 months” and the controls should have none of these or other asthmatic or allergic symptoms (eleven symptoms included). In September 2001, a follow up questionnaire was sent out by post to a randomly selected group of 2 156 children. To be included, the cases should still have at least two of the above mentioned symptoms and the controls should still have no asthmatic or allergic symptoms. Furthermore, the families should not have made any renovations due to mould or moisture or moved since the first questionnaire. No matching of cases or controls was made. The selection of cases and controls is further described in an earlier article [22].

Information on parental smoking and any atopic symptoms was given in an interview by the doctor at the time of the clinical examination. Data on cleaning habits were obtained by a questionnaire to the parents when visiting their home for measurements and inspections.

The medical and technical investigations in DBH phase II were carried out from October 2001 until April 2002. Three teams with a physician and a skilled nurse examined the 400 children and clinical samples were taken. The physician diagnosed asthma, rhinitis and eczema. The procedure and results of the medical examinations are described elsewhere [23]. Blood samples were drawn from 387 children and screened for sensitization to common allergens, (Phadiatop®, Pharmacia & Upjohn Diagnostics, Uppsala, Sweden) and the sensitized children were further tested for specific IgE (RAST) for cat, dog, horse, birch-, mugwort- and timothy grass pollen, house dust mites (Dermatophagoides pteronyssinus, Dermatophagoides farinae) and mould (Penicillium, Cladosporium).

During the same time period as the health examinations (within 10 days), six inspectors visited the children’s homes. The 400 children lived in 390 homes since there were 10 pairs of siblings. One inspector investigated two houses per day. All the inspectors were non-smokers and they were blinded in regard to the case-control status of the children and instructed not to discuss the health of the child and family with the parents.

The dwellings were inspected without any destructive methods or dismantling of structures. The investigators noticed type of constructions, type of materials in the building, and type of installation systems, etc., using a standardized room-by-room protocol. Due to time limits crawlspaces and cold attics were not inspected. Samples of dust and air were collected in the children's bedroom and the living room for analyses of chemical and biological compounds and measurements of ventilation rate (ach), temperature and relative humidity were made [15]. Ventilation rates of the entire home and of the bedroom of the child were measured during one week with a passive tracer gas method [24, 25].

Data on visible signs of dampness and assessment of mouldy odour were collected by the inspectors. The inspector used a scale in four grades to asses the severity of the observations on dampness and odour in the dwellings; grade 0 for "no remarks", grade 1 for "a possible smell or a small visible indication of moisture but no suspected effect on the indoor air quality, (IAQ)", grade 2 for "a slight odour or a small visible moisture damage that might affect the IAQ" and finally grade 3 for " a clear and strong odour or obvious moisture damage with extensive effect on the IAQ". Four dampness indexes; of severity, were calculated. Bathrooms, un-furnished rooms in basements and storerooms were not included in the indexes.

The dampness indexes were modified to a three-graded scale; grade 0 (No remarks), grade 1-2 (Mild) and grade 3 (Severe). Grade 1 and grade 2 were put together due to a vague distinction between these grades. A home was classified into one of the three grades based on the highest grade in at least one room, described below:

Indexes of mouldy odour and visible signs of dampness in the homes:

1. Mouldy odour: First impression of mouldy odour when entering the home or mouldy odour in at least one room.
2. Mouldy odour along the skirting board in at least one room: The inspectors bended on their knees to be able to sniff at spots near the skirting board in at least one spot in every room.
3. Discoloured "damp" stains in at least one room: Visible spots of mould, stains of dampness or discoloured stains on walls or ceiling.
4. Floor dampness in at least one room: Black areas on parquet flooring or bubbly, loosening floor covering material (PVC, Linoleum, etc.).

Statistical methods

Health data from the clinical examination has been analyzed against inspectors' observations of mould and moisture related problems and mouldy odour in the dwellings. Chi-square tests were used for comparisons between building characteristics and dampness indexes. Trends in the data were tested with linear by linear associations. Odds ratios (OR) were estimated in conditional logistic regression analyses with 95% confidence intervals. In multiple regression analyses, adjusted odds ratios (AOR) were calculated with adjustments for gender (male vs. female), age of the child (3-4, 5-6, 7-8 years of age), smoking parent (yes vs. no), asthma and allergy in family (asthma, rhinitis or eczema in at least one parent vs. no such symptoms), type of building (single family house, chain house, multi family house) and construction period (-1960, 1961-1983, 1984-). In further models, adjustments were additionally made for concentration of phthalates in settled dust in the child's bedroom, DEHP, di(2-etyl-hexyl) phthalate and BBzP, (butyl benzyl phthalate), (above vs. below median) and for ventilation rate of the home (above vs. below median). Student's t-test was used to compare ventilation rate and indexes of dampness. A p-value less than 0.05 were used as an indication of significance.

The study was approved by the ethic committee in Örebro, Sweden.

Results

Demographic data and building characteristics of the homes of the 400 cases and controls are presented in table 1. The parents of the cases reported twice as often allergic symptoms than the parents of the controls. Cases had more often a smoking parent than controls, but the difference was not significant. However, in families where both parents were smokers, all children were diagnosed as cases (n=11). Controls lived more often in older houses (constructed before 1940) while cases more often lived in houses from the 70ies.

In table 2 the distribution of moisture indexes is presented. A general finding was that mouldy odour indoor was more commonly observed by the inspectors than visible signs of dampness (discoloured "damp" stains and floor dampness). In 39.2% of the dwellings a mild or severe mouldy odour was detected in at least one room and in almost half of the dwellings (47.4%), a mild or severe mouldy odour along the skirting board was found. Discoloured stains were observed in 24.6% of the dwellings, while only 3.8% were regarded as severe. Of 96 dwellings included in the index "discoloured stains" only 6 had visible mould growth (mild grade of severity) on the wall. Signs of discoloration and loosening of flooring material, parquet or vinyl/linoleum flooring was uncommon (7.4%) and only 4 houses (1%) were considered to have severe signs of floor dampness.

All moisture problems were more frequently reported in single family houses and chain houses, as well as in buildings from the 60ies and 70ies and in buildings with natural ventilation.

A mild or severe mouldy odour was more frequently observed in single family and chain houses compared to multi family houses (42.5 vs. 13.6%; Chi-2 test: $p<0.001$) as well as mild or severe discoloured stains (26.3 vs. 11.4%; $p=0.030$) and a severe mouldy odour along the skirting board (17.3 vs. 6.8%; $p=0.074$). Buildings erected between 1960-1983 were more often affected by a mild or severe mouldy smell and mouldy odour along the skirting board than buildings from other periods (49.0 vs. 32.6% p=0.001 and 58.0 vs. 42.5%; p=0.003). Discoloured “damp” stains were more commonly observed in buildings with natural ventilation compared to buildings with mechanical ventilation systems (30.0 vs. 14.3%; p=0.001) and the same was observed for mouldy odour, (42.8 vs. 32.3%; p=0.045). A mild or severe mouldy odour along the skirting board was less often observed in houses with a balanced ventilation compared to buildings with natural or mechanical exhaust system (22.5 vs. 51.7%; p<0.001) and most common in houses with exhaust ventilation system (57.0 vs. 47.1%; p=0.067). Single family houses and chain houses with a crawlspace or a basement were more often affected by a mild or severe mouldy odour than those with a concrete slab on the ground (46.4 vs. 33.9%; p=0.026). However, severe mouldy odour along the skirting board were more often observed in houses with a concrete slab on the ground (22.0 vs. 14.4%; p=0.075) compared to the other types of foundation.

A mouldy odour along the skirting board and severe mouldy odour in indoor air were significantly associated with a low ventilation rate, table 2. There was no association between ventilation rate and discoloured stains and floor dampness. There was a correlation between mouldy odour in the dwelling and mouldy odour along the skirting board; kappa = 0.47; (overall agreement (167+120) / 390 = 0.74). However, in 69 dwellings where a mouldy odour along the skirting board was observed there were no remarks on mouldy odour in the rooms and in 37 dwellings with a mouldy odour indoor, no mouldy odour along the skirting board was detected.

Associations between the dampness indexes and health of the children are presented in table 3. A significant dose response relationship was found between severity of mouldy odour along the skirting board and doctor diagnosed case status, rhinitis and eczema. A mouldy odour in the dwelling and floor dampness were not associated with any of the tested health outcomes. Discoloured “damp” stains were negatively associated with health outcomes, but in general not significantly so.

From this study it has earlier been reported associations between a low ventilation rate and allergic symptoms [24]. Furthermore, we have shown a strong association between phthalates in settled dust (DEHP, BBzP) and doctor diagnosed asthma, rhinitis and eczema [26]. When adjusting for ventilation rate (below or above median: 0.34 ach) and for concentration of phthalates in settled dust (below or above median concentration) in analyses, the results reported in table 3 remained (data not shown), and a low ventilation rate and a high concentration of phthalates in dust remained associated to the health outcomes as reported earlier.

In table 4 the association between the health outcomes and a combination of ventilation rate (above or below median: 0.34 ach) and mouldy odour along the skirting board (no remarks against mild or grave) is presented. The highest odds ratios for e.g. case status were found in homes with a low ventilation rate in combination with a mouldy odour along the skirting board. The strongest association was found for rhinitis.

Sensitization (IgE in blood) was, as expected, more commonly found among cases (48%) than among controls (12%). When comparing cases with and without sensitization (n=92 vs. n=100), mouldy odour along the skirting board (mild or severe) was more frequently found among sensitized cases (62% vs. 45.0%, p=0.019).

Two of the six inspector's observations differed from the others, (inspector C and E). Inspector C observed considerably more often mouldy odour and mouldy odour along the skirting board than the others, and inspector E did not report any such odour in any house. In analyses without inspector C, the associations between mouldy odour and mouldy odour along the skirting board and the health outcomes decreased somewhat but remained roughly the same, while in the analyses where Inspector E was excluded the association became somewhat stronger as when excluding both of them, (data not shown). There were no significant differences in the distribution of cases and controls, homes (type of building etc) between the different inspectors, and the ORs for health vs. dampness indexes did not differ between the inspectors. Hence, in the results presented here, all inspectors are included in the analyses.

Discussion

The dwellings were more often affected by a mouldy odour in the room or along the skirting board than of visible mould or discoloured "damp" stains. Almost half of the houses had mild or severe mouldy odour or mouldy odour along the skirting board and one fourth had discoloured "damp" stains. This indicates that moisture problems in Swedish buildings are more often hidden inside the building structure compared with buildings in other climates.

Children living in dwellings where the inspectors observed a mouldy odour along the skirting board had a doubled risk of being a case or having specific symptoms (mainly rhinitis) compared to homes without such smell. A mouldy odour along the skirting board is most likely a proxy for hidden moisture damages in the building/floor structure. To detect the amount and cause of a moisture problem within the construction, dismantling of the constructions is needed for inspection and measurements of humidity and mould growth. However, to choose locality for such destructive measures, investigators working in this field often use the method of sniffing near the skirting board in combination with other techniques.

We found an association between sensitization among cases and mouldy odour along the skirting board. However, it is not possible to say if this association is driven by the association between mouldy odour along the skirting board and rhinitis since 81% of the children with rhinitis were IgE positive while about 50% of the children with asthma and/or eczema were IgE positive. The issue whether a mouldy odour along the skirting board is a risk factor for sensitization or not, cannot further be explored in our data which makes this an open question. On the other hand, there are reports indicating a relationship between dampness and sensitization. Verhoeff et. al. [12] compared sensitized asthmatic children with non-sensitized controls and found significantly greater odds ratios as when comparing non-sensitized asthmatics with non sensitized controls for observed dampness and mould. They concluded that home dampness might lead to sensitization to house dust mites and moulds but also to atopy in general. A Finnish study reported an association between exposures to moulds in a moisture damaged school and increased IgE sensitization among the school children compared to a control school [27]. Since only one child had positive IgE to moulds they concluded that health effects of moisture damaged buildings are not caused by IgE-mediated allergy to micro organisms, but more likely explained by other mechanisms association to mould exposure.

Since low ventilation rate and a mouldy odour along the skirting board were correlated with each other and both of them were associated to asthma and allergy among the children there is a risk for confounding. In order to investigate this possible bias, the association between mouldy odour along the skirting board and health outcomes were tested in both adjusted and stratified analyses. When adjusting for ventilation rate (in quartiles) in the multiple logistic models, the association between a mouldy odour along the skirting board remained (table 3). Also, the analyses presented in table 4 show that the association between health outcomes and mouldy odour along the skirting board is higher in the group with low ventilation rate compared with high ventilation rate. This means that our results cannot be explained by low ventilation rate only. But low ventilation rate seems to reinforce the association between health and mouldy odour along the skirting board. We found a significantly increased risk for asthma and allergy when combining a low ventilation rate and mouldy odour along the skirting board in the analyses which support the findings reported by a Norwegian study [28]. They concluded that a low ventilation rate might strengthen the effect of moisture problems in the building and other risk factors and found higher risk of bronchial obstruction among children in the group with lower air change rate in combination with dampness, environmental tobacco smoke, presence of textile wall and plasticizer-containing surfaces. These two studies are supporting the hypothesis that ventilation rate is an effect modifier for indoor pollutants.

Another possible confounder is the wet cleaning frequency in the homes, since families of cases wet cleaned more frequently and since there was a weak association between wet cleaning and mouldy odour along the skirting board. However, adjusting and stratifying data for cleaning habits did not change the associations between mouldy odour along the skirting board and asthma/allergy reported in table 3 (data not shown).

Studies with inspectors' assessment of mouldy odour in residents are few and other definitions of dampness are more often used. In a Finnish study of 363 homes with 121 asthmatic children, inspectors observed mouldy odour in 8% of the dwellings [29], with a non-significant association to asthma (OR=1.91 CI=0.81-4.49) [30]. In our study the frequency of severe mouldy odour in at least one room was doubled (16%) but was not associated with asthma and allergy. In fact, the prevalence of symptoms were in general lower in the group with severe mouldy odour compared with the group with no remarks, however, the differences were not significant. In 103 dwellings, there was no concordance between mouldy odour indoor and mouldy odour along the skirting board. A mouldy odour along the skirting board can bee seen as an indication of moisture damages in the buildings structure (foundation, outer wall), but a mouldy odour in general could be due to several factors in the building; odour from the attic, local spots of damages as in a closet or kitchen, but also odour from food, dirt, pets, fruit, fire wood, pot plants etc. Furthermore, the assessment of mouldy odour indoor could have been confused with other odours in the dwelling such as bad, stuffy or musty odour. One can speculate on whether a mouldy odour along the skirting board i.e. odour from the building structure is strongly associated to rhinitis and to some extent asthma and eczema, while a mouldy odour in the indoor air is not. This could be a chance finding, or due to that a mouldy odour along the skirting board is a proxy for something truly health relevant.

Discoloured “damp” stains were surprisingly negatively associated to symptoms, however not significantly. In other studies, discoloured stains (damp stains) and surface mould growth have been associated to health effects. For example, a British study reported that the more severe dampness or mould in the home, the more likely the subjects were to have more severe asthma [13]. However, except for a lower frequency of mild or severe damp stains in our study compared to the British study (25.6 vs. 51%) the definition, cause and nature of the stains differs. A dampness problem was defined by a measurement of the “moisture ratio” with a resistance meter instrument just above the skirting board, and a mould problem was present if visible mould growth on the wall was observed. The study by Williamson further noticed that 86% of the dwellings with visible mould growth also had areas of dampness. In our study, the discoloured stains, often smaller than 15 x 15cm, were not spots of mould growth since that only was observed in 6 dwellings (bathrooms excluded) and were in most cases not regarded to affect the indoor air quality, i.e. judged as “mild” grade of severity (table 2). There was an association between a low ventilation rate and mouldy odour (both in indoor and along the skirting board) but no association between a low ventilation rate and discoloured stains were found. This too indicates that discoloured stains in this study not primary is an indication of high relative humidity and spots of condensation and moulds indoors, but more likely signs of an old probably dried out water-leakage from e.g. radiators, watering the plants, rain etc and identified as a water mark on the wallpaper not giving rise to an indoor air problem. The negative association between discoloured stains and health might also be caused by a more rigorous repair activity among parents with a case child.

Indications of a moisture problem in the floor structure “floor dampness” were not associated with any of the examined health outcomes. Moisture problems in the floors were the less frequently found dampness index and severe problems were only found in two homes and there are doubts whether the index really can be used as a sign of moisture problems in the floor.

The frequencies of mould and dampness varies a lot between different studies; in the NORDDAMP review between 4-75% [5] and in ECRHS-study including 38 European study centres between 5-55% [10]. Dampness is often described as one or more of the following indications; visible mould, damp stains, condensation on windows and/or walls, high relative humidity in the air, mouldy odour, stuffy odour, need of repair, flooding, water damage etc (NORDDAMP). The important difference is that some of the indications are due to high moisture content in the indoor air which may give rise to condensation and mould growth on cold indoor surfaces while others are signs of hidden moisture problems in the building structure.

In a study from Australia, where 80 houses were inspected 92% had evidence of surface condensation, in 67% a musty odour was experienced and in 40% the inspector observed water intrusion [31]. Furthermore, in 60% of the houses the residents removed mould growth from the house on a regular basis. This example illustrates common types of dampness problems in tropic and sub-tropic climates. In the sub-arctic climate of Scandinavia, with a heating season from October to April, the relative humidity indoors can be low (<20%) for several months during the winter season. In combination with well-insulated constructions, the temperature on indoor surfaces is close to the room-temperature and the dew point temperature is low which limits the risk for surface condensation and visible mould. In this study there were only six dwellings with visible mould on the wall in a residential room (bathrooms not included). However, modern building structures in these climates are often heterogeneous constructed with multi layer structure containing wood, insulation, vapour barrier, gypsum board etc. The structure is energy efficient but any moisture, e.g. trapped moisture from the building process, leakage or moisture-convection etc. is a risk factor for mould growth within the construction compared to solid constructions of concrete or bricks. Areas with mould and moisture problems are seldom visually detected before dismantling the construction, but may be possible to detect by a mouldy smell in the room or close to the site of the damage. A mouldy odour along the skirting board can consequently be a proxy for hidden moisture problems inside the construction.

In a Finnish study of 450 houses, 80% of the houses (the whole house included) had current or previous moisture problem observed by inspectors, and in 55% there was an estimated need of repair due to dampness [21]. In the Finnish dwellings the observed moisture damages were moist spots on walls, signs of leakage, discoloured wooden flooring and damaged surface materials and the authors stated that even a small spot of moisture may be a sign of a serious damage underneath the surface covering. As in our study, they found the highest frequency of moisture damage in houses from the 1960s and 1970s.

The inspectors in the present study had no information about the health status of the child living in the inspected dwelling and no information on previous questionnaire reports on dampness or odour and they were instructed not to discuss any of these matters with the parents. This means that there is a limited risk for observation bias due to knowledge of the case-control status of the child. However, since the inspectors had experience of making investigations in damp buildings, there is a risk of bias when an inspector enters a “typical moisture problem house” as for example a single family house built in the seventies with concrete slab on the ground with insulation above the concrete and no mechanical ventilation system [32]. In such a house an inspector may be likely to make every possible effort to find mouldy odour or other signs of dampness because he/she knows that it is a risk building. However, the pre-established checklist was followed in all houses and sniffing along the skirting board in each room was made for all included dwellings which partly reduced the risk of such bias. Two of the inspectors differed from the others regarding the frequency of observations of mouldy odour and mouldy odour along the skirting board. However, the point estimates did not change significantly when these two inspectors were excluded from the analyses.

The subjective measure of odour by the human nose has some disadvantages; the sensitivity as seen in this study may be different for different people (even if they are trained inspectors) and an odour assessment is subjective. Furthermore, the ventilation rate and the air pressure differences in the building influences the air flow and by that the amplitude of the odour. Microbes smell different depending on species, phase of life cycle, temperature and kind of affected building material etc. Some objective measurements for detecting hidden mould has been tested such as MVOC, electronic nose and special trained dogs, but none of these methods have been shown to correlate with neither inspectors observations on dampness or health effects. According to a German study MVOC measures cannot be predictors for hidden mould due to the low concentrations of these components in the indoor air [33]. Electronic noses have successfully been used to identify mould growth on grains and bakery products, but is not yet applicable in building investigations [34]. The use of specially trained dogs for detection of mouldy odour has been poorly studied but the conclusions of a Finnish study was a high specificity but low sensitivity [35].

Searching for mouldy odour along the skirting board may be a fast and cheep method to be used as a proxy for hidden moisture problems in the building structure without destructive and expensive dismantling. Our results support the hypothesis that odour from microbiological an/or chemical degradation of building material due to moisture inside a construction or foundation can be transported into the indoor environment and increase the risk for allergic symptoms among children as well as sensitization. However, we do not know which health relevant exposures that are in action and both chemical microbiological agents are suspected. Further studies should develop the method of detecting smells near junctions and the skirting boards with an extensive inspection behind the wall or in the foundation. Furthermore, associations between smell and specific agents in indoor air and in dust ought to be explored.

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TABLES 1-4

Table 1 Demographic data and home characteristics for the 400 children.

	Controls N (%) 202	Cases n 198	p-value[1)]
Sex			
Boys	114 (56.4)	113 (57.1)	0.898
Girls	88 (43.6)	85 (42.9)	0.898
Age			
Age 2-4	74 (36.6)	77 (38.9)	0.642
Age 5-6	80 (39.6)	85 (42.9)	0.499
Age 7-8	48 (23.8)	36 (18.2)	0.171
Smoking parent	30 (14.9)	40 (20.2)	0.159
Atopic symptom in at least one parent	87 (43.1)	161 (81.3)	< **0.001**
Sensitized for common allergen	23 (11.8)	92 (47.9)	< **0.001**
Frequency of wet-cleaning the floor in child's bedroom[2)]			
2 times per week or more often	3 (1.5)	7 (3.7)	
1 time per week	44 (22.2)	70 (36.6)	
Once a fortnight	49 (24.7)	51 (26.7)	
Once a month or less	102 (51.5)	63 (33.0)	**0.001** [3)]
Type of building			
Single-family house (SH)	172 (85.1)	161 (81.3)	0.304
Chain house (CH)	11 (5.4)	12 (6.1)	0.792
Multi family house (MH)	19 (9.4)	25 (12.6)	0.303
Construction period			
-1940	67 (33.2)	47 (23.7)	**0.037**
1941-1960	35 (17.3)	37 (18.7)	0.723
1961-1970	25 (12.4)	28 (14.1)	0.603
1971-1983	44 (21.8)	63 (31.8)	**0.023**
1984-	31 (15.3)	23 (11.6)	0.275
Type of ventilation system			
Natural	142 (70.3)	124 (62.6)	0.104
Exhaust	37 (18.3)	56 (28.3)	**0.018**
Balanced	23 (11.4)	18 (9.1)	0.449
Type of foundation[4)]			
Basement	69 (40.1)	61 (37.4)	0.613
Crawlspace	58 (33.7)	42 (25.8)	0.137
Concrete slab on the ground	45 (26.2)	60 (36.8)	0.069

[1)] Pearson chi-square test.
[2)] Dwellings with textile wall to wall carpet in the child's bedroom excluded (n=4).
[3)] Tested with linear by linear association for trends.
[4)] Data available only for single family houses and chain houses. Other type of foundation, n=15 and missing information, n=6.

Table 2 Distribution of moisture problems indexes and mouldy odour in the 390 buildings.

	Grade of severity		Type of building (%)			Construction period of the building (%)					Type of ventilation system (%)			Type of foundation[1] (%)			Ventilation rate
			Single family houses (SH)	Chain houses (CH)	Multi family houses (MH)	-1940	1941-1960	1961-1970	1971-1983	1984-	Natural	Mech. exhaust	Mech. exhaust and supply	Base-ment	Crawl-space	Concrete slab on ground	mean ach
		n (%)	323	23	44	109	70	51	106	54	249	92	37	127	95	103	
Mouldy odour	No remarks	237 (60.8)	58.2	47.8	86.4	61.5	64.3	54.9	49.1	83.3	57.2	65.6	72.5	52.8	54.7	67.0	0.39
	Mild	89 (22.8)	23.5	34.8	11.4	22.9	22.9	21.6	27.4	14.8	24.5	20.4	17.5	28.3	25.3	15.5	0.38
	Severe	64 (16.4)	18.3	17.4	2.2	15.6	12.9	23.5	23.6	1.9	18.3	14.0	10.0	18.9	20.0	17.5	0.33
p-value																	0.193 [2] **0.033** [3]
Mouldy odour along the skirting board	No remarks	205 (52.6)	52.9	47.8	52.3	51.4	51.4	39.2	45.3	83.3	51.0	46.2	77.5	56.7	44.2	49.5	0.39
	Mild	122 (31.3)	29.7	34.8	40.9	37.6	42.9	35.3	23.6	14.8	33.5	33.3	12.5	29.9	40.0	26.2	0.37
	Severe	63 (16.2)	17.3	17.4	6.8	11.0	5.7	25.5	31.1	1.9	15.6	20.4	10.0	13.4	15.8	24.3	0.32
p-value																	**0.038**[2] **0.012**[3]
Discoloured “damp” stains	No remarks	294 (75.4)	74.0	69.6	88.6	70.6	77.1	72.5	73.6	88.9	70.0	89.2	77.5	70.1	72.6	78.6	0.38
	Mild	81 (20.8)	22.0	26.1	9.1	23.9	18.6	21.6	23.6	11.1	26.5	7.5	15.0	25.2	22.1	20.4	0.36
	Severe	15 (3.8)	4.0	4.3	2.3	5.5	4.3	5.9	2.8	0	3.5	3.2	7.5	4.7	5.3	1.0	0.42
p-value																	0.774[2] 0.443[3]
Floor dampness	No remarks	361 (92.6)	93.5	82.6	90.9	90.8	92.9	90.2	93.4	96.3	93.4	91.4	90.0	93.7	92.6	91.3	0.38
	Mild	25 (6.4)	5.3	17.4	9.1	8.3	7.1	5.9	5.7	3.7	5.8	7.5	7.5	4.7	6.3	7.8	0.34
	Severe	4 (1.0)	1.2	0	0	0.9	0	3.9	0.9	0	0.8	1.1	2.5	1.6	1.1	1.0	0.39
p-value																	0.514[2] 0.870[3]

[1] Data available only for single family houses and chain houses.
[2] Test of differences in mean ventilation rate between the severity of different moisture indexes (no remarks vs. mild or severe), student t-test.
[3] Test of differences in mean ventilation rate between the severity of different moisture indexes (no remarks vs. severe), student t-test.

Table 3 Associations between four dampness indexes and different health outcomes.

	Degree of severity	Controls	Cases	Cases status		Asthma	Asthma		Rhinitis	Rhinitis		Eczema	Eczema	
	n	202	198			121			99			129		
		n (%)	n (%)	OR	AOR[1]	%	OR	AOR[1]	%	OR	AOR[1]	%	OR	AOR[1]
Mouldy odour	No remarks	122 (60.4)	120 (60.6)	1	1	61.2	1	1	55.6	1	1	59.7	1	1
	Mild	45 (22.3)	47 (23.7)	1.06 (0.66-1.72)	1.07 (0.62-1.84)	24.8	1.10 (0.64-1.90)	0.99 (0.54-1.84)	30.3	1.48 (0.84-2.59)	1.78 (0.92-3.45)	26.4	1.20 (0.71-2.03)	1.26 (0.69-2.30)
	Severe	35 (17.3)	31 (15.7)	0.90 (0.52-1.55)	0.83 (0.44-1.56)	14.0	0.80 (0.42-1.53)	0.57 (0.27-1.26)	14.1	0.89 (0.44-1.78)	1.07 (0.46-2.46)	14.0	0.82 (0.43-1.54)	0.76 (0.36-1.61)
p-value[2]			0.877			0.698			0.302			0.573		
Mouldy odour skirting along the board	No remarks	116 (57.4)	95 (48.0)	1	1	49.6	1	1	41.4	1	1	44.2	1	1
	Mild	60 (29.7)	64 (32.3)	1.30 (0.84-2.03)	1.38 (0.83-2.28)	33.1	1.29 (0.78-2.14)	1.30 (0.73-2.29)	37.4	**1.75 (1.01-3.00)**	**2.23 (1.17-4.24)**	36.4	1.59 (0.97-2.62)	**1.86 (1.04-3.30)**
	Severe	26 (12.9)	39 (19.7)	**1.83 (1.04-3.22)**	1.69 (0.88-3.26)	17.4	1.56 (0.81-3.00)	1.28 (0.60-2.73)	21.2	**2.29 (1.16-4.49)**	**2.45 (1.08-5.54)**	19.4	**1.96 (1.04-3.69)**	1.93 (0.91-4.12)
p-value[2]			**0.029**			0.142			**0.007**			**0.017**		
Discoloured "damp" stains	No remarks	148 (73.3)	155 (78.3)	1	1	77.7	1	1	72.7	1	1	82.2	1	1
	Mild	44 (21.8)	38 (19.2)	0.83 (0.51-1.35)	0.86 (0.50-1.48)	20.7	0.89 (0.51-1.56)	0.86 (0.47-1.60)	26.3	1.22 (0.69-2.13)	1.39 (0.73-2.67)	16.3	0.67 (0.37-1.19)	0.64 (0.34-1.20)
	Severe	10 (5.0)	5 (2.5)	0.48 (0.16-1.43)	0.45 (0.13-1.55)	1.7	0.32 (0.07-1.47)	0.28 (0.5-1.52)	1.0	0.21 (0.03-1.64)	0.37 (0.04-3.43)	1.6	0.28 (0.06-1.30)	0.30 (0.06-1.57)
p-value[2]			0.158			0.205			0.604			**0.036**		
Floor dampness	No remarks	186 (92.1)	184 (92.9)	1	1	94.2	1	1	92.9	1	1	93.8	1	1
	Mild	14 (6.9)	12 (6.1)	0.87 (0.39-1.92)	0.87 (0.35-2.12)	5.0	0.70 (0.26-1.87)	0.82 (0.28-2.42)	6.1	0.87 (0.32-2.33)	1.16 (0.36-3.76)	4.7	0.66 (0.25-1.76)	0.78 (0.26-2.34)
	Severe	2 (1.0)	2 (1.0)	1.01 (0.14-7.25)	1.12 (0.13-9.79)	0.8	0.82 (0.07-9.10)	0.82 (0.05-12.33)	1.0	1.01 (0.09-11.29)	1.58 (0.10-26.14)	1.6	1.54 (0.21-11.06)	1.88 (0.20-17.29)
p-value[2]			0.791			0.512			0.830			0.747		

[1]Adjustments for sex, age, smoking in family, asthma, allergy and/or eczema in family, construction period, type of building.
[2]Tested with linear by linear association for trends.

Table 4 Association between different health outcomes and combinations of mouldy odour along the skirting board and ventilation rate in the home.

	No mouldy odour at the skirting board (no remarks)						Mouldy odour at the skirting board, (mild or severe)						
	High ventilation rate (above median) (Ref) n=114			Low ventilation rate (below median) n=92			High ventilation rate (above median) n=84			Low ventilation rate (below median) n=106			p-value [2)]
	%	OR	AOR[1)]	%	OR	AOR[1)]	%	OR	AOR[1)]	%	OR	AOR[1)]	
Case status	38.6	1	1	51.1	1.66 (0.95-2.90)	1.42 (0.76-2.65)	53.6	**1.84 (1.04-3.25)**	1.52 (0.80-2.90)	58.5	**2.24 (1.31-3.85)**	**2.39 (1.27-4.50)**	0.003
Asthma	30.7	1	1	38.4	1.41 (0.75-2.65)	1.20 (0.59-2.46)	44.3	1.80 (0.95-3.38)	1.44 (0.71-2.94)	41.3	1.59 (0.85-2.97)	1.60 (0.77-3.32)	0.093
Rhinitis	20.5	1	1	31.8	1.82 (0.87-3.78)	1.68 (0.73-3.84)	40.0	**2.59 (1.27-5.31)**	**2.52 (1.11-5.76)**	43.6	**3.01 (1.52-5.96)**	**4.40 (1.92-10.12)**	0.001
Eczema	26.3	1	1	39.2	1.80 (0.94-3.47)	1.43 (0.68-3.02)	46.6	**2.44 (1.28-4.67)**	**2.13 (1.01-4.48)**	48.2	**2.61 (1.40-4.87)**	**3.14 (1.48-6.67)**	0.002

[1)] Adjusted odds ratio: Adjustments made for sex, age, smoking in family, asthma, allergy and/or eczema in family, construction period.
[2)] Trend analysis made by linear by linear analysis.

How valid are parents questionnaire responses regarding building characteristics, mouldy odour and signs of moisture problems in Swedish homes?

PAPER II

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How valid are parents questionnaire responses regarding building characteristics, mouldy odour and signs of moisture problems in Swedish homes?

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Abstract

Aim: Questionnaires are a cheap means of studying large populations, but the information obtained from them is seldom validated. Earlier studies have reported both high and low levels of agreements between inspectors observations and occupants reports, regarding home environmental factors which included moisture problems. The aim of this study was to validate information received from a questionnaire survey regarding building characteristics, mouldy odour and signs of moisture problems in 390 Swedish homes.
Method: In a case control study on the association between home environmental factors and asthma/allergy among children, 390 homes were visited by trained inspectors for ocular inspection of visible moisture damage and perceptions of mouldy odour. Their observations were then compared to questionnaire reports collected 18-24 months earlier from the families.
Results: A high level of agreement was found between the inspectors' observations and the occupants' questionnaire reports of technical parameters. This included type of house, type of ventilation system and foundation particularly in single family houses. There was a low agreement regarding vinyl or linoleum floor coverings and indications of dampness and mouldy odour. However, the stronger the mouldy odour experienced by the inspector, the higher the level of agreement.
Conclusions: The questionnaire was a rather reliable source regarding technical parameters of the home but not for dampness problems. The questionnaire was better for predicting buildings without problems than detecting problems of mouldy odour and visible indications of moisture. To increase the validity of future questionnaires, simple drawings or information on critical spots for dampness could be used.

Keywords: Validation, questionnaire, inspections, mould, moisture, odour, dampness.

Background

Most scientific literature on moisture related problems in buildings and health effects contain data from questionnaires (1, 2). However, how valid is this information regarding building characteristics and signs of moisture problems in homes? Validation of questionnaire responses with data from inspections and/or measurements is of importance, since questionnaires are a cheap way of investigating large populations. Studies where such validations have been performed show that occupants and inspectors often disagree with their assessments of e.g. moisture damage and odour (3-10). Some studies report that occupants may under-estimate moisture damages compared to inspectors, while others have reported the opposite (1, 3, 9). In a number of studies, questionnaire data regarding moisture problems has been validated against dust- and air samples including analysis of viable fungi and ergosterol with divergent results (6, 11, 12). Therefore, there is a great need fore more knowledge about the validity of questionnaires when they are used in the description and evaluation of indoor air environments. The aim of this study was to validate parental questionnaire reports on building characteristics, visible moisture problems and mouldy odour with observations from professional inspectors.

Method

As a first phase of the Swedish study Dampness in Buildings and Health (DBH) a cross sectional questionnaire study on asthma and allergy in pre-school children and their home environmental was carried out in the year 2000. The baseline questionnaire was sent to the parents of 14 077 children, aged 1-6 years. The parents of 10 852 children responded, corresponding to a response rate of 79 % (13, 14).

The second phase of DBH was a nested case control (case non-case) study on 198 symptomatic children and 202 healthy controls. The selection of cases and controls is in detail described in another paper (15). There were 10 pairs of siblings, meaning that 390 families/homes were included.

Between October 2001 and April 2002, inspections and measurements were performed in the 390 homes by six inspectors (A-F), 18-24 months after the baseline questionnaire. Each inspector visited two houses per day. They made an ocular inspection and collected dust and air samples. They also measured ventilation rate, temperature and relative humidity in the indoor air.

The 390 homes were randomly allocated to the six inspectors. Firstly, all inspectors performed the very first inspection and measurements in one dwelling. Secondly, pairs of inspectors visited the two next homes together and after that one inspector alone visited two houses per day. The inspectors had no information about the health status of the child and the family at the time of the inspections, and were told not to discuss such issues with the family.

All variables in the checklist had pre-printed questions and an ocular room-by-room examination was carried out for visible signs of moisture damage and odour perception. The inspections were performed without destructive methods or dismantling of the building structure. Spaces like cold attics or crawlspaces were not visited due to time constraints.

Questions in the baseline questionnaire on visible mould, discoloured/damp stains and bubbly vinyl floor covering could be answered by "yes", "no" or "don't know" for the child's room, parents bedroom, other room and bathroom. Mouldy odour was reported; "often (every week)", "sometimes" or "no never" for the dwelling as a whole. "Don't know" answers and missing values were excluded.

The inspectors' observations on possible signs of mould and moisture, mouldy odour and indoor air quality (IAQ) were classified into four categories (0-3) depending on the assessment of severity of odour and visible moisture damage; 0 for "no remarks" i.e. no signs of moisture damage or divergent odour, 1 for "a possible smell or a visible local indication of moisture but no suspected effect on the IAQ", 2 for "a slight odour or a local visible moisture damage that could affect the IAQ" and finally 3 for "a clear and strong odour or obvious moisture damage with extensive effect on the IAQ".

Five different indexes on "dampness" were calculated from the questionnaire and from the checklist of the inspectors:

1. *Visible mould:* Visible mould on walls, floor or ceiling in the child's or parents bedroom.
2. *Damp stains:* Spots of damp- or discoloured stains on walls, floor or ceiling in the child's or parents bedroom.
3. *Bubbly vinyl flooring:* Loosening, bubbly or discoloured vinyl floor covering (or linoleum) in the child's room or the parents' bedroom.
4. *Blackened parquet:* Black areas on wooden parquet in the dwelling (residential areas).
5. *Mouldy odour:* Mouldy odour in the dwelling (residential areas).

The indexes include data on visible mould, damp stains and bubbly vinyl flooring only from the child's room and parents' bedroom since "other room" was not specified in the questionnaire. For flooring material, the kitchen was also included. Regarding observations and reports of mouldy odour and blackened parquet, all residential rooms were included. The size of damage was not specified, either in the questionnaire or in the inspector's checklist.

Statistical analyses

Cohen´s kappa (κ) was used to measure the agreement between inspectors observations and questionnaire reports. In addition, the values of proportion of observed agreement (p_o), positive- and negative proportional agreement (p_{pos} and p_{neg})

were used regarding to Chicchetti and Feinstein (16). Kappa values have been calculated in SPSS 11.5 and p_o, p_{neg} and p_{pos} by hand.

Three different models were used when comparing the questionnaire reports with the inspectors' observations of the dampness indexes. Model 1 included grade 1-3 of the inspectors' observations, Model 2 included grade 2 and 3 (grade 1 excluded), and finally Model 3 included grade 3 (grade 2 and 3 excluded) of the inspectors' observations.

The ethics committee in Örebro, Sweden, approved the study.

Results

The 390 dwellings consisted of 346 single-family houses (including 23 terrace houses) and 44 apartments in multifamily houses, table I.

Building characteristics

There was a very good agreement, expressed in kappa value (κ), positive- and negative proportional agreement (p_{pos}, p_{neg}) between the questionnaire reports and the inspectors' observations regarding the type of building, table I. However, eleven dwellings which were categorized in the questionnaire as terrace houses were categorized by inspectors as single-family houses. There was a very good agreement ($\kappa>0.80$) between the questionnaires and the inspectors' observations on foundation type for the single-family houses. However, twenty misclassifications were detected from the questionnaire reports regarding crawlspaces. Eight of these houses had concrete slab on the ground and twelve had a basement/semi-subterranean foundation according to the inspectors' observations.

Kappa values for ventilation systems were in the range 0.50 to 0.84 for single family houses. The highest agreement levels were found for dwellings with balanced ventilation and the lowest for natural ventilation without a kitchen fan. It was a fair agreement regarding natural ventilation in the multi family houses, but a poor and even negative agreement for exhaust and balanced ventilation. A common misclassification in the questionnaire reports was that families who had reported natural ventilation in some dwellings actually had exhaust ventilation according to the inspectors' observations (15 single family houses and 17 multi family houses).

The agreement levels on type of floor covering materials were in general higher in single family houses than in multi family houses, except for wood/laminate. Linoleum and vinyl had the lowest kappa values. Of 33 questionnaire reports in single-family houses on linoleum flooring in the child's bedroom, 22 had in fact vinyl floor covering according to the inspector's observations. Of 43 questionnaire reports in single family houses on linoleum flooring in the kitchen, 30 had vinyl floor covering and 40 out of

55 reports on “plastic cork” had vinyl flooring according to the inspectors’ observations.

Visible signs of moisture problems and mouldy odour

The inspectors perceived a mouldy odour six times more often in the homes than the parents had reported, see table II. If limiting the analyses to the inspectors’ assessment of “grave” mouldy odour (grade 3), they still reported a mouldy odour almost twice as often as the parents.

There was a low level of agreement for visible signs of moisture damages (visible mould, damp stains, bubbly vinyl flooring and blackened parquet) in the buildings (κ=-0.04-0.11, p_{pos}= 0-0.44), but a high level agreement for buildings without such questionnaire reports or inspector observations (p_{neg}= 0.89-1.0), table II. The agreement values for the index “damp/discoloured stains” turned out to be higher when including all grades of severity into the model (Model 1), compared to the model where only the most severe damp stains were included (Model 3). The opposite relation was found for perception of mouldy odour in the home; when restricting the analyses to only include homes with the most severe perceived mouldy odour (grade 3), the measures of agreement became higher. However, for both the indexes “damp stains” and “mouldy odour”, the positive proportional values were reduced with severity of the inspectors’ observations as a result of lower frequencies in those models.

No major difference was seen between inspectors on assessments on visible signs of moisture problems. However, two of the six inspectors’ assessments on mouldy odour distinguished them from the others. Inspector C experienced some mouldy odour in a majority of the dwellings (71%) and a severe odour in 17% (grade 3) while another inspector not reported any mouldy odour at all. In the houses of Inspector C, there were more questionnaire reports on mouldy odour than in the houses inspected by Inspector E, however not significant, and this could not explain their differences to the other inspectors. We analyzed the data in four different ways when comparing questionnaire data and inspections regarding mouldy odour; Inspector C excluded, Inspector E excluded, Inspector C and E excluded and finally inspector C assessments with a revised odour severity of one step down. However, the values of agreement remained about the same compared to the analysis of the original data, (data not shown).

Discussion

Questionnaire data about building characteristics was in general more valid from families living in single family than from families living in multi family houses. Many occupants had difficulties in determining the type of floor covering material, especially the difference between linoleum and vinyl. Andrae et al. (8) validated a questionnaire with inspections in 34 homes in Sweden. Despite rather high values of sensitivity and specificity, they experienced that occupants found it hard to answer questions about the construction and materials of the house. This pointed out the need for more informative questionnaires in the future regarding technical parameters.

The general result of the validation of visible moisture problems and mouldy odour assessments were low kappa-values but high observed agreement. The low kappa values correspond to a low concordance between the inspectors' observations and questionnaire reports on the visible signs of moisture damage and mouldy odour. On the contrary, observed agreement values were high, i.e. the overall agreement value when also including the great number of houses that neither by the parent nor by the inspectors was reported to have moisture damage. This paradox with low kappa but high observed agreement was resolved by including measures of negative and positive proportional agreement values to get more information about the pattern of the disagreement as suggested by Chicchetti and Feinstein (16). The high negative proportional agreement but very low positive proportional agreement, tells us that the questionnaire was reliable to categorize non-problem buildings but were not particularly appropriate for identifying buildings with mould or moisture problems. A Finnish study with questionnaire and inspection data for moisture damage, visible mould and mouldy odour in 363 residences, also recorded low kappa values and high negative proportional agreements (10). However, their values of positive proportional agreement (p_{pos}) were higher for visible signs of moisture damage compared to our study, maybe due to a higher frequency of such damage in the Finnish study. On the contrary, p_{pos} for mouldy odour was somewhat higher in our Swedish study.

A time lap of 18 to 24 months between the questionnaire and the inspections could have influenced the difference between the inspectors' observations and questionnaire reports. However with respect to the inclusion criteria (for cases and controls), no major changes or repairs due to water damage, dampness or mould should have been undertaken since the baseline questionnaire was carried out. There is a lack of information regarding whether or not the rooms have been switched between family members, although we consider this to be of limited risk, especially the location of the kitchen and the parents' bedroom. In addition, we did not know if the surface material e.g. floor covering or wall paper had been changed from the time of the baseline questionnaire to the inspections.

Another explanation to the low agreements on visible signs of moisture problems and perceptions of mouldy odour in the homes may be attributed to how dampness and odour is defined and perceived. The determination of mouldy odour and of the severity of a damp stain can differ between a layman and a trained inspector. A lot of different smells are associated to mould growth and inspectors who in their daily work investigates such damage increases their sensibility to these smells. However, even though the inspectors have been trained, all perceptions of odour are subjective. This subjectivity is also discussed in a Norwegian study where they found poor reproducibility between and within the inspectors (17). Therefore, to use inspectors as "golden standard" may not be more "true" than using self-reported data from questionnaires.

When excluding and including the inspector who more often perceived mouldy odour than the others, and the inspector who observed no mouldy odour, the agreement values did not change significantly. Therefore, the original judgments of these inspectors were used in the analyses. We have not studied the inter-inspector validity, but in a Finnish study, 15 out of 363 residences were inspected for moisture damages by two inspectors independently. They found a moderate agreement for observed moisture damage (κ=0.40) and very good agreement for a perception of poor indoor air quality (κ=0.84), but poor/negative agreement for mould odour (κ=0.00) and other odour (κ=-0.12) between these inspectors (10).

Differences in agreement between questionnaire reports on dampness and inspectors' observations might partly be addressed to differences in the character of moisture damage in different climates, i.e. easily detected areas of visible mould on the walls vs. hidden damage inside the building structure. An Australian study showed high kappa-values for mould and dampness (18) while, another Scandinavian study reported quite low concordance for moisture damages and mouldy odour (10).

Mould growth visible on indoor surfaces (except for basements and bathrooms) is seldom present in buildings in Scandinavia due to low relative humidity during the long heating season in combination with well-insulated external walls. Elevated moisture levels are more often found inside the construction and are in most cases caused by leakage, moisture from the ground, built-in moisture from the time of construction or condensation in colds spaces owing to convective forces. These types of damage may result in microbiological growth and chemical degradation of materials and are often detected by a mouldy or divergent smell in the room or near junctions such as along the skirting board. However, even though visible dampness problems on surfaces might be easier to detect, it do not always lead to high agreement levels between questionnaire reports and inspectors observations. In Australia, 80 households were inspected and visible mould growth on indoor surfaces were found in every house at some time during the study, but only 23% of the residents considered their house to be "damp" (6).

In our study the trained inspectors observed more signs of dampness and mouldy odour than did the occupants. This finding is also reported by other studies in Finland (3) and in the UK (9). The opposite was reported in the NORDDAMP-review, where it was concluded that occupants mostly reported more dampness problems than inspectors had observed, explained in their conclusion, as a result of longer time interval for occupants reports compared with the inspectors momentary visit (1). However, many of the reviewed studies were conducted in countries where visible mould and dampness on surfaces are more commonly seen and easy to detect, which could explain some of the frequency difference between occupants and inspectors reports on "dampness".

A plausible factor that explains the higher frequency of observed signs moisture problems and mouldy odour is that a trained inspector knows the weak points of the building depending on type of construction, construction period and materials. This can lead him/her directly to the more sensitive parts of the building. This is also the conclusion in a Finnish study (3) where they suggested that the higher prevalence of dampness indications observed by inspectors was a result of a “trained eye” and knowledge about critical problem constructions. Furthermore, occupants might get “blind” to defects in their own home if they are used to a discoloured spot or a specific smell. It is often speculated if people living with a mouldy odour inside their house are seldom aware of the problem themselves. Furthermore, friends and neighbours are often likely to keep quiet about the problem as they know that it may involve extensive costs and trouble for the affected families.

Conclusions

The questionnaire was considered to be reliable source regarding technical parameters such as type of house, location and type of foundation. The agreement on type of ventilation system was moderate to good for single-family houses but poor for multi family houses. The questionnaire was valid for wooden flooring but not for vinyl and linoleum since these materials were often mixed up. The questionnaire was better for predicting non-problem dwellings due to the high values of negative proportional agreement than detecting problems of mouldy odour and visible indications of moisture. Simple drawings, pictures or examples could be used to increase the validity of future questionnaire studies including building characteristics and signs of moisture damage.

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	All houses						Single family houses / Terrace houses						Multi family houses					
	Inspection	Questionnaire	Kappa	p_o	p_{pos}	p_{neg}	Inspection	Questionnaire	Kappa	p_0	p_{pos}	p_{neg}	Inspection	Questionnaire	Kappa	p_0	p_{pos}	p_{neg}
Type of building	n	n					n	n					n	n				
Single family house (SH)	323	308	0.85	0.95	0.97	0.88												
Terrace house	23	34	0.66	0.95	0.68	0.98												
Flat in MH	44	37	0.93	0.99	0.94	0.99												
Location																		
Urban	33	31	0.46	0.97	0.50	0.96	14	19	0.21	0.93	0.24	0.96	19	12	0.65	0.83	0.77	0.87
Suburban	252	218	0.61	0.82	0.85	0.76	227	189	0.61	0.81	0.85	0.77	25	29	0.61	0.81	0.85	0.75
Country side	100	129	0.80	0.91	0.86	0.94	100	128	0.80	0.91	0.86	0.93	0	1	-	0.98	0	0.99
Type of foundation																		
Concrete slab on the ground							103	93	0.87	0.95	0.91	0.96						
Crawlspace							93	109	0.82	0.92	0.88	0.95						
Basement/ semi-subterranean house							141	122	0.85	0.93	0.91	0.94						
Ventilation system																		
Natural ventilation without kitchen fan	20	37	0.46	0.92	0.50	0.96	19	31	0.50	0.93	0.53	0.96	1	6	0.25	0.87	0.29	0.93
Natural ventilation with kitchen fan	229	234	0.60	0.81	0.85	0.75	220	214	0.63	0.83	0.87	0.76	9	20	0.29	0.64	0.50	0.72
Exhaust ventilation	92	42	0.50	0.86	0.58	0.91	62	38	0.65	0.91	0.70	0.95	30	4	0.03	0.39	0.20	0.50
Balanced ventilation	37	34	0.77	0.96	0.79	0.98	33	33	0.84	0.97	0.86	0.99	4	1	-0.04	0.87	0	0.93
Floor covering material																		
Plastic floor covering in kitchen (PVC)	245	177	0.50	0.74	0.76	0.72	207	153	0.52	0.75	0.76	0.74	36	24	0.33	0.68	0.77	0.50
Linoleum in kitchen	12	43	0.22	0.90	0.26	0.94	9	34	0.24	0.91	0.27	0.95	3	7	0.12	0.82	0.20	0.90
"Plastic cork" in the kitchen	13	55	0.22	0.87	0.27	0.93	13	48	0.25	0.88	0.30	0.93	0	7	-	0.84	0	0.91
Wood/laminate in the kitchen	106	87	0.77	0.91	0.82	0.94	100	83	0.76	0.91	0.83	0.94	5	3	0.73	0.96	0.75	0.98
Plastic floor covering in the child's bedroom	211	159	0.48	0.74	0.72	0.75	176	137	0.49	0.74	0.72	0.76	32	21	0.33	0.66	0.72	0.57
Linoleum in the child's bedroom	13	33	0.14	0.91	0.18	0.95	9	26	0.14	0.92	0.17	0.96	4	6	0.10	0.82	0.20	0.90
Wood/laminate in the child's bedroom	159	139	0.76	0.89	0.85	0.91	151	131	0.74	0.88	0.85	0.89	8	7	0.92	0.98	0.93	0.99

Table I. Agreement between parents' reports of building characteristics and inspectors' observations in 390 homes.

Table II. Frequencies of moisture problem and moldy odor from inspections and questionnaire reports and agreements between observed and reported data.

		Total number of observations (grade 1-3) and questionnaire reports (yes)	Inspectors observations, severity grade vs. questionnaire reports: Grade 0 (no observations)	Grade 1	Grade 2	Grade 3		Model 1: all data	Model 2: grade 2 and grade 3 vs. questionnaire reports (yes)	Model 3: grade 3 vs. questionnaire reports (yes)
Visible mould Visible mould on the walls, floor or ceiling in the child's bedroom or parent's bedroom.	Inspection	5		2	3		κ	-0.04	-0.004	-
							p_0	0.98	0.99	1.00
	Questionnaire	1	1				p_{pos}	0	0	0
							p_{neg}	0.99	1.00	1.00
Damp stains Spots of damp stains/discolored stains on the walls, floor or ceiling in the child's bedroom or parent's bedroom.	Inspection	47		22	18	7	κ	0.11**	0.10*	-0.02
							p_0	0.88	0.92	0.97
	Questionnaire	9	5	2	2		p_{pos}	0.44	0.29	0
							p_{neg}	0.89	0.94	0.98
Bubbly plastic flooring Loosening, bubbly or discoulored plastic floor covering in the child's room or parent's bedroom.	Inspection	3		2	1		κ	-0.01	-0.01	-
							p_0	0.98	1.00	0.99
	Questionnaire	5	5				p_{pos}	0	0	0
							p_{neg}	0.99	0.98	1.00
Blackened parquet Black areas on wooden parquet in the dwelling.	Inspection	16		9	5	2	κ	0.04	-0.02	-0.01
							p_0	0.93	0.95	0.96
	Questionnaire	12	11	1			p_{pos}	0.08	0	0
							p_{neg}	0.96	0.98	0.99
Mouldy odour indoor Mouldy odour in the bedrooms, living room or other residential room.	Inspection	133		42	52	39	κ	0.06*	0.11**	0.23***
							p_0	0.67	0.75	0.87
	Questionnaire	20	9	1	2	8	p_{pos}	0.55	0.53	0.47
							p_{neg}	0.67	0.76	0.89

Level of significance for kappa, p-value:
*** $p < 0.001$, ** $0.001 < p < 0.01$, * $0.01 < p < 0.05$

Association between ventilation rates in 390 Swedish homes and allergic symptoms in children

PAPER III

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Association between ventilation rates in 390 Swedish homes and allergic symptoms in children

Abstract The aim of the study was to test the hypothesis that a low-ventilation rate in homes is associated with an increased prevalence of asthma and allergic symptoms among children. A total of 198 cases (with at least two of three symptoms: wheezing, rhinitis, eczema) and 202 healthy controls, living in 390 homes, were examined by physicians. Ventilation rates were measured by a passive tracer gas method, and inspections were carried out in the homes. About 60% of the multi-family houses and about 80% of the single-family houses did not fulfill the minimum requirement regarding ventilation rate in the Swedish building code (0.5 air changes per hour, ach). Cases had significantly lower ventilation rates than controls and a dose–response relationship was indicated.

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Key words: Ventilation rate; Homes; Asthma; Allergic symptoms; Children.

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Practical Implications
A low-ventilation rate of homes may be a risk factor for allergies among children. Families with allergic children should be given the advice to have good ventilation in the home. In investigations, of associations between environmental factors and allergies, the air change rate in homes has to be considered.

Background

Increased costs for energy, and thus for heating of buildings, starting with the oil embargo in 1973, has induced tightening of building envelopes and reduced ventilation in cold climate (Öie et al., 1999; Sundell, 1994). This decrease in ventilation rates coincides in time with the increase in allergic diseases among children and adults.

In a multidisciplinary review of the scientific literature on ventilation and health (EUROVEN) it was concluded that a low-ventilation rate in offices is associated with an increased risk of health effects (SBS symptoms) (Seppänen and Fisk, 2002; Wargocki et al., 2002). However, only a few conclusive studies were found regarding ventilation of homes and its association to health effects. For homes in a Nordic climate it was concluded that ventilation rates above 0.5 air changes per hour (ach) decrease the risk of infestation of house dust mites, and thus the risk of allergic sensitization and symptoms. In one study from Norway (Öie et al., 1999) and one from Sweden (Emenius et al., 2004) no obvious direct association could be seen between ventilation rates of homes and asthma and allergy among children. However, in the study by Öie et al. it was found that bronchial obstruction among children was associated with some pollution sources (vinyl surfaces on walls and floors, and 'dampness') and that this association became elevated at a low-ventilation rate (below 0.5 ach).

The aim of this study was to test the hypothesis that a low-ventilation rate in homes is associated with asthma and allergic symptoms among children in Sweden.

Method

This study is a part of a large investigation on the impact of the indoor environment on asthma and allergy among children in Sweden, DAMPNESS IN BUILDINGS AND HEALTH (DBH) (Bornehag et al., 2004a). The first step of the DBH-study was a cross-sectional questionnaire investigation involving 14,077 children aged 1–6 years in Värmland, Sweden (DBH-step 1) (Bornehag et al., 2004b). The present study is a part of the second step (DBH-step 2): a nested case–control investigation including 198 symptomatic children (cases) and 202 non-symptomatic controls. A description of the design of the questionnaire study (DBH-step 1) and the selection procedure for cases and controls (DBH-step 2) are described in Bornehag et al. (2004a).

Inclusion criteria for cases and controls

The selection criteria for the cases in DBH-step 2 were (1) in the initial questionnaire, reports of at least two symptoms of 'wheezing during last 12 months without a cold,' 'rhinitis during last 12 months without a cold' and 'eczema during last 12 months.' In the follow-up questionnaire, 1.5 years later, they had to: (2) report at least two of three possible symptoms. Inclusion criteria for the controls (i.e. non-cases) were (1) no symptoms in the first questionnaire and (2) no symptoms in the follow-up questionnaire. For both groups they should not have: (3) rebuilt their homes because of moisture problems, and (4) changed residence since the first questionnaire. All children with at least two symptoms in the first questionnaire were invited to the case–control study ($n = 1056$ corresponding to 9.7% of the total population). In the first questionnaire 5303 (48.9%) reported no airway, eye, nose, or skin symptoms. Of these, 1100 children were randomly selected and invited to cooperate in the case–control study. This process ultimately yielded 198 cases and 202 controls. A more detailed description of the selection procedure and the influence of potential selection biases is described elsewhere (Bornehag et al., unpublished).

Building investigations

The 400 children lived in 390 buildings, there being 10 pairs of siblings. Between October 2001 and April 2002, visual inspections and indoor air quality (IAQ) assessments were performed in the 390 dwellings. Six professional inspectors according to a manual carried out the inspections.

Ventilation rates of the entire home and of the bedroom of the index-child were measured during 1 week with a passive tracer gas method – 'the homogeneous emission technique.' This PFT (perfluorocarbon tracer) technique, described in NT VVS 118 (Nordtest, 1997), yields information on the mean ventilation rates during the measured week.

Physical examination

The medical examinations of the 400 children (3–8 years) were performed during the same 2 weeks as the technical inspections and measurements. A team of four medical doctors examined the children following a structured anamnesis. A blood sample was drawn from 387 children and screened for common allergens (Phadiatop®). The allergens screened for were: timothy, common silverbirch, mugwort, cat, horse, and dog, two house dust mites (Dermatophagoides pteronyssinus and Dermatophagoides farinae), and one mould (Cladosporium).

Statistical analysis

Differences in ventilation rates between buildings were tested with parametric and non-parametric tests (Student's *t*-test and Mann–Whitney *U*) as the measured ventilation rates were not fully normally distributed. In order to investigate dose–response relationships, the ventilation rate data were divided into quartiles. Associations were then estimated with crude and adjusted Odds Ratio (OR) in logistic regression models. Adjustments were made for sex, smoking in the family, and inspector's observations of moisture-related problems in the home expressed in a 5-step scale from 'no' to 'severe damages.' Finally, we have earlier reported an association between the concentration of phthalates in dust (butyl benzyl phthalate, BBzP) and case status (Bornehag et al., 2004c). Therefore, adjustments were made for BBzP in dust in quartiles. Trends in data were tested with linear-by-linear associations. A P value of less than 0.05 was used as significance value. Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, 11.5).

The local Ethics Committee approved the study.

Results

The physical examination of the children showed good agreement between doctors' diagnoses and case–control status. All children with obvious asthma were found among cases while two children with rhinitis and eight children with eczema were found among controls. Approximately half of the cases with doctor-diagnosed asthma and eczema, respectively, were IgE positive to at least one of the tested allergens. Among cases with asthma, 49 children were non-atopics (IgE-negative) and 54 were atopics (IgE-positive) and among cases with eczema, 54 children were non-atopics and 56 were atopics. Regarding rhinitis, about 80% of the cases were IgE-positive, i.e. 16 children were non-atopics and 68 were atopics.

Type and age of homes

Almost 83% of the children lived in single-family houses (Table 1). Half of the single-family houses were constructed 1960 or earlier; row houses and multi-family houses were somewhat newer. Most single-family houses had natural ventilation and a kitchen fan, and multi-family houses were mostly ventilated with mechanical systems.

Building characteristics and ventilation rates

Valid ventilation rates in the 390 available buildings were obtained for 386 homes as regards mean ventilation for the total building, and for 378 homes regarding the index-child's bedroom.

Multi-family houses had higher mean ventilation rates than other types of homes (Table 1). In the following, results are mainly focused on single-family houses as they represent 83% of the study population and consist of more homogenous groups of buildings and families (Bornehag et al., 2004b).

Single-family houses with a mechanical exhaust and supply ventilation system had higher ventilation rates compared with buildings with other ventilation systems (Table 2). Buildings from the 1960s and the 1970s (1961–1983) had lower ventilation rates than buildings from earlier or later construction periods, and homes with concrete on ground as foundation were found to have the lowest ventilation rate. Finally, single-family houses with only one floor had lower ventilation rates compared to buildings with more than one floor.

Ventilation rate and health

There were no significant differences in type of buildings between cases and controls. Regarding single-family houses, cases were more likely than controls to live in houses that had mechanical exhaust ventilation, were constructed in the period 1961–1983, had a concrete foundation, and were one-storey buildings (Table 2).

Cases living in single-family houses had significantly lower ventilation rates than controls, both in the total building and in the child's bedroom (Table 3). In multi-family houses and row houses there were no significant differences in ventilation rates between cases and controls.

In single-family houses, a dose–response relationship between ventilation rate and the risk of being a 'case-child' was found in crude analyses with data on ventilation rates divided into quartiles (Table 4). When adjusting for potential confounders the same tendency of a dose–response relationship as in the crude analyses was found, but the results did not reach significance.

Doctor-diagnosed disease

Case children with doctor-diagnosed rhinitis and eczema, living in single-family houses had a lower ventilation rate in the child's bedroom compared with controls (Table 5). However, no association was found between ventilation rate and doctor-diagnosed asthma. When the ventilation rates were divided into quartiles, trend analysis (linear-by-linear association) showed a significant association ($P < 0.05$) for rhinitis (data not shown). When comparing the group with the lowest ventilation rates (first quartile) with the group with the highest ventilation rates (fourth quartile) there was an increased risk of rhinitis among children in the first quartile, although, not significant (OR 1.65; 95% confidence interval (CI) 0.81–3.35).

Table 1 Description of the homes for 198 cases and 202 controls

Building characteristics[a]	Number of buildings with different characteristics [n (%)]			
Type of building	Single-family houses (SH)	Row houses (RH)	Multi-family houses (MH)	Total
Number of buildings in the study: n (%)	323 (82.8)	23 (5.9)	44 (11.3)	390[b]
Construction period				
Till 1960	159 (49.2)	3 (13.0)	17 (38.6)	179 (45.9)
1961–1983	128 (39.6)	12 (52.2)	17 (38.6)	157 (40.3)
1984 onwards	36 (11.2)	8 (34.8)	10 (22.7)	54 (13.9)
Ventilation system				
Natural incl. kitchen fan	239 (74.0)	8 (34.8)	10 (22.8)	257 (65.9)
Mechanical exhaust	52 (16.1)	11 (47.8)	30 (68.2)	93 (23.8)
Mechanical exhaust and supply	32 (9.9)	4 (17.3)	4 (9.1)	40 (10.2)
Mean ventilation rate[c]				
Ach in total building (n)	0.36 (320)	0.35 (23)$^{RH–MH*}$	0.48 (43)$^{SH–MH***}$	
Ach in child's bedroom (n)	0.35 (315)	0.37 (23)$^{RH–MH*}$	0.51 (40)$^{SH–MH***}$	

$*P < 0.05$; $***P < 0.001$.

[a]All data from inspections in DBH-step 2.

[b]There were 10 pairs of siblings in the study population.

[c]Test of difference between groups of buildings made by Student's t-test.

Table 2 Difference in mean ventilation rate between different building characteristics in single-family houses

Building characteristics	Ventilation rate[a] (mean ach)		Case–Control status [*n* (%)]	
	Total building	Child's bedroom	Cases ($n = 161$)	Controls ($n = 172$)
Ventilation system				
Natural (N)	0.37	$0.34^{N–MES**}$	114 (71.7)	128 (78.0)
Mechanical exhaust (ME)	$0.32^{ME–MES***}$	$0.32^{ME–MES**}$	31 (19.5)	20 (12.2)
Mechanical exhaust/supply (MES)[b]	0.44	0.47	14 (8.8)	16 (9.8)
Construction period				
Till 1960 (I)	$0.41^{I–II***}$	$0.37^{I–II***}$	73 (45.3)	93 (54.1)
1961-1983 (II)	$0.30^{II–III**}$	$0.29^{II–III***}$	77 (47.8)	54 (31.4)
1984 onwards (III)	0.39	0.42	11 (6.8)	25 (14.5)
Type of foundation				
Basement (B)	$0.36^{B–CS*}$	$0.34^{B–CS*}$	60 (38.0)	67 (39.4)
Crawl Space (CS)	$0.42^{CS–C***}$	$0.40^{CS–C**}$	40 (25.3)	55 (32.4)
Concrete on ground (C)	0.32	0.31	58 (36.7)	48 (28.2)
Number of floors				
1 floor	0.31***	0.29***	56 (35.2)	53 (31.4)
>1 floor	0.39	0.38	103 (64.8)	116 (68.6)

$*P < 0.05$, $**P < 0.01$, $***P < 0.001$.
[a]Test of difference in mean air change rate (ach) between groups made by Student's *t*-test.
[b]Mechanical exhaust and supply system.

Table 3 Differences in mean ventilation rate between cases and controls in different groups of buildings

Type of buildings	Cases	Controls	*P*-value	
			t-test	Mann–Whitney *U*
Single-family houses (*n*)	161	172		
Mean ach in total building (*n*)	0.34 (161)	0.38 (169)	0.025	0.014
Ach in child's bedroom (*n*)	0.32 (158)	0.37 (166)	0.020	0.011
Chain houses (*n*)	12	11		
Mean ach in total building (*n*)	0.37	0.32	0.627	0.622
Ach in child's bedroom (*n*)	0.40	0.33	0.412	0.712
Multi-family houses (*n*)	25	19		
Mean ach in total building (*n*)	0.49 (25)	0.47 (18)	0.793	1.000
Ach in child's bedroom (*n*)	0.50 (23)	0.52 (17)	0.807	0.967
All types of building (*n*)	198	202		
Mean ach in total building (*n*)	0.36 (198)	0.39 (198)	0.126	0.053
Ach in child's bedroom (*n*)	0.34 (193)	0.38 (194)	0.099	0.068

Specific IgE in blood

Table 6 examines the ventilation rate among cases and controls with and without specific IgE in blood (i.e. atopics and non-atopics). Within the group of cases and controls there were no difference in ventilation rate between atopics and non-atopics.

Discussion

Ventilation rate

The measured air change rate in the 390 buildings was generally low. The minimum requirement for homes according to the Swedish building code is 0.5 ach. The mean ventilation rate for single-family houses was 0.36 ach and for multi-family houses 0.48 ach. About 80% of the single-family houses and 60% of the multi-family houses did not fulfill the minimum legal requirements. In an earlier nationwide investigation it was found that about 86% of the single-family houses and about 50% of the multi-family houses did not fulfill the minimum requirements (Stymne et al., 1994; Norlén and Andersson, 1995). Furthermore, it was shown in the present study that buildings from the

Table 4 Association between ventilation rate (ach) indoor and case status in single-family houses

Quartile for ventilation rate	Odds ratio (95% CI)					
	Total building			Child's bedroom		
	Min–Max (ach)	Crude analysis	Adjusted analysis[a]	Min–Max (ach)	Crude analysis	Adjusted analysis[a]
Fourth quartile (ref)	0.44–1.43	1.0	1.0	0.42–1.79	1.0	1.0
Third quartile	0.33–0.43	1.32 (0.71–2.44)	1.17 (0.57–2.42)	0.31–0.41	0.90 (0.48–1.69)	0.94 (0.46–1.95)
Second quartile	0.24–0.33	1.52 (0.82–2.82)	1.35 (0.66–2.74)	0.21–0.31	1.56 (0.84–2.90)	1.56 (0.77–3.12)
First quartile	0.05–0.24	1.99 (1.07–3.71)	1.95 (0.94–4.04)	0.02–0.21	1.73 (0.93–3.22)	1.77 (0.87–3.65)
P-value[b]		0.027	–		0.029	–

Association expressed as crude and adjusted odds ratio (OR) with 95% confidence interval (CI).
[a]Adjusted for sex, smoking in family, observed moisture problems in the dwelling [classified from 1 (extensive problems) to 5 (no observed moisture problems)] and butyl benzyl phthalate (BBzP) in dust (quartiles).
[b]Linear-by-inear association.

Table 5 Ventilation rate in single-family houses for case children with a doctor-diagnosed disease compared with controls

	Cases with disease		Controls		*P*-value	
Diagnosed disease[a]	*n*	Mean ventilation (ach)	*n*	Mean ventilation (ach)	*t*-test	Mann–Whitney *U*
Total building ventilation						
Asthma	101	0.36	169	0.38	0.253	0.148
Rhinitis	82	0.35	169	0.38	0.233	0.086
Eczema	107	0.34	169	0.38	0.032	0.028
Children's bedroom ventilation						
Asthma	99	0.34	166	0.37	0.207	0.195
Rhinitis	79	0.32	166	0.37	0.073	0.023
Eczema	106	0.31	166	0.37	0.024	0.016

[a]Obvious doctor-diagnosed disease (asthma, rhinitis, or eczema, respectively) among cases (possible disease and no disease excluded) compared with all controls.

Table 6 Difference in ventilation rate for controls and cases with and without IgE in blood (atopics and non-atopics) in single-family houses

	Mean and (median) ventilation rate, (ach)			
	Controls		Cases	
Ventilation	Non-atopic (142)	Atopic (21)	Non-atopic (79)	Atopic (77)
Total building	0.38 (0.35)	0.38 (0.35)	0.33 (0.32)	0.34 (0.30)
Children's bedroom	0.37 (0.32)	0.36 (0.33)	0.32 (0.29)	0.31 (0.27)

sixties and seventies had the lowest ventilation rate. This finding accords well with reports from Norway (Öie et al., 1998, 1999).

In two recent Nordic studies, no direct association was found between home ventilation rates and asthma and allergy among children (Emenius et al., 2004; Öie et al., 1999). However, in both studies much higher ventilation rates were reported and the frequency of multi-family houses was higher than in the current study. In the Norwegian study, 63% of the homes had a ventilation rate above 0.5 ach and 52% of the buildings were multi-family houses (Öie et al., 1998, 1999). In the Swedish study, the mean ventilation rate was 0.68 ach and about 75% of the buildings were multi-family houses (Emenius et al., 2004). The tracer gas method used and the laboratory performing the analyses was the same in all these studies. The higher ventilation rates in the studies by Öie et al. (1998, 1999) and Emenius et al. (2004) might explain why they could not find an association between ventilation rate and health, in contrast to our study on homes with lower ventilation rates. Associations between ventilation rates and health effects may occur only when the air change rate is below 0.5 ach. However, in the Norwegian study, ventilation rate was found to be an effect modifier of risks. With low-ventilation rate the risks associated with moisture problems, and vinyl floor and wall materials in the building increased (Öie et al., 1999).

Many indoor-generated exposures will be increased in buildings with a low-ventilation rate. Furthermore, a low-ventilation rate increases the time for indoor air reactions of, e.g. ozone and terpenes with formation of, e.g. free radicals and formaldehyde (Weschler and Shields, 2000).

A reduced ventilation rate also means increased indoor air humidity, and therefore a risk of increased infestation of house dust mites (Emenius et al., 1998; Harving et al., 1994; Sundell et al., 1994; Warner et al., 2000). House dust mite exposure is a well-known risk for sensitization and symptoms among mite sensitized persons (Eggleston et al., 1998; Holm et al., 1999; Nahm et al., 1998; Ricci et al., 1999; Sporik et al., 1999; Warner et al., 1999).

The lack of an association between ventilation rate and atopic status of the children indicates that there are no immunological mechanisms involved. Instead, a low-ventilation rate could be seen as a risk factor for irritation.

Design of the study

The second phase of the DBH-study is per definition not a case–control study, but a case non-case study of all persons with prevalent symptoms at two separate periods 1.5 years apart. This means that the risk estimates are not reflecting incident cases but severe prevalent cases. Hence, the risks associated to any of the factors found in this study are associated to duration/severity of the disease rather than the induction of disease. Although this is a theoretical issue of concern the public health effect of this is negligible, since the prevalent severe cases are the main burden of society.

To be included as a 'case' a child was required to have at least two symptoms. Consequently, this study was not fine-tuned to examine associations between building factors and *single* symptoms (i.e. asthma, rhinitis, or eczema). However, even if the design is suboptimal, meaning harder to find associations between single symptoms and exposures, the associations between selected building factors and single symptoms are meaningful and possibly under estimates true associations.

Selection bias

The selection process for cases and controls has been analyzed elsewhere (Bornehag et al., unpublished). Some potential selection biases were identified (for participating children/families). Factors associated with participating were more health problem in the case families, more health-related lifestyle factors such as non-smoking parents and a higher socio economic status of the family. However, no obvious selection bias regarding ventilation factors could be found.

The associations shown between home ventilation and the health effects studied are rather weak and several associations did not reach statistical significance. In crude analyses, significant associations were found but in adjusted analyses the estimated risks were reduced and did not reach significance. One reason for non-significant associations could be a low-statistical power due to a small sample size. However, the reduced estimated risks indicate that there are other factors (covarying with ventilation rate) of importance for allergic symptoms among children. Thus, the hypothesis that low-ventilation rates in homes increase the risk of allergic symptoms among children could not be rejected.

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Building characteristics associated with moisture related problems in 8,918 Swedish dwellings

PAPER IV

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Submitted to Indoor Air

Building characteristics associated with moisture related problems in 8,918 Swedish dwellings

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Abstract

Moisture problems in buildings have in a number of studies been shown to increase the risk for respiratory symptoms. The study Dampness in Buildings and Health (DBH) was initiated with the aim to identify health relevant exposures related to dampness in buildings. As a first step, a cross sectional questionnaire study was conducted including, all children between 1-6 years of age in a county in Sweden (n=10,862 children; 8,981 homes), response rate 79%. Questionnaire data of some building characteristic and reports of dampness (visible dampness, floor dampness, window pane condensation, mouldy odour and perception of dry air) were analysed in multiple logistic regression models. Building characteristics that were associated with one or more of the dampness indicators were for single family houses; older houses, flat roofed houses built in the 1960’s and 1970’s, houses with a concrete slab on the ground that were built before 1983. Moreover, tenancy, i.e. a majority of the families living in multi family houses, was strongly associated with all the dampness indexes. An earlier renovation due to a mould or moisture problems were associated with mould odour and perception o dry air.

Introduction

Numerous studies have reported that living or working in a building with mould and moisture problems, “dampness”, increases the risk of ill health effects, such as coughing, wheezing, allergies and asthma (Peat et al. 1998, Bornehag et al. 2001, Bornehag et al. 2004a, Damp Indoor Spaces and Health Institute of Medicine 2004). However, the building characteristics that are associated with such problems are seldom reported. For example, dampness and mould exposure has been associated with older homes, buildings from the sixties and seventies, water leakage, tenancy and poorer housing conditions with no insulation (Spengler et al. 1994, Nevalainen et al. 1998, Engvall et al. 2001, Zock et al. 2002, Howden-Chapman et al. 2005).There is a lack of a more detailed analysis between the relationship of questionnaire reports on different types of moisture problems and building characteristics.

“Dampness” has been reported from between 4% to nearly 80% of the buildings in studies around the world. There is also a wide variation in the definition of the term “dampness” (Bornehag et al. 2001, Bornehag et al. 2004a). Different housing characteristics and climate conditions are likely explanation of the wide variation in frequencies and characteristics of moisture problems. Common indicators of “dampness” are for example visible mould, damp stains, condensation on walls, condensation on windows, flooding, water damage, odours and smells etc. (Bornehag et al. 2001).

Earlier, we have presented associations between questionnaire reports on signs of moisture problems in the home and airway, nose and skin symptoms among the children in a cohort of Swedish children (Bornehag et al. 2005b). The aim of the present study is to identify building characteristics that are associated with parental reports on signs of dampness.

Method

This study is part of a large survey of the home environment and its impact on asthma and allergies among small children in Sweden, “Dampness in Buildings and Health, DBH” (Bornehag et al. 2004b). In the first step of the DBH study (DBH-phase I), a questionnaire was sent to the parents of all children aged 1-6 years (n=14 077) in the county of Värmland in Sweden. The questionnaire included 84 questions regarding the health of the child and its parents, focusing on asthmatic and allergic symptoms, background data for the child and the family, building characteristics and signs of moisture problems and odours.

The questionnaire was distributed by post with three postal reminders. Of the 14 077 children, 100 were included in a pilot study and 195 could not be reached by post. The parents of 10 851 children from 8918 families/households responded to the questionnaire, corresponding to a response rate of 79%. The present study is based on data from these 8918 dwellings.

Questions regarding signs of moisture problems could be answered by “yes”, “no” or “don’t know” for the child’s room, parents’ bedroom, other room and bathroom. The questions about visible signs of moisture and condensation were for the current situation in the dwelling. Questions about mouldy odour and perception of dry air were to be answered for the last three months. We have used five different indexes to describe signs of moisture problems and odour to illuminate different types of common moisture related problems in dwellings. “Don’t know” answers and missing values were excluded in the indexes. Bathrooms and basements were not included in the indexes.

Visible dampness: Visible mould or damp/discoloured stains on the ceiling, walls or floor in the child’s bedrooms or the parents’ bedroom.
Floor moisture: Discoloured or blackened parquet or cork-flooring; or bubbly, loosening or discoloured vinyl or linoleum floor covering in the child’s room, parent’s bedroom or other room.
Mouldy odour: Mouldy odour or “earth cellar”-odour in the dwelling sometimes or often (every week) during the last three months.
Condensation on windows: More than 5 cm of condensation on the inside of the window pane during wintertime in the child’s or parents bedroom.
Dry air: Perception of dry air sometimes or often (every week) during the last three months.

Since there are many differences between single family houses and multi family houses, these types of buildings have in general been analysed separately. Single-unit dwellings and chain houses were categorized together as single family houses (SH+) and apartments in multi-dwelling blocks have been expressed as multi family houses (MH). The construction period of the buildings were clustered into three groups: before 1960, 1960-1983 and after 1983. Dwellings with natural ventilation could be either with or without a mechanical kitchen fan over the stove. A “balanced ventilation system" means that there were mechanical fans for both exhaust and supply air. Information about the type of foundation and shape of the roof was only obtained from single family houses (SH+). Owned dwellings included dwellings in tenancy-owned association which is a third type of ownership for Swedish dwellings. This is more common for apartments in multi family houses than for single family houses.

The question whether the dwelling had undergone an extensive renovation could be answered by "yes", "no" or "don't know". If so, was the renovation due to a mould or moisture problem. Hence, the variable about renovation status was constructed as: "No extensive renovation", "renovation" (not due to mould or moisture damage) and "renovation due to mould and moisture damage".

Chi-square tests were used to compare frequencies between the groups of buildings. Analyses of associations between building characteristics and signs of moisture problems (index 1-5), were performed with multiple logistic regressions by back- and forward elimination technique. Only variables that were significant both in the backward and the forward elimination analyses were included in the final model. First, these analyses were performed for all houses (SH+ and MH separately), followed by an analysis for each construction periods (before 1960, 1961-1983 and after 1983).

In all the analyses, statistical significance was considered when $p<0.05$. Statistical analyses were performed using Statistical Package for Social Science (SPSS 11.5, 2002).

The ethics committee in Örebro, Sweden, approved the study.

Results

Frequencies of different building characteristics are shown in table 1. The most frequent type of dwelling was single family houses followed by apartments in multi family houses and chain houses. Nearly half of the single family houses (SH+) were built before 1960, whilst multi family houses (MH) tended to be built at a later date. Natural ventilation occurred most often, especially in the older houses. A basement or a crawlspace was more common in single family houses built before 1960, whereas a concrete slab on the ground became more common after 1960. Flat roofs were most commonly reported from single family houses built in the 1960's and 70's. Among chain houses built 1961-1983, 25.5% had a flat roof (data not shown). The majority of the buildings had water-filled radiators for heating, but electrical radiators were often used in single family houses from the 60's and 70's. Less than half of the houses had undergone an extensive renovation, but this was more common with those built before 1960. Renovation due to mould or moisture problems was reported in only 3.9% of the homes; however, it was more commonly reported from houses built in the 1960's and 70's. Most of the single family houses were occupied by the actual owner, while most occupants in multi family houses rented their dwelling.

Respondents in multi family houses reported significantly more signs of moisture problems and bad indoor air quality compared to occupants in single family houses; Visible dampness (2.0% vs. 1.3%, Chi-square test: p=0.049), Floor moisture (14.1% vs. 4.4%, p<0.001), Mouldy odour (6.3% vs. 4.1%, p<0.001) and a perception of Dry air (33.4% vs. 17.2%, p<0.001). However, condensation on the inside of window panes (>5cm) during winter time in the bedrooms, was reported slightly more often from single family houses compared to multi family houses (15.8% vs. 12.6%, p=0.03).

In tables 2 and 3, frequencies of Visible dampness, Floor moisture, Condensation on windows and Mouldy odour for a number of different building characteristics are presented; stratified for construction period. In table 4, significant associations between the building characteristics and moisture indexes are presented for single family houses. Multi variate analyses for multi family houses are not presented in a separate table, as the number of dwellings was too low for stratified analyses (see table 3). Reports on Floor moisture and Mouldy odour in multi family houses were associated with tenancy, and Condensation on windows was associated to older houses and to buildings with natural ventilation. The following results focus on single family houses.

Visible dampness was in general associated with older buildings constructed before 1960, see table 4. Of the 92 reports of Visible dampness in single family houses, only one was reported from a house erected after 1983. A flat roof was associated to visible dampness in single family houses constructed in the 60’s and 70’s.Visible dampness was reported more often by occupants in rented homes compared to that by occupants in owned dwellings, regarding buildings constructed before 1983.

Floor moisture was more commonly reported from homes with a balanced ventilation system in buildings constructed after 1983. In buildings constructed before 1983, Floor moisture was associated with a concrete slab ground foundation. Floor moisture was also associated with flat roofed buildings and rented buildings constructed before 1960.

Condensation on windows was strongly associated with old houses and buildings with natural ventilation. In houses built before 1960, renovated dwellings (not due to moisture damage) had significantly less condensation on windows. Rented homes were associated with window condensation, but only in those that were constructed before 1983.

Mouldy odour was associated with houses built before 1983, with rented houses and houses with a former renovation due to mould or moisture. Mouldy odour was also associated with flat roofed buildings built in the 1960’s and 1970’s.

Reports of condensation on the inside of the window pane in the parents bedrooms was specified in the questionnaire: No condensation (SH+: 64%, MH: 78.7%), 0-5cm

(SH+: 21.8%, MH: 10.6%), 5-25 cm (SH+: 11.8%, MH: 9.2%) and more than 25 cm of condensation (SH+: 1.8%, MH: 1.6%).

A significant dose response association was found between the amount of condensation on the window pane in the bedroom and reports of perception of dry air. This occurred in both uni variate and multi variate analyses, and for both single family houses and multi family houses, see table 5. A perception of dry air was associated with single family houses built in the 60's and 70's, with electrical radiators in the home, with a former renovation due to mould and moisture, and to tenancy (data not shown).

Discussion

This study illustrates that there are wide differences in the frequency of reported signs of moisture problems between buildings with different characteristics. In the NORDDAMP-review, it was concluded that the outdoor climate is important for the prevalence of different indicators of "dampness" (Bornehag et al. 2001). In tropical climates, visible moulds are found in many buildings (23-79%), but in cold areas, like in the Nordic countries, such indicators are typically found in 4-25% of the buildings. In contrast, more moisture problems are hidden inside the building structure and are detected by a bad odour. Compared to studies from the UK (a more temperate climate), the frequency of visible signs of dampness in this study were very low (less than 2%). Reports from a study of 597 households in the UK showed that "dampness" was found in 30.8% and visible mould growth in 45.9% of the those (Platt et al. 1989). In a study from New Zealand (temperate and sub-tropic climate), 35.1% of 613 households reported visible mould in at least one room, and in 46.5% of these households visible mould was reported in the bedroom (Howden-Chapman et al. 2005).

Other Scandinavian studies have, in line with our results, reported low frequencies of visible signs of moisture problems. In a population-based study of 1916 children in the city of Espoo in Finland, visible mould (during the last 12 months or earlier) was reported from 4.5% of the dwellings and "wet spots" from 15.4% (Jaakkola et al. 2005). A Swedish study of 181 cases with recurrent wheezing and 359 controls, visible signs of dampness (damp stains, spots of mould or mould odour) in residential rooms were reported from 10.5% of the cases and from 8.1% of the controls. However, the frequency of visible mould was not shown separately (Emenius et al. 2004b).

Visible mould on indoor surfaces in buildings is rare in Scandinavia (except for bathrooms and basements) because of two main reasons. The outdoor climate generates a low relative humidity indoors during the cold season, and in combination with relatively well insulated outer walls, the dew point on surfaces is low. Hence, condensation on the inside of the outer walls seldom occurs. Condensation on the inside of the window pane is more common, as the insulation of double or triple glazed windows is inferior to that of the walls. Visible signs of dampness on walls or on the ceiling are more often discoloured or damp stains rather than areas of visible mould growth. These stains are caused by leakages from pipes or precipitation. The index Visible dampness in our study for example, was associated with flat roofed single family houses, indicating a common leakage problem associated with this type of construction, which have been reported by Nevalanen et al. (1998).

Condensation on the inside of the windows during wintertime is an indicator of poor ventilation and, thus, high indoor air humidity. Therefore it makes sense that this was reported to a lesser extent in newer houses, in houses with mechanical ventilation and in multi family houses since all these factors have been associated with a higher ventilation rate (Emenius et al. 2004a, Bornehag et al. 2005a).

We found a strong dose-response association between the perception of “dry air” and the amount of condensation on windows. This shows that this sensation is not primarily due to exposure to physically dry air (the results show the opposite). Instead it gives further evidence to that this perception is due to polluted indoor air i.e. a poor ventilation rate. The same results were reported from a Swedish study of 4943 office workers (including reports about their home).The study showed that the sensation of dryness was associated with condensation on windows in the home, mould and moisture damages and with the prevalence of sick building syndrome (Sundell and Lindvall 1993).

Tenancy, whether You own Your home or not, is associated with more frequent reports of “dampness” in both SH and MH houses. It can be discussed whether rented dwellings are of a lower quality compared to owned, or whether psychological parameters such as possibilities to control the environment and responsibilities play a role, as well as socio economic factors. In Sweden, there is a socio-economic difference between tenants and people who own their own dwelling, as well as people living in single family houses compared to those families living in apartments in MH (Sundquist and Johansson 1997). To buy a house is for most people the largest investment in life, which may decrease the willingness to detect moisture problems since the cost and effort to repair such damage is known to be high. People who own their own homes have to do the job (or pay for it) themselves, whilst a tenant can often contact the landlord who will organize the repairs. A Scottish study on housing tenure and health found that dampness, condensation, poor state of repair etc. was significantly reported more by occupants in rented homes compared to owned homes (Macintyre et al. 2003). In a Swedish study of 9 808 apartments in multi family buildings, the frequency of reported dampness from participants living in owned dwellings was two to three times lower than that reported from participants living in rented ones (Engvall et al. 2001). In contrast to these studies, another study from the UK found that self-reported dampness was strongly associated with ownership (Packer et al. 1994).

A former renovation due to mould and moisture damage was associated to reports of mouldy odour. This indicates that the renovations have not totally solved the problems, or that the occupants are biased, and therefore more aware of “dampness” than respondents who have not had to deal with such problems in their house before. Houses built in the sixties and seventies were reported to have had more renovation due to mould or moisture problems compared to those houses built in other construction periods. Houses built in this period also had more reports of Floor moisture and perception of “Dry air” than houses built in other construction periods. Flat roofed houses built in the sixties and seventies were also associated with mouldy odour. More dampness problems in buildings from the sixties and seventies have also been reported from other Scandinavian studies (Nevalainen et al. 1998, Engvall et al. 2001).

The risk for selection bias is limited because of the high response rate in the questionnaire investigation and the lack of any main difference between the responders and non-responders with regards to health and building characteristics, (Bornehag et al. 2005b).

To conclude, building characteristics and other factors that showed strong associations with reports on “dampness” in single family houses were:
Visible dampness – older houses, tenancy and flat roofed houses built in the 1960-70’s.
Floor moisture – houses with a concrete slab ground foundation, flat roofed and rented houses.
Condensation on windows – older houses, natural ventilation systems (low ventilation rate) and tenancy
Mouldy odour – older houses, a former renovation due to a mould or moisture problem, tenancy and flat roofed houses built in the 1960-70’s.
A perception of dry air – houses built in the 1960-70’s, electrical radiators and in houses that have been renovated due to a mould or moisture problem.

This study illuminates that “dampness” is a rather complex term that can be described by various definitions. These different definitions are associated with different building characteristics. No particular building characteristic could be singled out as the most responsible factor for reports of moisture related problems. The most important factors associated with the different reported signs of moisture and odour were type of house, construction period, type of foundation, type of ventilation system and tenancy. Future questionnaire studies should be aware of these key factors when analysing reported signs of moisture problems and indoor air quality.

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Tables to the paper: Building characteristics associated with moisture related problems in 8,918 Swedish dwellings. Tables 1-5.

Table 1. Building characteristics of 8,918 dwellings

	All houses	Single family houses (SH+)				Multi family houses (MH)			
Characteristics [1]	n (%)	All SH+	Before 1960	1960-1983	After 1983	All MH	Before 1960	1960-1983	After 1983
Type of dwelling		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Single family house	6282 (70.4)	-				-			
Chain house	782 (8.8)	-				-			
Multi-family house	1617 (18.1)	-				-			
Construction period									
Before 1960	4065 (45.6)	3523 (49.9)				456 (28.2)			
1960-1983	2970 (33.3)	2388 (33.8)				563 (34.8)			
After 1983	1266 (14.2)	926 (13.1)				293 (18.1)			
Ventilation system[2]									
Natural	5729 (64.2)	4855 (67.7)	3065 (96.6)	1398 (66.8)	230 (29.1)	734 (45.4)	286 (80.8)	245 (65.5)	81 (45.0)
Mechanical exhaust	934 (10.5)	617 (9.5)	54 (1.7)	429 (20.5)	177 (22.4)	240 (14.8)	51 (14.4)	105 (28.1)	48 (26.7)
Balanced	824 (9.2)	706 (10.0)	54 (1.7)	265 (12.7)	383 (48.5)	104 (6.4)	17 (4.8)	24 (6.4)	51 (28.3)
Foundation[3]									
Crawlspace	-	2278 (32.2)	1392 (42.5)	335 (14.8)	461 (53.7)	-	-	-	-
Concrete slab on the ground	-	1802 (25.5)	174 (5.3)	1282 (56.5)	320 (37.3)	-	-	-	-
Basement	-	2492 (35.3)	1707 (52.2)	653 (28.8)	78 (9.1)	-	-	-	-
Roof [3]									
Other type	-	6209 (87.9)	3195 (97.4)	1999 (91.2)	832 (97.3)	-	-	-	-
Flat roof	-	314 (4.4)	86 (2.6)	192 (8.8)	23 (2.7)	-	-	-	-
Heating system									
Water-filled radiators	5962 (66.9)	4621 (65.4)	2817 (82.4)	1311 (56.2)	359 (46.8)	1197 (74.0)	384 (88.3)	439 (82.7)	180 (67.7)
Electrical radiators	2010 (22.5)	1964 (24.0)	565 (16.5)	917 (39.3)	151 (19.7)	270 (16.7)	49 (11.3)	87 (16.4)	54 (20.3)
Airborne heating	462 (5.2)	407 (5.8)	36 (1.1)	105 (4.5)	257 (33.5)	43 (2.7)	2 (0.5)	5 (0.9)	32 (12.0)
Renovation									
No extensive renovation	5050 (56.6)	4028 (57.0)	1442 (42.0)	1779 (76.5)	758 (83.8)	882 (54.5)	209 (57.3)	316 (71.5)	258 (96.3)
Renovation	2896 (32.5)	2521 (35.7)	1882 (54.8)	375 (16.1)	135 (14.9)	317 (19.6)	147 (40.3)	105 (23.8)	8 (3.0)
Renovation due to mould and moisture	350 (3.9)	306 (4.3)	112 (3.3)	171 (7.4)	11 (1.2)	39 (2.4)	9 (2.5)	21 (4.8)	2 (0.7)
Ownership									
Owners occupied	6806 (76.3)	6405 (90.7)	3216 (91.4)	2251 (94.5)	782 (84.6)	294 (18.2)	107 (23.5)	109 (19.4)	54 (18.4)
Tenant	2066 (23.2)	648 (9.2)	303 (8.6)	132 (5.5)	142 (15.4)	1318 (81.5)	348 (76.5)	452 (80.6)	239 (81.6)

[1] Missing data for different building characteristics excluded.
[2] Natural ventilation with or without a mechanical kitchen fan
[3] Data only for single family houses (SH+) and multi family houses (MH)

Tables to the paper: Building characteristics associated with moisture related problems in 8,918 Swedish dwellings. Tables 1-5.

Table 2. Frequencies of different indexes of "dampness" in single family houses with different building characteristics.

	Visible dampness n=92 (1.3%)				Floor moisture n=303 (4.4%)				Condensation on windows n= 1070 (15.8%)				Mouldy odour n= 280 (4.1%)			
	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
		60 (1.3)	27 (1.1)	1 (0.1)		119 (3.5)	125 (5.4)	43 (4.8)		648 (19.1)	350 (15.2)	41 (4.6)		145 (4.2)	107 (4.6)	12 (1.3)
Ventilation system																
Natural	68 (1.4)	51 (1.7)	14 (1.0)	0	196 (4.1)	100 (3.3)	80 (5.9)	5 (2.3)	880 (18.8)	574 (19.4)	265 (19.6)	18 (8.3)	212 (4.5)	123 (4.1)	71 (5.2)	5 (2.2)
Mechanical exhaust	5 (0.8)	0	5 (1.2)	0	19 (2.9)	1 (1.9)	15 (3.5)	3 (1.7)	43 (6.5)	8 (15.4)	29 (6.2)	5 (2.8)	18 (2.7)	2 (3.8)	14 (3.4)	2 (1.1)
Balanced	4 (0.6)	0	3 (1.1)	1 (0.3)	37 (5.3)	2 (3.7)	11 (4.2)	24 (6.3)	22 (3.2)	4 (7.4)	12 (4.6)	6 (1.6)	8 (1.2)	2 (4.0)	6 (2.3)	0
Foundation																
Crawlspace	28 (1.2)	20 (1.5)	5 (1.5)	1 (0.2)	84 (3.8)	48 (3.5)	14 (4.2)	17 (3.8)	330 (15.1)	260 (19.5)	44 (13.7)	18 (4.0)	86 (3.9)	60 (4.4)	17 (5.2)	4 (0.9)
Concrete slab on the ground	25 (1.4)	8 (4.7)	15 (1.2)	0	108 (6.2)	14 (8.2)	73 (5.8)	17 (5.4)	217 (12.5)	34 (20.2)	165 (13.4)	15 (4.8)	76 (4.4)	15 (8.9)	52 (4.2)	7 (2.3)
Basement	31 (1.3)	27 (1.6)	4 (0.6)	0	87 (3.6)	47 (2.8)	30 (4.7)	5 (6.6)	454 (18.9)	310 (18.9)	127 (20.0)	5 (6.7)	97 (4.0)	62 (3.7)	29 (4.5)	1 (1.4)
Roof																
Gable roof	73 (1.2)	55 (1.7)	14 (0.7)	1 (0.1)	250 (4.1)	107 (3.4)	92 (4.7)	39 (4.8)	927 (15.5)	584 (19.0)	279 (14.4)	37 (4.6)	223 (3.7)	120 (3.8)	78 (4.0)	11 (1.4)
Flat roof	11 (3.7)	1 (1.2)	10 (5.5)	0	21 (7.0)	2 (2.4)	15 (8.2)	2 (10.0)	56 (18.7)	18 (21.7)	34 (18.5)	2 (9.5)	24 (7.9)	3 (3.5)	20 (10.8)	0
Heating system																
Radiators (water-filled)	6 (1.4)	47 (1.7)	14 (1.1)	0	184 (4.1)	98 (3.6)	66 (5.1)	11 (3.2)	743 (16.7)	511 (18.8)	196 (15.4)	17 (5.0)	198 (4.4)	111 (4.0)	69 (5.4)	7 (2.0)
Electrical radiators	24 (1.4)	12 (2.2)	10 (1.1)	0	80 (4.9)	15 (2.7)	51 (5.7)	9 (6.2)	275 (17.1)	118 (21.8)	133 (15.2)	14 (9.2)	67 (4.1)	28 (5.1)	32 (3.6)	3 (2.1)
Airborne heating	4 (1.0)	0	3 (2.9)	1 (0.4)	20 (5.0)	1 (2.8)	4 (3.8)	15 (5.9)	22 (5.6)	6 (18.2)	14 (13.7)	2 (0.8)	7 (1.8)	2 (6.3)	4 (4.0)	1 (0.4)
Renovation																
No extensive renovation	53 (1.3)	33 (2.3)	18 (1.0)	1 (0.1)	187 (4.8)	51 (3.6)	96 (5.5)	37 (5.0)	604 (15.5)	298 (21.4)	272 (15.8)	31 (4.2)	150 (3.8)	57 (4.0)	79 (4.6)	11 (1.5)
Renovation	28 (1.1)	22 (1.2)	5 (1.3)	0	84 (3.4)	57 (3.1)	18 (4.9)	4 (3.0)	379 (15.6)	310 (17.1)	42 (11.5)	8 (6.2)	91 (3.7)	68 (3.7)	16 (4.4)	0
Renovation due to mould and moisture	4 (1.3)	2 (1.8)	2 (1.2)	0	19 (6.3)	7 (6.4)	9 (5.4)	0	52 (17.9)	23 (21.7)	27 (16.4)	1 (10.0)	25 (8.6)	13 (12.0)	10 (6.2)	1 (10.0)
Ownership																
Owners occupied	69 (1.1)	44 (1.4)	23 (1.0)	1 (0.1)	251 (4.0)	98 (3.1)	115 (5.2)	29 (3.8)	936 (15.2)	562 (18.1)	325 (14.9)	30 (4.0)	239 (3.8)	126 (4.0)	97 (4.4)	7 (0.9)
Tenant	23 (3.7)	16 (5.5)	4 (3.2)	0	52 (8.5)	21 (7.3)	10 (8.1)	14 (10.4)	134 (22.7)	86 (30.4)	25 (21.0)	11 (8.6)	41 (6.7)	19 (6.4)	10 (8.3)	5 (3.8)

Tables to the paper: Building characteristics associated with moisture related problems in 8,918 Swedish dwellings. Tables 1-5.

Table 3 Frequencies of different indexes of "dampness" in multi family houses with different building characteristics.

	Visible dampness n=30 (2.0%)				Floor moisture n=204 (14.1%)				Condensation on windows n= 168 (12.6%)				Mouldy odour n=91 (6.3%)			
	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
		9 (2.1)	11 (2.1)	0		53 (12.6)	82 (16.1)	23 (8.4)		62 (15.6)	70 (14.8)	9 (3.4)		30 (7.2)	28 (5.5)	12 (4.4)
Ventilation system																
Natural	16 (2.3)	4 (1.5)	4 (1.7)	0	88 (13.2)	29 (10.9)	34 (15.4)	5 (6.2)	91 (14.7)	41 (16.3)	35 (16.4)	3 (4.1)	41 (6.2)	17 (6.5)	13 (5.9)	3 (3.9)
Mechanical exhaust	1 (0.4)	0	1 (1.0)	0	31 (13.8)	6 (11.8)	17 (16.7)	4 (8.9)	17 (8.2)	8 (16.7)	7 (7.6)	1 (2.2)	11 (4.9)	6 (12.2)	4 (4.1)	0
Balanced	2 (2.0)	0	1 (4.3)	0	14 (13.9)	2 (12.5)	4 (18.2)	6 (11.8)	11 (11.5)	2 (12.5)	5 (25.0)	1 (2.0)	5 (5.1)	0	1 (4.3)	4 (8.5)
Heating system																
Radiators (water-filled)	20 (1.8)	6 (1.6)	6 (1.4)	0	149 (13.6)	39 (10.8)	64 (15.9)	16 (9.3)	135 (13.2)	52 (15.4)	57 (14.8)	7 (4.3)	67 (6.1)	24 (6.8)	18 (4.5)	10 (5.8)
Electrical radiators	9 (3.7)	2 (4.3)	5 (6.4)	0	36 (16.1)	8 (19.5)	13 (17.1)	2 (4.1)	28 (14.1)	8 (18.6)	13 (19.4)	0	16 (7.1)	5 (11.5)	7 (9.5)	0
Airborne heating	0	0	0	0	6 (14.3)	0	1(25.0)	4 (12.5)	1 (2.6)	0	0	1 (3.3)	2 (5.3)	0	0	2 (7.1)
Renovation																
No extensive renovation	16 (1.9)	4 (2.0)	5 (1.7)	0	99 (12.0)	23 (11.5)	42 (14.4)	19 (7.8)	94 (12.2)	35 (18.8)	41 (14.8)	8 (3.3)	48 (5.9)	17 (8.7)	14 (4.8)	9 (3.7)
Renovation	6 (2.0)	3 (2.1)	2 (1.9)	0	43 (14.5)	17 (12.1)	11 (11.2)	2 (25.0)	30 (10.9)	13 (9.8)	13 (14.4)	0	12 (4.1)	6 (4.3)	3 (3.1)	0
Renovation due to mold and moisture	1 (2.8)	1 (11.1)	0	0	10 (29.4)	2 (33.3)	4 (21.1)	1 (50.0)	9 (31.0)	4 (57.1)	3 (17.6)	1 (100%)	5 (16.1)	2 (28.6)	2 (11.1)	1 (50.0)
Ownership																
Owners occupied	1 (0.4)	0	1 (0.9)	0	24 (8.7)	3 (3.0)	13 (12.4)	6 (11.3)	23 (9.0)	7 (7.8)	12 (11.8)	2 (4.1)	4 (1.5)	2 (2.0)	2 (2.0)	0
Tenant	29 (2.4)	9 (2.7)	10 (2.4)	0	180 (15.4)	50 (15.6)	69 (17.1)	17 (7.7)	145 (13.5)	55 (17.9)	58 (15.7)	7 (3.3)	86 (7.3)	28 (8.9)	26 (6.4)	12 (5.4)

Table 5. Associations between condensation on the inside of window pane in the parents' bedroom and perception of dry air indoors.

	Perception of dry air					
	Single family houses/chain houses			Multi family houses		
	n (%)	OR	AOR[1)]	n (%)	OR	AOR[1)]
Condensation on windows						
No condensation	685 (15.8)	1	1	298 (29.5)	1	1
0-5 cm condensation	273 (18.8)	**1.23 (1.05-1.43)**	**1.24 (1.02-1.49)**	48 (35.8)	1.33 (0.91-1.94)	1.47 (0.85-2.54)
5-25 cm condensation	161 (20.8)	**1.39 (1.15-1.69)**	**1.39 (1.15-1.69)**	51 (44.7)	**1.93 (1.30-2.86)**	**1.89 (1.01-3.12)**
More than 25 cm of condensation	36 (30.3)	**2.31 (1.55-3.44)**	**2.31 (1.55-3.44)**	11 (57.9)	**3.28 (1.31-8.24)**	2.28 (0.66-7.84)

[1)]Adjusted for all characteristics described in table 1.

Table 4. Associations between building characteristics and four moisture indexes in single family houses

	Odds Ratio[1] (95% CI)															
	Visible dampness n=92 (1.3%)				Floor moisture n=303 (4.4%)				Condensation on windows n= 1070 (15.8%)				Mouldy odour n= 280 (4.1%)			
	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983	All	Before 1960	1960-1983	After 1983
Construction period																
Before 1960	1								1				1			
1960-1983	0.60 (0.34-1.07								0.96 (0.80-1.15)				1.01 (0.72-1.41)			
After 1983	0.09 (0.12-0.67)								0.38 (0.24-0.62)				0.21 (0.08-0.52)			
Ventilation system																
Natural					1			1	1	1	1	1				
Mechanical exhaust					0.51 (0.29-0.90)			1.36 (0.19-9.89)	0.32 (0.22-0.47)	0.74 (0.64-0.96)	0.28 (0.18-0.44)	0.32 (0.10-1.01)				
Balanced					1.09 (0.72-1.65)			5.01 (1.15-21.82)	0.14 (0.24-0.62)	0.19 (0.05-0.78)	0.14 (0.07-0.29)	0.12 (0.04-0.38)				
Foundation																
Crawlspace					1	1	1									
Concrete slab on the ground					1.69 (1.18-2.04)	2.06 (0.97-4.39)	2.15 (1.18-3.91)									
Basement					0.83 (0.57-1.20)	0.79 (0.50-1.26)										
Roof																
Gable roof	1		1		1								1		1	
Flat roof	3.89 (1.76-8.55)		7.24 (2.75-19.09)		2.00 (1.19-3.34)								2.03 (1.42-4.08)		2.87 (1.59-5.18)	
Heating system																
Radiators (water-filled)																
Electrical radiators																
Airborne heating																
Renovation																
No extensive renovation									1	1			1	1		1
Renovation									0.79 (0.67-0.95)	0.79 (0.65-0.97)			0.89 (0.63-1.27)	1.01 (0.65-1.56)		0
Renovation due to mould and moisture									1.28 (0.89-1.83)	1.38 (0.82-2.33)			2.41 (1.54-3.81)	4.00 (1.89-8.45)		44.5 (1.89-1047.0)
Ownership																
Owners occupied	1	1	1		1	1			1	1	1		1	1		1
Tenant	5.47 (3.03-9.87)	5.92 (3.03-11.6)	4.79 (1.32-17.37)		2.08 (1.34-3.22)	3.24 (1.86-5.66)			1.83 (1.39-2.42)	1.79 (1.29-2.49)	2.04 (1.14-3.67)		2.42 (1.54-3.81)	2.00 (1.10-3.64)		32.3 (3.08-339.2)

1) Association expressed as Odds Ratio including 95% confidence interval estimated with multiple logistic regression with forward and backward elimination technique. Only significant variables from the final model are presented in the table and empty cells means that the factor was eliminated in the elimination process.

Day-care attendance and increased risk for respiratory and allergic symptoms in preschool age

PAPER V

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Day-care attendance and increased risk for respiratory and allergic symptoms in preschool age

Background: The reported impact of day-care attendance on respiratory and atopic symptoms has varied between studies from different countries. Regarding to the 'hygiene-hypothesis', day-care attendance may lead to less sensitization later in life, but the question still is whether day-care attendance and subsequent exposure to more frequent early infections is a risk or a protection against future allergic disease or asthma (atopic and nonatopic).
Methods: A cross-sectional postal questionnaire was replied by parents of 10 851 children, aged 1–6 years, in the year 2000 in a Swedish region (DBH-phase 1). The questionnaire focused on respiratory and atopic symptoms, the home environment and information on day care of the children.
Results: Children in day care were reported to have more symptoms than children in home care: adjusted odds ratio (AOR) for wheezing last 12 months, AOR 1.33 (CI 95%: 1.12–1.58), cough at night apart from colds last 12 months AOR 1.56 (CI: 1.17–2.07), doctor diagnosed asthma AOR 1.23 (CI: 0.88–1.71), rhinitis last 12 months AOR 1.15 (CI: 0.92–1.44), doctor diagnosed hay fever AOR 1.75 (CI: 0.94–3.23), eczema last 12 months, AOR 1.49 (CI: 1.24–1.79), allergic reactions to foods, AOR 1.27 (CI: 1.07–1.52), >6 colds last 12 months of 2.57 (CI: 2.12–3.12) and ear infection ever AOR 2.14 (CI: 1.87–2.45). The increased risks were mainly seen and reached significance in the youngest group of children, aged 1–4 years. Adjusting and stratification for the number of airway infections last year did not change the risk associated with day-care attendance for allergic diseases.
Conclusions: Attending day care was associated with an increased risk of symptoms related to airways infections as well with eczema and allergic reactions to food. No sign of protection from day-care attendance for allergic diseases was found up to 6 years of age. Multiple airway infections and day-care attendance were found to be independently associated with asthma and allergic symptoms.

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Key words: allergy; asthma; children; day care; respiratory infections.

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The prevalence of asthma and allergy has increased over the past decades in Sweden as in the entire Western world (1, 2). Numerous factors have been associated to an increased prevalence, such as urban living, exposure to tobacco smoke, lack of microbiological exposure and living in a home with mould and dampness. Dose response associations have been shown between home ventilation rates, and exposure to phthalates in dust and allergic diseases (3, 4). None of these, however, have been convincingly shown as the basal factor underlying the 'allergy epidemic' (2, 5, 6).

Early childhood infections have been proposed to protect against allergic diseases, 'the hygiene hypothesis' (7). Attendance at a day-care centre involves a high exposure to infections and, in some studies, also a protection against later asthma and hay fever, particularly in children with few siblings (7–10). During the first years of life, however, children attending day care have an increased morbidity in airways infections and respiratory symptoms compared with children that stay at home (11–13).

The starting age in public day care varies between different countries. In Sweden, most children stay at home until about 18 months of age. In this paper, the aim is to analyse the impact of current day-care attendance, and age when starting at day-care centres on respiratory and allergic diseases in a total population of children aged 1–6 years in a Swedish region.

Method

Study population

This study is part of a multidisciplinary survey on indoor environment in homes and health effects among preschool children, called

Dampness in Buildings and Health (DBH) (14). A questionnaire with 84 questions was sent out in March 2000 to all families with children between 1 and 6 years of age in the county of Värmland in Sweden (DBH-phase 1). Of 14 077 mailed questionnaires, 100 were used in a pilot study and 195 could not be reached by post, and a response rate of 79%, yielded 10 851 included children. A nonrespondent analysis was performed to investigate possible selection biases. Of 200 nonrespondent families, 166 were reached by telephone. There were no significant differences in reports of symptoms, type of dwelling, or reports of dampness, between responding and nonresponding families (15).

Questions on allergic symptoms were the same as used in the ISAAC questionnaire (16). The following symptom reports were studied: wheezing, cough at night apart from cold, rhinitis symptoms apart from cold (sneezing, runny nose or congestion), itching eczema and the number of colds, all for the last 12 months; doctor diagnosed asthma and hay fever, ever any allergic reactions to any food and ever any ear infection.

The questions about day care included current type of day care (day-care centre, family day care), time spent there (< 20 h/week and 20 h/week or more) and age when the child started. Family day care in Sweden means that the child is in a private home together with three to six children. Information on the child's starting age at day care was only obtained from children attending day-care centres and not family day care.

Statistics

Associations between day-care status, symptoms and covariates were first tested with chi-square test. Background information interfering with day-care status was used as adjustment variables in multiple logistic regression analyses. Logistic regression analyses were used to calculate crude and adjusted odds ratio (AOR) with 95% confidence interval. Statistical analyses have been made in SPSS 11.05. Adjustments have been made for: gender (male *vs* female), age (1–3 years of age *vs* 3–6 years of age), breastfeeding, full or partial (< 3 months *vs* 3 months or more), siblings (one or more siblings *vs* no siblings), current smoking mother or father (yes *vs* no), atopic parent (asthma, allergic disease from nose or eyes or eczema *vs* no such symptoms among mother or father), single parenthood (one adult over 18 years of age living in the home *vs* two or more adults), furred pets at home *vs* no furred pet, living in the centre of the town (urban), outside in a housing area (suburban) or in the countryside (rural) and type of house (single family house or chain house *vs* apartment in a multi-family house). Additionally, adjustments were moreover made for airway infections in some analyses.

Ethics

The study was approved by the Ethics Committee in Örebro, Sweden.

Results

Attending day care was common in the investigated population of children 1–6 years of age since 87.2% of the children were in current day care or had attended day care earlier in life, Table 1. In the youngest group of children, aged 1–2 years, 71.2% were currently or had earlier been in day care while the corresponding frequency for the older children aged 5–6 years, was 92.6%.

Table 1. Different type of day care in relation to age of the child

	Type of day care, *n* (%)				
	Home care	Day care >20 h/week	Day care <20 h/week	Family day care	Earlier day care but not now
1–2 years	578 (28.8)	736 (36.7)	293 (14.6)	359 (17.9)	39 (1.9)
2–3 years	274 (13.8)	858 (43.2)	337 (17.0)	338 (17.0)	181 (9.1)
3–4 years	195 (9.3)	947 (45.3)	367 (17.6)	397 (19.0)	183 (8.8)
4–5 years	150 (6.6)	1148 (50.7)	368 (16.3)	405 (17.9)	192 (8.5)
5–6 years	178 (7.4)	1217 (50.7)	435 (18.1)	403 (16.8)	166 (6.9)
Total	1375 (12.8)	4906 (45.7)	1800 (16.8)	1902 (17.7)	761 (7.1)

Table 2 gives demographic characteristics for different type of day-care attendance. Children cared at home were younger, had more often one or more siblings, lived more often in a rural area, in single-family houses and had more often furred pets at home compared with children attending day care. Furthermore, they less often lived with a single parent and less often had a parent with atopic disease. To start at a day-care centre before 1 year of age was uncommon (4.9%). Children with such an early start at day-care centre were more likely to be breast fed < 3 months, having no siblings, a smoking parent, living together with one single parent, living in urban or suburban region, and in a multi-family house or chain house. The variables (about family and exposures) listed in Table 2 are known to be associated with symptoms of asthma, allergy and infections. As they also correlate to various aspects of day care they were used as adjustment variables in the multiple logistic regression analyses.

In Table 3, the association between symptoms in different types of day care is presented with their AOR for day care compared with home care. In crude analyses, all the listed symptoms were positively more frequently found for children at day care compared with at home care. Respiratory symptoms such as wheeze, nightly cough, multiple colds and ear infection were in the adjusted analyses significantly associated with day-care attendance as well as allergic reactions to foodstuffs and eczema. Doctor diagnosed asthma were more associated to family day care, and with having earlier attended day care.

The risks of symptoms were more or less similar between the groups of children irregardless of the time spent at the day-care centre (> 20 h/week *vs* < 20 h/week), except for eczema last 12 months (21.2 *vs* 18.7%; χ^2-test: $P = 0.024$) and having more than six colds (21.5 *vs* 19.3%: $P = 0.050$).

When stratifying for age (1–4 and 4–6 years) all symptoms were more common among children in day care compared with home care. However, significant results were mainly found in the younger group of children (wheezing, cough at night, reactions to foods, multiple colds and ear infections) in adjusted analyses. Among the older children (4–6 years old), a significant difference in symptoms between home care and day-care

Table 2. Different type of day care in relation to demographic characteristics

Characteristics	Type of day care, *n* (%)						If day-care centre, age for starting, *n* (%)			
	Home care	Day-care centre >20 h/week	Day-care centre <20 h/week	Family day care	Earlier day care but not now	*P*-value*	Before 1 year of age	1–2 years	After 2 years of age	*P*-value†
Total study population, *n*	1375 (12.8)	4906 (45.7)	1800 (16.8)	1902 (17.7)	761 (7.1)		363 (4.9)	5601 (75.6)	13.3 (19.5)	
No breastfeeding or <3 months	215 (15.7)	712 (14.6)	283 (15.9)	286 (15.1)	109 (14.5)	0.430	19.9	14.3	16.2	0.008
Sibling (one or more)	1101 (80.6)	3768 (77.7)	1413 (79.2)	1420 (75.4)	704 (92.6)	0.394	72.9	78.4	85.6	0.004
Smoking mother or father	307 (22.3)	1104 (22.5)	481 (26.7)	517 (27.2)	174 (22.9)	0.322	36.4	22.0	25.9	<0.001
Atopic parent	604 (43.9)	2360 (48.1)	865 (47.5)	904 (43.6)	332 (43.9)	0.011	49.6	48.4	44.7	0.423
Single parenthood	57 (4.2)	588 (12.2)	141 (7.9)	199 (10.6)	32 (4.2)	<0.001	16.5	9.8	11.0	<0.001
Rural	680 (50.1)	1268 (26.4)	581 (32.9)	820 (44.0)	278 (36.8)	<0.001	20.4	28.1	34.5	<0.001
Sub-urban	576 (42.4)	2884 (59.9)	977 (55.4)	884 (47.4)	412 (56.6)	<0.001	63.7	59.5	52.8	0.020
Urban	80 (5.9)	543 (11.3)	162 (9.2)	107 (5.7)	52 (6.9)	<0.001	15.0	9.9	10.5	0.001
Single family houses (SH)	1087 (81.2)	3295 (68.9)	1262 (72.0)	1466 (79.0)	602 (80.4)	<0.001	48.0	70.7	72.3	<0.001
Chain houses (CH)	82 (6.1)	502 (10.5)	154 (8.8)	131 (7.1)	131 (8.7)	<0.001	14.0	9.8	8.7	0.006
Multi family houses (MH)	170 (12.7)	984 (20.6)	337 (19.2)	259 (14.0)	82 (10.9)	<0.001	37.2	18.1	17.8	<0.001
Furred pet at home	681 (49.5)	1665 (33.9)	719 (39.9)	929 (48.8)	337 (44.3)	<0.001	34.4	35.2	41.4	0.287

*Chi-square test; home care *vs* day-care centre (>20 h/week and <20 h/week).
†Chi-square test; before 1 year of age *vs* later start (1–2 year and after 2 years of age).

Table 3. Prevalence of symptoms in different day care and association between different day care and symptoms expressed adjusted odds ratio including 95% confidence interval

Symptoms	Home care (reference)		Day care >20 h/week		Day care <20 h/week		Family day care		Earlier day care but not now	
	%	AOR (reference)	%	AOR* (95% CI)	%	AOR* (95% CI)	%	AOR* (95% CI)	%	AOR* (95% CI)
Wheezing last 12 months	17.1	1.0	19.6	1.33 (1.12–1.58)	20.6	1.41 (1.16–1.71)	20.5	1.37 (1.13–1.67)	16.1	1.10 (0.85–1.42)
Cough at night last 12 months (>2 weeks)	4.9	1.0	8.3	1.56 (1.17–2.07)	8.2	1.61 (1.17–2.20)	7.1	1.51 (1.10–2.07)	6.1	1.21 (0.80–1.83)
Asthma diagnosed by doctor	3.7	1.0	5.4	1.23 (0.88–1.71)	5.5	1.33 (0.92–1.92)	6.4	1.70 (1.19–2.44)	6.1	1.61 (1.04–2.48)
Rhinitis last 12 months	8.5	1.0	12.1	1.15 (0.92–1.44)	11.4	1.17 (0.91–1.51)	11.5	1.22 (0.95–1.57)	10.7	1.24 (0.90–1.71)
Hay fever diagnosed by doctor	0.9	1.0	2.5	1.75 (0.94–3.23)	2.6	1.72 (0.89–3.35)	2.3	1.81 (0.94–3.51)	1.8	1.21 (0.52–2.78)
Eczema last 12 months	13.2	1.0	21.2	1.49 (1.24–1.79)	18.7	1.33 (1.07–1.64)	16.8	1.21 (0.98–1.49)	18.5	1.37 (1.06–1.77)
Allergic reactions of food	15.5	1.0	21.0	1.27 (1.07–1.52)	20.3	1.22 (1.00–1.49) 1	18.4	1.10 (0.90–1.34)	17.3	1.13 (0.88–1.45)
More than six colds last 12 months	11.5	1.0	21.5	2.57 (2.12–3.12)	19.3	2.32 (1.87–2.88)	15.6	1.74 (1.40–2.17)	13.2	1.61 (1.21–2.14)
Ear infection ever	42.4	1.0	64.7	2.14 (1.87–2.45)	62.5	1.95 (1.68–2.28)	57.8	1.70 (1.46–1.97)	60.5	1.78 (1.47–2.16)

*Adjusted odds ratio (AOR), adjusted for gender, age, siblings, smoking parent, atopic parent, single parenthood, furred pet, breastfeeding <3 months, type of house, urbanity.

centre attendance was seen in crude analyses for rhinitis last year, doctor diagnosed hay fever, eczema last year, allergic reactions to food and ear infection, while ear infection was the only disease that reached significance in the adjusted analyses (Table 4).

Of 7406 children (61 missing information on age for starting), 363 (4.9%) started at the day-care centre before 1 year of age, 5601 (75.6%) started between 1 and 2 years of age and 1442 (19.5%) started after 2 years of age (Table 5). Wheezing, cough at night, rhinitis, eczema and allergic reactions to food where more prevalent among children entering day-care centre during the first year of life compared with later entrance. On the contrary, children starting at a day-care centre after 2 years of age had a higher risk of doctor diagnosed asthma and hay fever compared with children who started earlier.

We found a strong co-variation of the prevalence of asthma and allergic symptoms and the number of reported colds last 12 months. The association was more pronounced for respiratory symptoms than for atopy-related symptoms, data not shown. To evaluate if the associations between day-care attendance and health symptoms can be explained by more common cold infections among children in day care, we both adjusted and stratified the data. When adjusting for the number of colds last year (< 6, 6–10 or > 10 colds) together with the other adjustment variables in Table 3, AORs for day-care attendance and for starting age at day-care centre (Table 5) remained roughly the same. In stratified analyses, the association between day care and symptoms were stronger in the group of children with less than six colds last year than among children with more colds last

Table 4. Association between symptoms and day care in different age groups expressed as adjusted odds ratios

	Age 1–4 years				Age 4–6 years			
	Home care, *n* (%)	Day care, *n* (%)	*P*-value*	AOR† 95% CI	Home care, *n* (%)	Day care, *n* (%)	*P*-value	AOR† 95% CI
Wheezing last 12 months	186 (18.1)	836 (24.1)	<0.01	1.47 (1.22–1.78)	46 (14.1)	465 (15.0)	0.65	1.03 (0.72–1.47)
Cough at night last 12 months (>2 weeks)	49 (4.7)	318 (9.1)	<0.01	1.82 (1.31–2.52)	17 (5.2)	228 (7.3)	0.17	0.97 (0.57–1.64)
Asthma diagnosed by doctor	34 (3.3)	185 (5.3)	0.01	1.46 (0.99–2.16)	16 (4.9)	172 (5.5)	0.65	1.02 (0.56–1.86)
Rhinitis last 12 months	95 (9.2)	434 (12.5)	<0.01	1.09 (0.85–1.41)	20 (6.2)	351 (11.3)	0.01	1.32 (0.81–2.15)
Hay fever diagnosed by doctor	7 (0.7)	55 (1.6)	0.03	1.61 (0.71–3.65)	5 (1.5)	111 (3.5)	0.05	1.71 (0.68–4.32)
Eczema last 12 months	139 (13.3)	733 (20.7)	<0.01	1.44 (1.17–1.78)	42 (12.8)	642 (20.3)	<0.01	1.32 (0.92–1.89)
Allergic reactions of food	166 (16.0)	753 (21.5)	<0.01	1.29 (1.06–1.57)	45 (13.8)	627 (20.0)	0.01	1.28 (0.90–1.81)
More than six colds last 12 months	129 (12.4)	1019 (29.1)	<0.01	3.03 (2.46–3.74)	28 (8.6)	367 (11.7)	0.09	1.22 (0.80–1.88)
Ear infection ever	401 (38.5)	2086 (59.3)	<0.01	2.24 (1.92–2.61)	179 (54.9)	2179 (64.9)	<0.01	1.71 (1.33–2.19)

*Pearson chi-square for home care *vs* day-care centre attendance.

†Adjusted odds ratio (AOR), adjusted for gender, siblings, smoking parent, atopic parent, single parenthood, furred pet, breastfeeding <3 months, type of house, urbanity.

year. However, in the group of children with >10 colds (total $n = 151$, home care $n = 16$), the prevalence of symptoms were higher for children in day care but this difference was not significant for any symptom.

Discussion

The strength of the present study includes a large sample size and a population based design. The sample size allow statistical models with adjustment for covariates such as gender, age, smoking parent, single parenthood, atopic parent, furred pet at home, breastfeeding, type of dwelling, urbanity and reported dampness at home. The high response rate and the nonresponder analysis (15) indicate that the results are highly representative for this region in Sweden.

Information on type of day care was collected for the current situation. The questionnaire focused mainly on allergic and asthmatic symptoms during the last 12 months. Parental report of ear infection ever, doctor diagnosed hay fever and asthma and allergic reactions to food should be reliable if collected within the first few years of the life of the children. In most instances, only clinically insignificant rash after some foods may have been forgotten. One may argue that parents to children in day care may remember colds or long-lasting nightly cough of their child if their work was disrupted compared with parents who always are at home. However, the main part of the health variables may not be affected by this recollection bias, particularly considering the relatively short recollection time interval (12 months). In addition, many of the included symptoms would probably not give rise to disruption of work for parents with children in day care, e.g. doctor diagnosed hay fever or asthma, eczema or reactions of food resulting in limited risk for recollection bias.

There is a risk of bias if parents to sensitive children actively behave different, like choosing a family day care instead of day-care centre or chose to stay at home to care their child for a longer time (late start at day care or home care) to minimize the infection exposure. Children in family day care and children who earlier had attended day care had a higher prevalence of asthma (7.4% and 6.1%) than children attending day-care centres (5.5%) currently. This could be an indication of that parents to children with severe asthma more often choose to quit day-care centre care and/or change to family day care. Our findings on a late start (after 2 years of age) at day-care centre as a risk factor for hay fever and asthma may be also a result of such a behaviour. Some parents of children with asthma or other diseases may choose to stay at home during the whole preschool time. It has, however, not been possible to identify such families in this data set and such behaviour cannot explain our results, rather the opposite. In some places in Sweden, allergic and asthmatic children with severe disease have access to special 'allergy day-care centres' where higher demands on hygiene, 'no pets' and infections among the children are taken into account. The number of children attending such centres is, however, so low that it can only marginally affect the results.

There is a general agreement that symptoms of colds and complications in terms of both wheezing and ear infections in small children increases with exposure to other children in day-care settings (13, 17–20). In the present study, there were significantly higher frequencies of the number of respiratory symptoms, infections and allergic disease among children who attended day care than among children in home care. While wheezing is more readily related to airway infections, the increased occurrence of eczema and food allergy is not expected (21, 22).

Our findings of an increased prevalence of atopic symptoms among children in day-care centres could not be explained by a co-variation with multiple colds. The prevalence of the many symptoms and diagnoses were in general increased with the number of colds. However, the

Table 5. Association between age for starting at day care and symptoms among children aged 1–6 years

Outcome	Home care (reference), $n = 1375$		Day-care centre attendance: Start before 1 year of age, $n = 363$			Start at 1–2 years of age, $n = 5601$			Start after 2 years of age, $n = 1442$			*P* trend†
	%	OR	%	OR (95% CI)	AOR (95% CI)*	%	OR (95% CI)	AOR (95% CI)*	%	OR (95% CI)	AOR (95% CI)*	
Wheezing last 12 months	17.1	1.0	23.1	1.46 (1.10–1.94)	1.54 (1.14–2.10)	19.7	1.19 (1.02–1.39)	1.32 (1.11–1.56)	17.1	1.00 (0.82–1.22)	1.32 (1.06–1.65)	<0.01
Cough at night last 12 months apart from colds	4.9	1.0	12.3	2.76 (1.85–4.12)	2.03 (1.31–3.14)	7.9	1.70 (1.30–2.21)	1.54 (1.17–2.04)	7.4	1.56 (1.14–2.14)	1.60 (1.13–2.26)	0.02
Asthma diagnosed by doctor	3.7	1.0	5.6	1.55 (0.91–2.64)	1.28 (0.72–2.28)	5.1	1.41 (1.04–1.92)	1.31 (0.94–1.81)	6.7	1.87 (1.32–2.66)	1.76 (1.20–2.60)	0.06
Rhinitis last 12 months	8.5	1.0	17.7	2.32 (1.66–3.23)	1.64 (1.14–2.35)	11.5	1.40 (1.14–1.73)	1.13 (0.90–1.41)	11.5	1.39 (1.08–1.79)	1.21 (0.92–1.60)	0.05
Hay fever diagnosed by doctor	0.9	1.0	3.3	3.91 (1.72–8.78)	2.25 (0.96–5.27)	2.1	2.39 (1.31–4.34)	1.48 (0.80–2.75)	3.7	4.33 (2.31–8.15)	2.39 (1.23–4.63)	0.02
Eczema last 12 months	13.2	1.0	23.1	1.99 (1.49–2.65)	1.58 (1.16–2.16)	20.6	1.71 (1.45–2.03)	1.44 (1.20–1.73)	18.7	1.52 (1.24–1.87)	1.25 (1.00–1.57)	0.04
Allergic reactions to food	15.5	1.0	20.4	1.40 (1.04–1.88)	1.15 (0.83–1.58)	21.1	1.46 (1.24–1.71)	1.30 (1.10–1.55)	18.5	1.24 (1.02–1.51)	1.15 (0.92–1.43)	0.08
More than six colds last 12 months	11.5	1.0	23.5	2.38 (1.77–3.19)	2.65 (1.92–3.66)	21.4	2.10 (1.75–2.51)	2.50 (2.07–3.03)	14.3	1.28 (1.03–1.60)	2.15 (1.68–2.75)	<0.01
Ear infection ever	42.4	1.0	61.7	2.19 (1.72–2.77)	2.03 (1.57–2.63)	64.4	2.46 (2.18–2.77)	2.16 (1.90–2.47)	62.0	2.21 (1.90–2.57)	1.64 (1.39–1.94)	0.34

*Adjusted odds ratio (AOR), adjusted for gender, age, siblings, smoking parent, atopic parent, single parenthood, furred pet in the home, breastfeeding <3 months, type of house (home), and urbanity.
†Linear by linear association for trends for starting age at day-care centre *vs* symptoms.

group of children with few colds (less than six colds) during the past year had the highest ORs and AORs for allergic diseases associated with day-care centre attendance compared with children with a larger number of colds. This indicates that the higher risk for allergic diseases in children attending day-care centres should be explained by other factors than frequent infections. Building ventilation rate, quality and frequency of cleaning and other building related factors should be considered. Another recognized property of day-care centres is the presence of allergens from furred pets, a prerequisite for allergic sensitization and contributing to expression of symptoms (23).

The question whether exposure to early infections in terms of day care is a risk or a protection against future allergic disease or asthma (allergic and nonallergic) is ambiguous (24). Most asthma exacerbations in school age are caused by viral infections in the respiratory tract, mainly rhinovirus (25). In infants and small children respiratory syncytial virus (RSV) is a main cause of lower respiratory symptoms (26). RSV infection in very early age has been related to asthmatic symptoms later in childhood (27), in the Tucson Children's Respiratory Study up through 11 years of age (28).

In a number of epidemiological studies early upper respiratory tract infections have been followed by a lower occurrence of asthma (8, 29) and atopy (30) sometimes after an initial increase in asthma occurrence (8). Other studies of early respiratory infections have exhibited an increased prevalence of atopy (31) and asthma (32), particularly after RSV infections (26, 27). Day-care attendance, particularly during the two first years of life and in absence of older siblings, is reported to imply some protection against later asthma and allergy (8, 29, 10, 33). In adults, an increased exposure to infections has also been suggested to cause a lower occurrence of adult hay fever after childhood day-care attendance in the ECRHS study (34). There are other studies with no effect on asthma or allergy of early respiratory infections or infectious exposure in terms of day care (35–37). A 13-year follow-up study showed that children in large day-care centres suffered more often from common cold than children in home care, but during the early school years earlier day-care attendance was a protective factor for common cold until about 13 years of age (9). When we stratified our data into two groups of ages (1–4 and 5–6 years), the prevalence of symptoms where higher among children attending day-care centres in both age groups, but the relationship was stronger in the age group 1–4 years. However, the prevalence of asthma among the children 5–6 years of age at home and in day care were mainly the same (4.9% and 5.5%), and an evidence for a potential 'protective' effect could not be seen.

A German study by Kramer *et al.* (10) found that an early start of day-care (before 6 months) decreased the risk for atopy, hay fever and irritated eyes later in life especially for children from small families. In our study, a somewhat higher risk for asthma (P-trend $= 0.06$) and hay fever (P-trend $= 0.02$) were observed in the group of children entering day-care centre care after 2 years of age compare with children who started earlier. However, the accuracy of the trend value for hay fever in Table 5 could be questioned as the prevalence is very low (2.1–3.7%). In our data, only 4.9% of the children attending day-care centres started during their first year of life which might affect the comparisons with studies from some other countries.

The study only included preschool children between 1 and 6 years of age, which leaves the long-term development of respiratory and atopic conditions an open question, a challenge for a follow-up study. But even if the increase of disease related to day care may level out later in life, the reported amount of disease and symptoms during the preschool age involves a considerable strain for the children and their families as well as an economic load for the society. The decrease in hospitalization for childhood asthma during the last decades does not include the first four years of life (38), when the asthma morbidity still often requires hospital care.

Our study did not show any protective effect of day-care attendance for any symptom in any age group. On the contrary, there was an increased risk for most symptoms studied, particularly in the lower age groups. Considering the significant increase of the allergic diseases in Sweden over the last decades (2, 39) our findings justify a significant public health concern.

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Appendix A

Questionnaire DBH phase I

Bostad - Barn - Hälsa

Undersökning av bostadsmiljöns betydelse för astma och allergier hos små barn i Värmland

Beskrivning av undersökningen finns i bifogade introduktionsbrev

Är ovanstående namn- och adressuppgifter korrekta?

Ja............... ☐
Nej.............. ☐

Ange eventuella ändringar av namn och adressuppgifter

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1. Bakgrundsdata för barnet och familjen

Frågor om födelsedata för barnet och amningsvanor

1. I vilken graviditetsvecka föddes barnet?

- Före vecka 32 .... ☐
- Under vecka 32 - 36 .... ☐
- Under vecka 37 - 42 .... ☐
- Under vecka 43 eller senare .... ☐
- Vet ej .... ☐

2. Vad var barnets födelsevikt?

- Mindre än 2500 g .... ☐
- 2500 - 4200 g .... ☐
- Mer än 4200 g .... ☐
- Vet ej .... ☐

3. I vilket land är barnet fött?

- Sverige .... ☐
- Annat land .... ☐

4. Till vilken ålder har Ditt barn ammats helt eller delvis?

- Ingen amning .... ☐
- Yngre än 3 månader .... ☐
- 3 - 6 månader .... ☐
- Äldre än 6 månader .... ☐

5. Vid vilken ålder började barnet med modersmjölkersättning, välling eller gröt?

- Yngre än 3 månader .... ☐
- 3 - 6 månader .... ☐
- Äldre än 6 månader .... ☐

6. Vid vilken ålder började barnet med smakportioner t ex fruktpuréer, mosade rotfrukter?

- Yngre än 3 månader .... ☐
- 3 - 6 månader .... ☐
- Äldre än 6 månader .... ☐

7. Vilken typ av blöjor används/användes mest?

- Tygblöjor .... ☐
- Allt-i-ett blöja (t ex Pampers, Libero) .... ☐
- Annan typ .... ☐

Frågor om familjen och hushållet

8. Hur många barn, som ej fyllt 7 år, bor stadigvarande i hemmet?

- 1 barn .... ☐
- 2 barn .... ☐
- 3 barn .... ☐
- 4 eller fler barn .... ☐

9. Hur många barn/ungdomar, 7 till 18 år, bor stadigvarande i hemmet?

- Ingen .... ☐
- 1 person .... ☐
- 2 personer .... ☐
- 3 personer .... ☐
- 4 eller fler personer .... ☐

10. Hur många personer över 18 år bor stadigvarande i hemmet?

- 1 vuxen .... ☐
- 2 vuxna .... ☐
- 3 vuxna .... ☐
- 4 eller fler vuxna .... ☐

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Frågor om eventuell daghemsvistelse

11. Vistas barnet på daghem eller hos dagmamma?

- Ja, på daghem mer än 20 tim/vecka ☐
- Ja, på daghem 20 tim/vecka eller mindre ☐
- Ja, hos dagmamma ☐
- Nej, men har varit på daghem tidigare ☐
- Nej, aldrig ☐

12. Om barnet går eller har gått på daghem, vid vilken ålder började barnet där?

- Före 1 års ålder ☐
- 1 - 2 års ålder ☐
- Efter 2 års ålder ☐

13. Om barnet går på daghem <u>nu</u>, ange daghemmets namn:

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2. Barnets och familjens hälsa

Frågor om andningsbesvär hos barnet

14 a) Har Ditt barn <u>någonsin</u> haft besvär av pipande eller väsande andning?

Ja......... ☐
Nej....... ☐ Vid Nej, gå till fråga 15

14 b) Om Ja, vid vilken ålder uppträdde besvären första gången?

Före 1 års ålder.......... ☐
Vid 1 - 2 års ålder....... ☐
Vid 3 - 4 års ålder........ ☐
Efter 4 års ålder.......... ☐

15 a) Har Ditt barn <u>under de senaste 12 månaderna</u> haft besvär av pipande eller väsande andning?

Ja .... ☐
Nej .... ☐ Vid Nej, gå till fråga 16

15 b) Om Ja, vid vilka tillfällen?
Flera alternativ möjliga.

a) Vid förkylning .... ☐
b) Vid ansträngning.................................. ☐
c) Vid skratt eller gråt............................... ☐
d) Vid lek eller utomhusvistelse .... ☐
e) Vid kontakt med pälsdjur....................... ☐

16. Har Ditt barn <u>under de senaste 12 månaderna</u> haft besvär av natthosta mer än två veckor utan att vara förkyld?

Ja .... ☐
Nej .... ☐

17. Har Ditt barn fått diagnosen astma av läkare?

Ja............... ☐
Nej.............. ☐

18. Har Ditt barn haft krupp (andningsbesvär med skällande hosta)?

Ja............... ☐
Nej .... ☐

19. Har Ditt barn fått diagnosen lunginflammation av läkare?

Ja................ ☐
Nej .... ☐

Frågor om besvär från näsa eller ögon hos barnet

20 a) Har Ditt barn <u>någonsin</u> haft nysningar, rinnsnuva eller nästäppa utan att ha varit förkyld?

Ja................ ☐
Nej .... ☐ Vid Nej, gå till fråga 21

20 b) Om Ja, vid vilken ålder uppträdde besvären första gången?

Före 1 års ålder..................... ☐
Vid 1 - 2 års ålder.................. ☐
Vid 3 - 4 års ålder.................. ☐
Efter 4 års ålder..................... ☐

21. Har Ditt barn <u>under de senaste 12 månaderna</u> haft nysningar, rinnsnuva eller nästäppa utan att ha varit förkyld?

Ja .... ☐
Nej .... ☐

22. Har Ditt barn under de senaste 12 månaderna haft nysningar, rinnsnuva eller nästäppa eller röda kliande ögon efter kontakt med pälsdjur?

Ja .... ☐
Nej .... ☐

23. Har Ditt barn under de senaste 12 månaderna haft nysningar, rinnsnuva eller nästäppa eller röda kliande ögon efter kontakt med pollen?

Nej .... ☐
Ja, enbart vid lövsprickning (maj) .... ☐
Ja, enbart för gräs (juni-augusti) .... ☐
Ja, både vid lövsprickning och för gräs .... ☐

24. Har Ditt barn fått diagnosen hösnuva eller allergisk snuva ställd av läkare?

Ja......... ☐
Nej....... ☐

25. Hur många förkylningar har Ditt barn haft under de senaste 12 månaderna?

Mindre än 6 förkylningar....... ☐
6 - 10 förkylningar................ ☐
Mer än 10 förkylningar......... ☐

26. Hur länge brukar varje förkylning vara?

Mindre än 2 veckor.............. ☐
2 - 4 veckor.......................... ☐
Mer än 4 veckor.................... ☐

27. Har Ditt barn någonsin haft öron-inflammation?

Nej................................. ☐
Ja, 1 - 2 gånger.............. ☐
Ja, 3 - 5 gånger.............. ☐
Ja, mer än 5 gånger....... ☐

Frågor om hudbesvär hos barnet

28 a) Har Ditt barn någonsin haft ett kliande eksem under minst 6 månader (kan ha kommit och gått)?

Ja................ ☐
Nej............. ☐ Vid Nej, gå till fråga 29

28 b) Om Ja, vid vilken ålder uppträdde besvären första gången?

Före 1 års ålder.................. ☐
Vid 1 - 2 års ålder............... ☐
Vid 3 - 4 års ålder............... ☐
Efter 4 års ålder.................. ☐

28 c) Har detta kliande eksem vid något tillfälle förekommit på något av följande ställen; armveck, knäveck, fotleder, lårens baksidor eller på halsen, kring öron eller ögon?

Ja................ ☐
Nej .... ☐

28 d) Har Ditt barn haft detta kliande eksem under de senaste 12 månaderna?

Ja .... ☐
Nej .... ☐

28 e) Hur ofta har Ditt barn vaknat på natten under de senaste 12 månaderna på grund av detta kliande eksem?

Aldrig... ☐
Högst en natt per vecka..................... ☐
Flera nätter per vecka........................ ☐

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Frågor om reaktioner på mat

29 a) Har barnet någon gång fått allergiska besvär av typen eksem, nässelutslag, diarré, läpp- eller ögonsvullnad av nedanstående födoämnen?

Ja .... ☐
Nej .... ☐
Vet ej .... ☐

29 b) Om Ja, av vilka födoämnen?

Mjölk eller mjölkmat .... ☐
Ägg .... ☐
Fisk .... ☐
Jordnötter .... ☐
Nötter, mandel....................................... ☐
Mjöl (vete, korn, råg, havre) .... ☐
Soja, ärtor, bönor.................................... ☐
Frukt .... ☐
Grönsaker, t ex tomat, morot .... ☐
Annat .... ☐

Frågor om antibiotika-behandlingar för barnet

30. Har barnet medicinerats med antibiotika, t ex penicillin? Flera alternativ möjliga.

Nej, aldrig..................................... ☐
Ja, under första levnadsåret .... ☐
Ja, under andra levnadsåret.......... ☐
Ja, senare...................................... ☐

31. Om barnet fick antibiotika under första levnadsåret, hur många kurer fick barnet?

1 kur .... ☐
2 kurer .... ☐
3 eller flera kurer .... ☐

Frågor om övriga familjens hälsa

32 a) Finns astma eller allergiska besvär i familjen?

Ja .... ☐
Nej .... ☐ Vid Nej, gå till fråga 33

32 b) Om Ja, vilka besvär och hos vem?

	Biologisk pappa	Biologisk mamma	Hel- eller halvsyskon
Astma................................	☐	☐	☐
Allergiska näs-/ ögonbesvär......................	☐	☐	☐
Eksem..............................	☐	☐	☐

33. Brukar någon av följande personer i hushållet hosta utan att vara förkyld?

	Ja	Nej
Pappa.....................	☐	☐
Mamma..................	☐	☐
Syskon....................	☐	☐

34. Hur många förkylningar har Ni haft i hushållet det senaste året?

	Ingen förkyl-ning	1-2 för-kylningar	3-4 förkyl-ningar	5 eller fler för-kyl-ningar	Vet ej/ej aktuellt
Pappa.................	☐	☐	☐	☐	☐
Mamma...............	☐	☐	☐	☐	☐
Närmast äldre syskon.................	☐	☐	☐	☐	☐
Närmast yngre syskon.................	☐	☐	☐	☐	☐

Frågor om hälsobesvär hos en förälder

35. Fråga nr 36 skall endast besvaras av en förälder. Ange vem som svarar på nedanstående fråga.

Mamma............................☐

Pappa..............................☐

36. Har Du under de senaste 3 månaderna haft något/några av nedanstående besvär/symtom?

	Ja, ofta (varje vecka)	Ja, ibland	Nej, aldrig	Om Ja, tror Du att detta beror på Din bostadsmiljö? Ja	Nej
Trötthet..	☐	☐	☐	☐	☐
Tung i huvudet.................................	☐	☐	☐	☐	☐
Huvudvärk..	☐	☐	☐	☐	☐
Illamående/yrsel...............................	☐	☐	☐	☐	☐
Koncentrationssvårigheter..............	☐	☐	☐	☐	☐
Klåda, sveda, irritation i ögonen.......	☐	☐	☐	☐	☐
Irriterad, täppt eller rinnande näsa..	☐	☐	☐	☐	☐
Heshet, halstorrhet..........................	☐	☐	☐	☐	☐
Hosta...	☐	☐	☐	☐	☐
Torr eller rodnad hud i ansiktet	☐	☐	☐	☐	☐
Fjällning/klåda i hårbotten/öron	☐	☐	☐	☐	☐
Torr, kliande, rodnad hud på händer	☐	☐	☐	☐	☐

3. Barnets bostad

De flesta frågorna i detta avsnitt avser barnets huvudsakliga bostad, dvs där barnet bor den största delen av tiden. I vissa fall vill vi dock ha reda på saker om bostaden där barnet föddes. Detta innebär att om barnet är fött i annan bostad ska förhållandena där anges vid sådana frågor.

37. Har barnet bott i den nuvarande bostaden hela sitt liv?

Ja .... ☐
Nej, bott här sedan: 2000.......... ☐
1999.......... ☐
1998.......... ☐
1997.......... ☐
1996.......... ☐
1995 .... ☐

38. Bor barnet mer än 10 dagar per månad i annan bostad till följd av t ex skilsmässa?

Ja .... ☐
Nej .... ☐

Frågor om den nuvarande bostadens omgivning

39. Var är bostaden belägen?

Innerstadsområde .... ☐
Annat tätbebyggt område .... ☐
Landsbygd .... ☐
Annat .... ☐

40. Bor barnet på gård/fastighet där djurhållning bedrivs? (T ex kor, grisar, hästar mm)

Ja .... ☐
Nej .... ☐

Frågor om den nuvarande bostaden

41. I vilken typ av bostad bor barnet nu?

Fristående villa.............................. ☐
Radhus eller kedjehus.................... ☐
Lägenhet i flerbostadshus............. ☐
Annat.. ☐

42. Kan Du uppskatta bostadens storlek?

Mindre än 60 m^2........................... ☐
61 - 74 m^2....................................... ☐
75 - 99 m^2....................................... ☐
100 - 150 m^2.................................. ☐
Större än 150 m^2 .... ☐

43. Kan Du ungefärligt ange bostadens byggnadsår?

Före 1940 .... ☐
1940 - 1960 .... ☐
1961 - 1970................................. ☐
1971 - 1976 .... ☐
1977 - 1983................................. ☐
1984 - 1993 .... ☐
Efter 1993 .... ☐
Vet ej .... ☐

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44. Äger Ni bostaden?

Ja, som eget ägande ☐
Ja, som bostadsrätt ☐
Nej, vi hyr den ☐

Frågor om barnets rum

45. På vilka våningsplan finns bostadens olika rum?

	Källarplan/ souterräng	Markplan	En trappa eller högre upp
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐

46. I vilket rum brukar barnet sova den största tiden? (Ange endast ett alternativ!)

Eget rum ☐
Delar sovrum med syskon ☐
Föräldrarnas sovrum ☐
Går mellan olika rum ☐

Frågor rörande den nuvarande bostadens konstruktion och material

47. Hur är huset grundlagt?

Betongplatta på mark ☐
Torpargrund/krypgrund/plintgrund ☐
Källare/souterräng ☐
Vet ej ☐

48. Har bostadshuset:

	Ja	Nej
a) Plant yttertak?	☐	☐
b) Takfönster?	☐	☐
c) Vindslucka inomhus till kallvind?	☐	☐
d) Bastu?	☐	☐
e) Gillestuga, arbetsrum eller sovrum i källare?	☐	☐

49. Kan Du redogöra för vilken typ av golvbeläggning som finns i olika rum i bostaden? Sätt kryss i lämplig ruta för varje rum.

	Linoleum	Plastmatta (PVC)	Trä/ parkett	Klinker/ sten/ kakel	Heltäckn. matta	Kork- o- plast	Annat vet ej
Barnets rum	☐	☐	☐	☐	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐	☐	☐	☐	☐
Kök	☐	☐	☐	☐	☐	☐	☐

50. Vilka ytskikt finns på väggarna i barnets rum? Flera alternativ är möjliga.

Papperstapet ☐
Textil/vävtapet ☐
Målad glasfiberväv ☐
Målad skiva eller målad tapet ☐
Träpanel ☐
Annat ☐

51. Vilka ytskikt finns på väggarna i föräldrarnas sovrum? Flera alternativ är möjliga.

Papperstapet ☐
Textil/vävtapet ☐
Målad glasfiberväv ☐
Målad skiva eller målad tapet ☐
Träpanel ☐
Annat ☐

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Frågor om värme och ventilation i nuvarande bostad

52. Vilka typer av värmeelement finns i bostaden?

El-element ☐
Oljefyllda el-element ☐
Vattenfyllda element ☐
Golvvärme ☐
Luftvärme ☐
Annat ☐
Vet ej ☐

53. Förekommer normalt vedeldning i köksspis/ kökspanna eller öppen spis i bostaden? OBS! Ej vedpanna i pannrum.

Ja ☐
Nej ☐
Vet ej ☐

54. Vilken typ av ventilationssystem finns i bostaden?

Självdrag utan köksfläkt ☐
Självdrag med köksfläkt ☐
Central fläkt som suger ut luft ur bostaden (frånluftsystem) ☐
Centrala fläktar som både suger ut luft och tillför ny luft (till- och frånluftsystem) ☐
Vet ej ☐

Frågor om genomförda om- och tillbyggnader av den nuvarande bostaden

55 a) Har bostaden genomgått någon större ombyggnad eller tillbyggnad?

Ja ☐
Nej ☐ } gå till fråga 56
Vet ej ☐

55 b) Om Ja, när skedde denna ombyggnad?
Flera alternativ möjliga.

Före 1993 ☐
1993 - 1994 ☐
1995 - 1996 ☐
1997 - 1998 ☐
1999 - 2000 ☐

55 c) Om Ja, berodde ombyggnaden på fukt- och mögelproblem i bostaden?

Ja ☐
Nej ☐
Vet ej ☐

56. Har golvbeläggningen bytts ut i något av följande rum under barnets livstid eller under 6 månader före barnets födelse?

	Ja	Nej	Vet ej
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐
Annat rum	☐	☐	☐

57. Har något av följande rum målats om under barnets livstid eller under 6 månader före barnets födelse?

	Ja	Nej	Vet ej
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐
Annat rum	☐	☐	☐

Frågor om eventuella fuktproblem i nuvarande bostad

58. Finns det synligt mögel på golv, väggar eller tak i något av följande rum?

	Ja	Nej	Vet ej
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐
Annat rum	☐	☐	☐
Badrum	☐	☐	☐

59. Finns det synliga fuktfläckar på golv, väggar eller tak i något av följande rum?

	Ja	Nej	Vet ej
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐
Annat rum	☐	☐	☐
Badrum	☐	☐	☐

60. Finns det misstänkta fukt- och mögelproblem i golv, väggar eller tak som ej syns invändigt?

Ja .... ☐
Nej .... ☐
Vet ej .... ☐

61. Finns det lossnande, bubblande eller missfärgade golvmattor (t ex plastmatta eller linoleum) i något av följande rum?

	Ja	Nej	Vet ej
Barnets rum	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐
Annat rum	☐	☐	☐
Badrum	☐	☐	☐

62. Om bostaden har källare, finns det där synligt mögel, fuktfläckar eller lossnande, bubblande golvmattor?

Ja .... ☐
Nej .... ☐
Vet ej .... ☐
Källare finns ej .... ☐

63. Finns det missfärgade/svärtade golv av parkett eller kork-o-plast i bostaden?

Ja.. ☐
Nej...................................... ☐
Vet ej.................................. ☐

64. Har det förekommit översvämning eller andra typer av vattenskador i följande rum?

	Ja, det senaste året	Ja, tidigare	Nej	Vet ej
Barnets rum	☐	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐	☐
Kök eller annat rum	☐	☐	☐	☐
Badrum	☐	☐	☐	☐

65. Om bostaden har källare, har där förekommit översvämning eller andra typer av vattenskador?

Ja, det senaste året .... ☐
Ja, tidigare .... ☐
Nej .... ☐
Vet ej .... ☐
Källare finns ej .... ☐

66. Förekommer det vintertid kondens eller imma nedtill på insidan av fönsterrutor i följande rum?

	Nej aldrig	Ja, mindre än 5 cm	Ja, 5-25cm	Ja, mer än 25 cm	Vet ej
Barnets rum	☐	☐	☐	☐	☐
Föräldrarnas sovrum	☐	☐	☐	☐	☐
Vardagsrum	☐	☐	☐	☐	☐

Frågor till föräldern om lukt i nuvarande bostad

67. Har Du under de senaste 3 månaderna känt Dig besvärad av någon eller några av följande lukter i Din bostad?

	Ja, ofta (varje vecka)	Ja, ibland	Nej aldrig
Instängd "dålig" luft	☐	☐	☐
Obehaglig lukt	☐	☐	☐
Stickande lukt	☐	☐	☐
Mögellukt	☐	☐	☐
"Jordkällare"	☐	☐	☐
Tobaksrök	☐	☐	☐
Torr luft	☐	☐	☐

68. Om det finns källare, har Du under de senaste 3 månaderna känt någon eller några av följande lukter?

	Ja, ofta (varje vecka)	Ja, ibland	Nej, aldrig
Instängd "dålig" luft	☐	☐	☐
Obehaglig lukt	☐	☐	☐
Mögellukt	☐	☐	☐
"Jordkällare"	☐	☐	☐

Frågor om barnets födelsebostad

Här följer två frågor om den bostad barnet bodde i tiden efter födseln. Observera att detta kan avse nuvarande bostad eller annan bostad om ni har flyttat.

69. Fanns det i födelsebostaden:

	Ja	Nej	Vet ej
a) Synligt mögel eller fuktfläckar på golv, väggar eller tak	☐	☐	☐
b) Lossnande, bubblande eller missfärgade golvmattor	☐	☐	☐
c) Missfärgade/svärtade parkett-golv eller kork-o-plastgolv	☐	☐	☐
d) Översvämning eller annan typ av vattenskada	☐	☐	☐
e) Kondens eller imma nedtill på insidan av fönsterrutor vintertid	☐	☐	☐
f) Misstänkta fukt- och mögel-problem i golv, väggar eller tak som ej syntes invändigt	☐	☐	☐

70. Förekom någon eller några av följande lukter i barnets födelsebostad?

	Ja	Nej
Instängd "dålig" luft	☐	☐
Obehaglig lukt	☐	☐
Stickande lukt	☐	☐
Mögellukt	☐	☐
"Jordkällare"	☐	☐
Tobaksrök	☐	☐
Torr luft	☐	☐

Frågor om pälsdjur

71 a) Har Ni pälsdjur/husdjur i nuvarande bostad?

Ja .... ☐
Nej .... ☐ Vid Nej, gå till fråga 72

71 b) Om Ja, vad?

Katt.. ☐
Hund .... ☐
Gnagare (kanin, hamster, råtta, marsvin m fl).... ☐
Fågel .... ☐
Akvariefiskar, reptiler etc................................ ☐
Annat pälsdjur .... ☐

---

72 a) Fanns pälsdjur/husdjur i bostaden under barnets första tid, dvs i födelsebostaden?

Ja .... ☐
Nej............. ☐ Vid Nej, gå till fråga 73

72 b) Om Ja, vad?

Katt .... ☐
Hund .... ☐
Gnagare (kanin, hamster, råtta, marsvin m fl) ... ☐
Fågel .... ☐
Akvariefiskar, reptiler etc .... ☐
Annat pälsdjur/husdjur .... ☐

---

73. Har Ni gjort er av med pälsdjur/husdjur pga allergisk sjukdom i familjen?

Ja.............. ☐
Nej............ ☐

---

74. Har Ni avstått från att skaffa pälsdjur/husdjur pga allergisk sjukdom i familjen?

Ja .... ☐
Nej .... ☐

---

75. Finns pälsdjur/husdjur som barnet regelbundet träffar hos nära vänner, släktingar eller dagmamma?

Ja........... ☐
Nej......... ☐

---

76. Kommer barnet regelbundet i kontakt med hästar, stall eller personer som bär "hästkläder"?

Ja........... ☐
Nej......... ☐

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Frågor om städvanor m m i bostaden

77. Hur ofta dammsugs, sopas eller våttorkas golvet i barnets rum?

Varje dag .... ☐
Ca 2 gånger/vecka .... ☐
1 gång/vecka .... ☐
Varannan vecka .... ☐
1 gång/månad .... ☐
Mer sällan.......... ☐

78. Har Era städvanor ändrats beroende på allergier inom familjen?

Ja .... ☐
Nej.......... ☐
Vet ej .... ☐

79. Används någon/några av följande saker i bostaden?

Centraldammsugare.......... ☐
Laserprinter.......... ☐
Luftfuktare.......... ☐
Jonisator.......... ☐
Kopiator.......... ☐
Luftrenare.......... ☐

Frågor om tobaksrökning

80 a) Röker någon i familjen?

Nej .... ☐ Vid Nej, gå till fråga 81
Ja, mamma .... ☐
Ja, pappa .... ☐
Ja, syskon .... ☐
Ja, annan .... ☐

80 b) Om Ja, var förekommer tobaksrökning i bostaden? (Flera alternativ möjliga)

Ute på balkong/uteplats .... ☐
Under köksfläkt.......... ☐
I de flesta rum .... ☐

81. Rökte någon av föräldrarna under barnets första levnadsår?

	Ja	Ja i början, men slutade	Nej
Mamma	☐	☐	☐
Pappa	☐	☐	☐

82. Rökte någon av föräldrarna under graviditeten?

	Ja	Ja i början, men slutade	Nej
Mamma	☐	☐	☐
Pappa	☐	☐	☐

4. Slutligen en fråga om kostvanor

I media påpekas ofta att det är vår moderna livsstil som gör oss allergiska. Ingen har dock kunnat förklara vad som menas med detta begrepp. Vi vill därför avslutningsvis försöka få ett grepp om vad vår moderna livsstil innebär när det gäller kostvanor.

83. I nedanstående lista finns ett antal matvaror uppräknade. Läs igenom listan och kryssa för det som Ni vet finns i Ert hushåll just NU.

Lättmargarin .... ☐
Snabbmakaroner............ ☐
Avokado.......................... ☐
Palsternacka.................. ☐
Hel kyckling.................... ☐
Margarin......................... ☐
Acidofilus........................ ☐
Nötfärs............................ ☐
Groddar........................... ☐
Kokkaffe.......................... ☐
Jungfruolja..................... ☐
Pulvermos....................... ☐
Löjrom............................ ☐
Mjölksyrade grönsaker.... ☐
Nötkött........................... ☐
Olivolja........................... ☐
Ekologisk mjölk .... ☐
Ljust bröd....................... ☐
Djupfryst svamp.............. ☐
Kefir .... ☐
Fläskkorv........................ ☐
Ingefära.......................... ☐
Honung........................... ☐

Cornflakes...................... ☐
Dragon........................... ☐
Lever.............................. ☐
Mjölk (3%) .... ☐
Kalaspuffar..................... ☐
O'boy.............................. ☐
Färsk fisk .... ☐
Bregott........................... ☐
Hemgjord saft.................. ☐
Lättmjölk......................... ☐
Kålrot............................. ☐
Koriander........................ ☐
Grovt bröd....................... ☐
Filmjölk........................... ☐
Morötter.......................... ☐
Konserverad svamp......... ☐
Äpple............................... ☐
Råris............................... ☐
Snabbkaffe...................... ☐
Fläskfärs......................... ☐
Grahamsmjöl................... ☐
Fiskpinnar....................... ☐
Muskotnöt .... ☐

Hembakat bröd .... ☐
Älgkött............................. ☐
Sojabönor........................ ☐
Smör .... ☐
Rågmjöl........................... ☐
Djupfryst fisk.................. ☐
Lightläsk/saft .... ☐
Blodpudding.................... ☐
Maizena.......................... ☐
Gravad lax....................... ☐
Havregryn....................... ☐
Vanillinsocker.................. ☐
Müsli............................... ☐
Hemkokt sylt.................... ☐
Bryggkaffe....................... ☐
Pommes frites................. ☐
Kassler............................ ☐
Tagliatelle....................... ☐
Bananer.......................... ☐
Solrosfrön....................... ☐
Keso............................... ☐
Lammkött........................ ☐
Grädde .... ☐

84. Vem har fyllt i formuläret?

Både mamma och pappa......... ☐
Endast mamma........................ ☐
Endast pappa........................... ☐
Annan....................................... ☐

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Plats för egna kommentarer:

Tack för Din medverkan!

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Appendix B

Questionnaire, Inspection protocol and Measurement protocol DBH phase II

Bostad-Barn-Hälsa

ID: ______________
Familjeenkät

Enkät till förälder/målsman

OBSERVERA Formuleringen ”barnets sovrum” avser det rum i bostaden där barnet **oftast** sover

Utredarens namn: …………………………………

Barnets namn: …………………………………………………………….

Förälder/Målsmans namn: ……………………………………………………………. *(som fyller detta formulär)*

Adress: …………………………………………………………….

ORT: (fyll i !) …………………………………………………………….

1	Vilket år är huset byggt?	år ………………… (ungefär) ☐ vet ej
2	Hur många kvadratmeter är bostaden?	Ca ____________ m^2 ☐ vet ej
3	Hur många personer bor stadigvarande i bostaden?	……. vuxna, över 18 år ………barn/ungdomar fyllda 7 men inte 18 …….. barn under 7 år
4	Vilken uppvärmning har huset <u>huvudsakligen</u> ? (max två alternativ)	☐ Olja ☐ El ☐ Fjärrvärme ☐ Ved ☐ Pellets ☐ Annat: …………………………………….. ☐ Vet ej
5	Finns det golvvärme i rummet där barnet brukar sova?	☐ Ja ☐ Nej
6	Har du under de senaste 3 månaderna känt dig besvärad av någon eller några av följande lukter i bostaden?	

	ja, ofta (varje vecka)	ja, ibland	nej, aldrig
Instängd ”dålig” luft	☐	☐	☐
Obehaglig lukt	☐	☐	☐
Stickande lukt	☐	☐	☐
Mögellukt	☐	☐	☐
”Jordkällare”	☐	☐	☐
Tobaksrök	☐	☐	☐
Torr luft	☐	☐	☐

Bostad-Barn-Hälsa

ID: ______________
Familjeenkät

7	Har ni efter våren 2000 haft översvämning/vattenskada i huset?	☐ ja, var? …………………………………………… …………………………………………………………… ☐ nej
8	Ser man ofta spindeldjur i bostaden?	☐ nej, sällan eller aldrig ☐ ja, spindlar ☐ ja, silverfiskar ☐ ja, annat……………………………………
9	Var sover barnet mest?	☐ ensam i eget rum ☐ i rum med………..stycken andra barn ☐ i rum med ……….stycken vuxna ☐ annat…………………………………………
10	Hur många nätter i månaden sover barnet i det sovrum dagens mätningar görs?	☐ alla eller nästan alla nätter/större denel av natten ☐ varannan natt eller oftare (genomsnitt) ☐ mindre än 15 nätter i månaden
11	Brukar barnets säng vara bäddad dagtid?	☐ nej ☐ ja, täcket/filt är lagt över sängen ☐ ja, med täcke/filt och överkast
12	Är barnets sovrum någonsin speciellt sanerat avseende kvalster?	☐ nej ☐ ja, så här:…………………………………… ……………………………………………………………..
13	Brukar sängkläderna i barnets rum vädras ute?	☐ ja, dagligen ☐ ja, några gånger per vecka ☐ ja, några gånger per månad ☐ nej, mycket sällan
14	Hur ofta byts lakan i barnets säng?	☐ 1 –2 ggr / vecka ☐ varannan vecka ☐ 1 gång/månad ☐ mer sällan
15	Hur ofta dammsugs golvet i barnets sovrum?	☐ varje dag ☐ ca 2-3 ggr / vecka ☐ 1 ggr / vecka ☐ varannan vecka ☐ 1 gång/månad ☐ mer sällan

ID: ______________
Familjeenkät

16	Hur ofta våttorkas golvet i barnets sovrum?	☐ varje dag ☐ ca 2 ggr / vecka ☐ 1 ggr / vecka ☐ varannan vecka ☐ 1 gång/månad ☐ mer sällan
17	Bonas golvet i barnets sovrum?	☐ ja ☐ nej
18	Hur torkas tvätten <u>oftast</u>?	☐ i egen torktumlare / torkskåp ☐ fritt upphängt i bostaden ☐ utanför bostaden/annat hus etc
19	Vilken typ av dammsugare används hemma? ☐ Centraldammsugare ☐ ”Vanlig” dammsugare ☐ annan typ……………………………….	Märke: ………………………………………….. Årsmodell ca ……………………… ☐ Med HEPA/Microfilter
20	Vädras det i barnets sovrum (höst/vinter)?	☐ Fönstret står oftast på glänt ☐ Vädringsfönster oftast öppet ☐ Tvärdragsvädring varje dag ☐ Tvärdragsvädring några gånger per vecka ☐ Fönstervädring sker sällan ☐ annat: ……………………………………..
21	Finns pälsdjur/husdjur hemma?	☐ Ja, inne i bostaden ☐ Ja, ute i stall/hundgård el likn. ☐ Nej
22	Om ja, vilka djur? ☐ Katt, antal ______ ☐ Hund, antal ____________ ☐ Gnagare (kanin, hamster, marsvin etc) ☐ Fågel ☐ Akvariefiskar, reptiler etc ☐ Annat: ……………………………. ☐ Annat: ……………………………. ☐ Annat: …………………………….	
23	Om ja, brukar t.ex. hund eller katt sova i barnets säng?	☐ Ja, de flesta nätter ☐ Ja, ligger sängen vid enstaka tillfällen ☐ Nej, aldrig eller mycket sällan

Bostad-Barn-Hälsa

ID: ______________
Familjeenkät

24	Träffar barnets regelbundet pälsdjur hos vänner, släktingar osv?	☐ Ja ☐ Nej
25	Rider någon i familjen regelbundet?	☐ Ja ☐ Nej
26	Om ni bor på lantgård; Brukar barnet vistas i djurstallar?	☐ Ja, ofta ☐ Ja, ibland ☐ Nej, aldrig eller mycket sällan
27	Om ni bor på lantgård med djurhållning, vilka djur finns och hur många?	☐ Häst, antal…………………….. ☐ Mjölkkor, antal …………………………… ☐ Kalvar, köttdjur, antal…………………………. ☐ Gris, svin, antal………………………………………. ☐ Höns,antal……………………………. ☐ Får, antal…………………. ☐ ……………………………….antal………………… ☐………………………………….. antal………………..
28	Om ni bor på lantgård med djurhållning; Är barnet fött på denna gård?	☐ Ja ☐ Nej
29	Om ni bor på lantgård med djurhållning; fanns djurhållning även vid tiden för barnets födelse?	☐ Ja ☐ Nej

Övriga kommentarer:

Tack för er medverkan!

Bostad-Barn-Hälsa

Besiktning

Utredarens signatur …………………………………

Familjens efternamn ……………………………………

Datum …………………

Allmänna data om bostaden

50	Typ av bostad	O Fristående villa O Radhus eller kedjehus O Lägenhet i flerbostadshus O Annat, ……………………………………………………………
51	Bostadens läge	O Innerstadsområde O Annat tätbebyggt område O Landsbygd O Annat ………………………………………………………………..
52	Ventilation	O Självdrag utan köksfläkt *(Ingen köksfläkt, ev bara självdragsventil)* O Självdrag med köksfläkt *(Vanlig köksfläkt, ej kopplad som frånluft)* O F – Frånluftssystem O FT- Från och tilluft O FTX- Från och tilluft med värmeväxlare O ………………………………………………………………………………
53	Finns följande i eller i anslutning till bostaden?	O Braskamin, kakelugn, köksspis O Vedupplag O Oljepanna (i bruk) O Garage, bilverkstad O Hobbyrum, snickeri O Annat *(som kan påverka innemiljön)*…………………………………
54	Krukväxter	O Ovanligt få (nästan inga) O Normalt O Ovanligt mycket

Bostad-Barn-Hälsa

ID nr: _______________

Besiktning

Bostadens rum och ytskikt

55 **Antal rum i bostaden**

……………st sovrum, gästrum, arbetsrum etc

……………st vardagsrum etc

……………st badrum, toalett

56 **Bostadens olika rum**

	Plan –1 (källare/souterräng dvs med motfylld vägg)	Plan 0 (vanligen entré planet)	Plan +1	Plan +2+
Barnets sovrum	O	O	O	O
Föräldrarnas sovrum	O	O	O	O
Vardagsrum *(Mätrum)*	O	O	O	O
Kök	O	O	O	O
Ev tvättstuga	O	O	O	O

57 **Ytskikt väggar**
Flera alt. är möjliga

	Pappers-tapet	Plastad papperstapet	Målad glasfiber-väv	Målad skiva/tapet	Trä-panel	Våtrums matta	Kakel	Textil vävtapet	Annat
Barnets sovrum	O	O	O	O	O	O	O	O	O
Föräldr. sovrum	O	O	O	O	O	O	O	O	O
Vardagsrum* *(mät)*	O	O	O	O	O	O	O	O	O
Kök	O	O	O	O	O	O	O	O	O
Badrum	O	O	O	O	O	O	O	O	O
Hall	O	O	O	O	O	O	O	O	O
Ovriga rum	O	O	O	O	O	O	O	O	O

58 **Ytskikt golv**

	Linoleum	PVC-matta	Trä/parkett	Laminat	Heltäckningsmatta	Kork-o-plast	Klinkers/sten	Annat
Barnets sovrum	O	O	O	O	O	O	O	O
Föräldr. sovrum	O	O	O	O	O	O	O	O
Vardagsrum	O	O	O	O	O	O	O	O
Kök	O	O	O	O	O	O	O	O
Badrum	O	O	O	O	O	O	O	O
Hall	O	O	O	O	O	O	O	O
Övriga rum	O	O	O	O	O	O	O	O

(Flera alt. är möjliga)

ID nr: _______________
Besiktning

Småhus / radhus

59	Antal bostadsplan ”ovan jord”: (räkna ej källarplan eller souterräng)	O 1 plan O 1 ½ plan O 2 plan O 2 ½ plan O 3 plan O Annat……………………..…………………………..
60	Grundläggning	O Källare O Krypgrund O Platta på mark O Souterräng * *(* Fyll i nedan där det passar. Kan ha olika typer av grundläggning på olika ställen)*
61	Om källare/soutteräng	O Ej inredd källare O Inredd källare, invändig isolering O Inredd källare, utvändig isolering O Inredd källare, ingen isolering O Gillestuga, sovrum eller likn i källare, (valideringsfråga) <u>Bjälklag mot bostaden</u> (taket i källaren) O Träbjälklag O Betongbjälklag O Lättbetong O Annat …………………………………………………
62	Om krypgrund	O Uteluftsventilerad krypgrund O Varmgrund <u>Krypgrundsbjälklag</u> O Träbjälklag O Betongbjälklag O Lättbetong O Annat …………………………………………………
63	Om platta på mark	O Flytande golv (överliggande isolering) O Uppreglat golv (överliggande isolering) O Underliggande isolering
63b	Om platta på mark/källare/souteräng	O PVC eller linoleummatta finns klistrad direkt på betong (*i sovrum eller vardagsrum)*
64	Yttertak	O Sadeltak eller liknande med god lutning O Låglutande yttertak, utvändigt takavlopp O Låglutande yttertak, invändigt takavlopp O Annat……………………………………………………………….
65	Yttervägg	O Betong O Lättbetong O Träregelverk O Annat…………………
66	Fasad	O Tegel O Puts O Träpanel O Eternit O Annat……………………

ID nr: _______________
Besiktning

Flerbostadshus

67	Antal våningar totalt i huset.	……………………………………..(räkna ej källare under mark)
68	Själva lägenhetens antal våningar	……………………………………
69	På vilket våningsplan ligger lägenheten?	O Källare, souterräng (-1) O Markplan *(Ange våningsplan för lägenhetens entre)* (0) O ½ trappa upp eller högre upp (mellanplan) (+1) O Högst upp
70	Husets grundläggning **OBS!** *Endast för lägenheter som ligger i markplan*	O Källare O Krypgrund O Platta på mark O Vet ej
71	Mellanbjälklag	O Betong O Lättbetong O Trä O …………………………………………… O PVC eller linoleummatta klistrad direkt på betong *(sovrum eller vardagsrum)* .
72	Ytterväggar	O Betong O Lättbetong O Regelverk av trä O ……………………………………………
73	Fasad	O Tegel O Puts O Träpanel O Eternit O Annat ……………………………………

Bostad-Barn-Hälsa

ID nr: ______________
Besiktning

Barnets rum

74	Vad har barnets rum för tilluft?	O Ingen anordning för tilluft O Vädringsfönster O Uteluftsventil i yttervägg eller fönsterkonstruktion O Tilluft från mekaniskt system
75	… och frånluft?	O Ingen anordning för frånluft O Överluft över dörr / urspårning i överkant dörr O Frånluftsdon självdrag (vid murstock el. anslutet till) O Frånluftsdon för mekaniskt vent. system
76	Fönstertyp i barnets rum	O Englasfönster O Tvåglasfönster (kopplat traditionellt, ofta trä) O Treglasfönster (ofta med isolerglas)
77	Är någon del av rummets väggar motfyllda?	O Ja O Nej
78	Står någon del av sängen mot motfylld vägg eller yttervägg? (max två kryss)	O Nej O Mot kallvind eller ”kattvind” O Mot yttervägg O Mot motfylld vägg
79	Vad har innertaket för yta?	O målad yta O träpanel O ………………………………………………..
80	Finns något av följande i barnets rum?	O TV O Dator O Stereo, klockradio eller mindre stereo/bandspelare
81	Kondens på fönster vid besiktningstillfället?	……… cm
82	Typ av skivor bakom ytskikt i väggen *(Kan vara lätta att känna med nålen vid uppsättningen av Pentiaqs utrustning)*	O Annat material……………………………. O Gipsskivor O Spånskivor O ”Tretex” skivor *(mjuka)* O Masonit O Vet ej

Bostad-Barn-Hälsa

ID nr: ______________
Besiktning

OBS! Ej badrum.

Subjektiv bedömning av lukt samt okulär bedömning			**Rumsvis**						**Generellt för planet**		
0		Inga tecken på lukt eller skada	Barnets sovrum	Föräldrarnas sovrum	Vardagsrum	Annat rum: ……………………	Annat rum: ……………………	Annat rum: ……………………	Plan -1 (Källarplan)	Plan 0 *"entré"*	Plan +1 och högre
1	*Lukt*	Möjlig lukt, osäker, kanske lukt									
	Okulärt	Lokal indikation, inaktiv, ej av större betydelse									
2	*Lukt*	Förmodad lukt/skada									
	Okulärt	Mer utbredd skada. Förmodat aktiv.									
3	*Lukt*	Uppenbar lukt/skada									
	Okulärt	Aktiv skada, större omfattning.									
83 *Lukt*	**Lukt** - allmänt i rummet/planet	Instängt, ovädrat									
		Unket, "mögellukt"									
		Avvikande, "kemiskt"									
		Annat: …………………………									
Lukt	**Lukt** (unken & likn) - på speciell plats	Golvvinkel yttervägg									
		Golvvinkel innervägg									
		Fönstersmyg									
		Annat: …………………………									
84 *Okulärt*	**Tak (innertak)**	Fuktfläckar, missfärgningar									
		Annat: …………………………									
85 *Okulärt*	**Yttervägg**	Fuktfläckar (ex vid fönster)									
		Mögelfläckar									
		Tapet-, färg- eller putssläpp									
86 *Okulärt*	**Innervägg**	Fuktfläckar (ex vid fönster)									
		Mögelfläckar									
		Tapet-, färg- eller putssläpp									
87 *Okulärt*	**Golv**	Lossnande, bubblande, missfärgad matta									
		Svärtad parkett eller kork-o-plast									
		Färgsläpp, färgflagor									
			Barnets sovrum	Föräldrarnas sovrum	Vardagsrum	Annat rum.	Annat rum.	Annat rum.	Plan -1 (Källarplan)	Plan 0 *"entré"*	Plan +1 och högre

0	Inga tecken på lukt eller skada	
1	*Lukt*	Möjlig lukt, osäker, kanske lukt
	Okulärt	Lokal indikation, inaktiv, ej av större betydelse
2	*Lukt*	Förmodad lukt/skada
	Okulärt	Mer utbredd skada. Förmodat aktiv.
3	*Lukt*	Uppenbar lukt/skada
	Okulärt	Aktiv skada, större omfattning.

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Badrum/Våtrum

	Bad 1	Bad 2	Bad3	
Lukt				Fuktig luft, instängt
Lukt				Lukt av mögel, unken lukt
Lukt				Lukt av avlopp
Okulärt				Fuktfläckar/missfärgningar på golv, väggar eller tak
Okulärt				Kondens på ytskikt/fönster
Okulärt				Mögelfläckar (+ ytskikt, fogar) (Misstänkt mikrobiell aktivitet)
Okulärt				Sprickor, skador i ytskikt eller golvbrun. Mattsläpp, färgsläpp etc
Okulärt				Duschdraperi (kolla om mögel/lukt)

89. Kommentarer:

Info som inte har kommit med i protokollet

Inspektörens uppfattning om bostaden

Misstankar om innemiljöproblem etc

ID nr: _______________
Besiktning

90	Lukt, ”Första intrycket”, Spontanreaktion!	Tydlig	Svag
	Instängt, ovädrat	O	O
	Unken, jordkällare, ”mikrobiell”	O	O
	Avvikande, ”kemiskt”	O	O
	Matos	O	O
	Tobaksrök	O	O
	Annat …………………………..	O	O

Subjektiv bedömning, skala 1-5. (*Bedömning 1-3 problem finnes, 4 nästan utan anmärkning, 5 utan anmärkning)*

	1	2	3	4	5
91 Ytornas/materialens ålder	Gammalt	Ngt äldre	Blandat	Rel nytt	Nytt
Underhåll av huset (ute)	Dåligt	Eftersatt	Normalt	Hyfsat	Bra
Innemiljöproblem (fukt)	Massiva	Påtagliga	Troligen	Ringa	Inga
Innemiljö (annat än fukt)	-				+

92	Luftkvalitet, helhetsintryck av bostadens luft	Tydlig	Svag
	Instängt, ovädrat	O	O
	Unken, jordkällare, ”mikrobiell”	O	O
	Avvikande, ”kemiskt”	O	O
	Matos	O	O
	Tobaksrök	O	O
	Annat …………………………..	O	O

Bostad-Barn-Hälsa

ID: ____________
Mätning/provtagning

Mätningar

OBSERVERA Formuleringen ”barnets sovrum” avser det rum i bostaden där barnet **oftast** sover.

Arbetsordning (förslag):
1) MVOC-provtagning i barnets rum
2) Momentan T/RF mätning; ute, inne, sängen Placera ut!
3) Sporer 4x2 mätningar
4) Dammprover i vardagsrum
5) Läs av T/RF
6) Dammprover och mätningar i barnets sovrum + säng
7) Pappkasse
8) Pentiaq utrustning
9) Besiktning/validering
10) Information till föräldrarna. (Pentiaq, pappkasse)
11) Foto vardagsrum och fasad samt ev skada eller annat intressant

Utredare (Signatur):

………………………………….

Datum:

………………………………...

Familjens efternamn:

………………………………..

mVOC

Ansvarig: Johan Mattsson
Tel: + 47 22 96 55 00 johan@mycoteam.no
Proverna skickas till:
Mycoteam AS
Postboks 5 Blindern
N-0313 Oslo, Norge.

Aluminiumfolie runt röret efter provtagning
Skickas varje vecka
Förvaring i kylskåp

Mätplats: Barnets sovrum (tex är nattygsbord.)

Pumpning ca: 60 minuter

Kommentar (Ex. växter nära, strul etc):

Provrörsnummer:…………………….

Starttid: ………………………..

Stopptid:…………………………..

Exakt pumpningstid: ………………..minuter
(OBS! Skriv ned tiden på etiketten!)

Kom håg! Nu är det time för att placera ut fuktgivarna! (Vaisala)

Sporer / bakterier

Förvaring i kylskåp
Skickas varje vecka

Proverna skickas till:
Mycoteam AS
Postboks 5 Blindern
N-0313 Oslo, Norge.

1 minut per provtagning. Totalt 8 prover på 4 ställen.
Inplastas noga efter provtagning. Ca 1 meter över golv/mark (helst)

Ca 1 meter över golv.

1a	☐	Ute (svamp)	1b	☐	Ute (bakterier)
2a	☐	Barnets sovrum (svamp)	2b	☐	Barnets sovrum (bakterier)
3a	☐	Kök (svamp)	3b	☐	Kök (bakterier)
4a	☐	Vardagsrum (svamp)	4b	☐	Vardagsrum (bakterier)

Övrig notering

Bostad-Barn-Hälsa

ID: ____________
Mätning/provtagning

DAMMPROVTAGNINGAR VARDAGSRUM

Glukaner / LPS

(Vägt filter)

Ca 100 mg

Ansvarig: Torben Sigsgaard

Färdigt prov förvaras i kylskåp.
Skicka ca 100 prov åt gången

Golv, vardagsrum

(representativ yta för rummet; matta/hårt golv)

Prover skickas till:
Kirsten Östergaard
Institut Miljö & Arbejdsmedicin
Aarhus Universitet
Vennelyst Blvd 6
DK 8000 Aarhus C
Danmark

Övrigt om mätningen eller mätplatsen.

☐ **Hårt golv** ☐ **Matta**

m² **m²**

Mögel / ergosterol

Ca 100 mg

Ansvarig: Torben Sigsgaard /
Lennart Larsson

Färdigt prov förvaras i kylskåp.
Skickas varje vecka, ev varannan

Golv, vardagsrum

(representativ yta för rummet; matta/hårt golv)

Prover skickas till:
Lisbeth Larsen
Teknologisk Institut
Bioteknik
Postboks 141
DK 2639 Taastrup
DANMARK

Övrigt om mätningen eller mätplatsen.

☐ **Hårt golv** ☐ **Matta**

m² **m²**

Allergener, vardagsrum

Ca 100-150 mg

(Färdigt prov fryses. Skicka i två omg)

Matta, vardagsrum

ev soffa om inte matta finns

Ansvarig: AKM Munir, 013-222 000

Mattans/soffans material …………………………………

tips: etikett på mattans baksida

Mattans/soffas ålder ca : ………………………………

(kan stå på etikett)

Mattans storlek ca:………m x ………m = ………..m²

OBS!
Dammsug: 2 minuter per m²

Övrigt om mätningen eller mätplatsen.

☐ **Matta** ☐ **Soffa**

m² **m²**

Bostad-Barn-Hälsa

ID: ____________
Mätning/provtagning

VOC på damm

Ca 20-100 mg

(Förvaras i kylen. Skickas varje vecka)

Ansvarig: Verner Lagesson, Anders Nilsson
Ander: 013-22 45 17

Skickas till:
Anders Nilsson
Avdelningen för Yrkes och Miljömedicin
Institutionen för Hälsa och Miljö
Linköpings universitet
Linköping

Övrigt om mätningen eller mätplatsen.

Ovan golv, vardagsrum

NYTT!

Dammsug ovan golv. Komplettera eventuellt med ett extra filter som dras över ytan med handen. Lägg ev extrafilter i samma filterburk som det dammsugna provet.

Rum (helst vardagsrum)	Provet innehåller damm från följande ytor:
☐ Vardagsrum ☐ Barnets rum	☐ Golvlister ☐ Hyllplan ☐ Dörrfoder ☐ Tavelram etc ☐ …………………… ☐ ……………………

Momentana mätningar RF och T (Kalibrerade värden)

Om flera minusgrader:
Utetemperatur kan även kollas via bilens temperaturgivare eller familjens utomhustermometer.

Var aktsam om att använda Vaisala utomhus vi många minusgrader – risk för kondens.

Övrigt om mätningen

Mätning under bäddmadrass. Om skumgummimadrass, mät då under denna.

(Om ribbor under skumgummimadrass, lägg givaren under en ribba)

Väderleken:	☐ regnar /nyss regnat ☐ snöar ☐ blåser kraftigt
Ute	T: …………..°C (skuggan) RF: …………%
Inne	T: …………...°C Vardagrum RF: …………...% Vardagrum T: …………...°C Barnets rum RF: …………...% Barnets rum
Säng	T: …………...°C Barnets säng RF: …………...% Barnets säng **Tid** för sängmätningar: kl………………….

Bostad-Barn-Hälsa

ID: ____________
Mätning/provtagning

DAMMPROVTAGNINGAR BARNETS SOVRUM

Barnets säng

Är sängen bäddad?
- ☐ ja
- ☐ nej

Vilken typ av sängbotten har barnets sovplats? (under madrassen)
- ☐ ribbotten
- ☐ perforerad skiva
- ☐ tät botten tex plywood
- ☐ annat………………

Vilken typ av madrass har sängen?
- ☐ resårmadrass (”DUX”)
- ☐ skumgummi/latex
- ☐ annat…………………
- ☐ vet inte

Har sängen bäddmadrass?
- ☐ nej
- ☐ ja, en tunn
- ☐ ja, av tjockare typ

Har madrassen någon inneslutning typ kvalsterskydd/ sängvätarskydd?
- ☐ nej
- ☐ ja, kvalsterskydd
- ☐ ja, plastad frotté
- ☐ ja, annat………………

Allergener
Ca 100-150 mg

Barnets säng
ev soffa om inte matta finns

(Färdigt prov fryses. Skicka i två omg)

Ansvarig: AKM Munir, 013-222 000

Dammsug madrassen under lakanet.
(dvs under eventuellt skydd, tex plastad frotté)

OBS! Normalt:
Stor säng: 4 minuter (2 m^2)
Kudde: 1 minut (0,5 m^2)

Dammsug både översida och undersida madrass om sängen är liten!

Madrassens material …………………………
dvs den madrass som dammsugits

Madrassens ålder ca *:* ………………………………
fråga föräldrarna

Sängens storlek ca:………m x ………m

Övrigt om mätningen eller mätplatsen.

☐ **Madrass** ☐ **Kudde**

m^2 **m^2**

ID: ____________
Mätning/provtagning

Glukaner / LPS

(Vägt filter)
Ca 100 mg
Ansvarig: Torben Sigsgaard

Golv, barnets sovrum

(under sängen är bra)

Prover skickas till:

Kirsten Östergaard
Institut Miljö & Arbejdsmedicin
Aarhus Universitet
Vennelyst Blvd 6
DK 8000 Aarhus C, Danmark

Färdigt prov förvaras i kylskåp.
Skicka 100 prov åt gången

Övrigt om mätningen eller mätplatsen.

☐ Hårt golv	☐ Matta
m²	m²

Mjukgörare på damm

(Vägt filter)
Ca 20-100 mg
(Förvaras i kylen. Lämnas varje vecka)

Ansvarig: Bo Lundgren, SP
Lämna till Lars Rosell, SP varje vecka.

Övrigt om mätningen eller mätplatsen.

Ovan golv, barnets sovrum

OK att ta damm även ur syskons eller föräldrars sovrum om golvbeläggning och golvkonstruktion är lika.

Golvmaterial i rummet	=
Om PVC-matta; Ålder:	= år
Rum ☐ Barnets sovrum ☐ Andra rum	Provet innehåller damm från följande ytor: ☐ Golvlister ☐ Hyllplan ☐ Dörrfoder ☐ Tavelram etc ☐ …………………….

”PAPPKASSEMETODEN”

Helle Würst , AMI (DK)
(Pappkartonger)

Vardagsrum (ev sovrum)

tejp, häftstift etc för att säkra att kartongen sitter uppe
OBS! Markera respektive kartong med (1) , (2)

Sätt på avsedda klisterlappar:
- kontaktpersoner
- lämnas till + datum
- att de skall tejpa igen kartongen och lägga den i plastpåse

Placering av pappkartongerna: Vilket rum?	Höjd over golvet (m)	Mått mellan kartong och tak (cm)	Placering (nära fönster eller dörr?)
1) ……………………………………………			
2) ……………………………………………			

☐ Information till familjen om demontering och var de skall lämna kartongerna, hur de skall göra och när!

Ventilation

☐ **Ja** Information till familjen om demontering. Utdelning av frankerade kuvert etc.

OBS! Gå igenom sakta och noga. Visa ordentligt både på ritning och skiss var de olika mätarna och spårgaserna sitter.

Förklara skillnaden mellan mätare och spårgaser om varför man måste posta mätarna dagen före.

Rita gärna upp en grov planskiss. I den bruna lilla papplådan finns lämpligt papper.

Bestäm vilka rum som du skall använda. Mät upp dessa (yta). Lägg in dem. Antingen ”vänstervarv” eller med största rummet först (bugg i programmet).

Programmet talar om hur många spårgaskällor (max 12 st)som skall utplaceras. Placera dem på lämpligt ställe, ej närmast fönstret, ej där solinstrålning sker, ej på oisolerad vägg etc. Mer info om principer för utplacering ger CA.

Spårgaskällorna anpassas med hjälp av tråden som dras ut (m.h.a. vagnen) till angiven längd. Tejpa fast tråden med en klisterremsa som finns med.

I barnrummet placeras två typer av spårgaskällor bredvid varandra. I barnrummet placeras även en RF/T-givare.

Överblivna spårgaskällor läggs i ett särskilt medföljande kuvert och postas vid tillfälle.

Först när spårgaskällorna utplacerats, öppnas aluminiumpåsen med provtagarna (glasrör med kol). Dessa skall sedan placeras ut på lämpliga ställen. Max 5 i genomsnitt per bostad. Uppföljning efter ett antal hus för att se om det går. Principen är att luften som ”färgats” skall passera mätaren.

Utplacering av RF/T och T givare i barnrum respektive vardagsrum (husmitt)

Källare: Om källare inte används som bostadsutrymme räcker det att hänga en spårgasampull (ev helt utdragen) i källartrappen för att märka luft som strömmar upp i bostaden från källaren. Dessa hus kategoriseras i Pentiaq program som hus utan källare.

Kvar hos familjen lämnas

- Brunt kartongkuvert med adress till Pentiaq
- Kuvert för spårgaserna adresserat till TG system i Gävle.
- Nedmonteringsinstruktion med angivet antal spårgaskällor och mätare.
- Diskett med sparad fil från excell-programmet
- Stor plastklämma
- Aluminiumpåsen med ev oöppnad förpackning
- Nåldyna

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