Validation of questionnaire data with inspections on dampness indications in 390 Swedish dwellings—DBH step 2

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ABSTRACT
A questionnaire on e.g. building characteristics including dampness, and allergic symptoms among children from 8 918 homes was carried out in the year 2000. 18-24 months later, 6 professional inspectors visited 390 of the homes and made inspections and measurements. Questionnaire reports on building characteristics, type of ventilation system, and building materials were in good agreement with observations from the inspectors (κ=0.68-0.87). Individual kappa-values for the inspectors varied in the range of 0.33-0.96. However, regarding visible signs of dampness there was a remarkable low agreement between questionnaire reports and observations from the inspectors (κ=0.17-0.20). Also regarding perceptions of moldy odor there was a fairly low agreement (κ=0.21-0.28). This may be due to the time lap between the questionnaire study and the inspections. Questionnaire reports include perceptions for a longer time while observations from inspectors are from only one visit for a couple of hours.

INDEX TERMS
Validation, questionnaire, inspection, dampness, IAQ assessment

INTRODUCTION
Epidemiological studies in the area of dampness in buildings and health effects include subjective questionnaires and objective measurements, both with regard to human health and building characteristics (Bornehag et al. 2001) . In a study where both questionnaires and objective inspections used for 34 homes, visible mold growth was noted by the inspectors in 14 out of 23 houses with questionnaire reported dampness, but only in three out of 13 homes without such questionnaire reports (Andrae et al. 1988). In other studies it has been found that occupants often have not noticed their moisture problems, and that inspectors often disagree in their judgments (Nevalainen et al. 1998). It is discussed whether symptomatic people have a tendency to over report dampness indications. Recall bias and reported bias have been discussed by (Brunekreef et al. 1989), (Brunekreef 1992), (Dales et al. 1997), (Bornehag et al. 2001), (Strachan 1988). Some studies have also validated questionnaire data with dust- and air samples and analysis of viable fungi, ergosterol, (Dales et al. 1997), (Garrett et al. 1998).

This paper focuses on associations between self-reported questionnaire data, and data collected by professional inspectors, regarding e.g. building characteristics, visible signs of dampness, and perceptions of moldy odor. Validation of subjective (questionnaire) data and objective (inspections and measurements) data is of importance as questionnaire studies

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means a cheap way to investigate a large population. The feature of this paper is to validate the questions from the questionnaire from the year 2000 regarding building characteristics, type of ventilation and foundation and also visible indications of dampness and moldy odor with observations from inspections.

METHOD

During October 2001 to April 2002, a case-control study of 400 children (198 cases and 202 referents) was performed in the county of Varmland in Sweden as the second part of the research project “Dampness in Buildings and Health”, DBH. The study cohort is a sub-group from a cross sectional study carried out in the year 2000, n=14 007 children (responsrate 79%) (Bornehag et al. 2002), (Hägerhed et al. 2002).

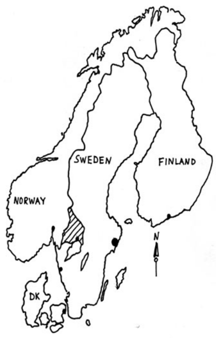

Figure 1.
Map of Sweden and area included in the study

From questionnaire data on allergic and asthmatic symptoms, an invitation to the study was sent out to 2300 families. The invitation included questions about symptoms, renovation and if the family had moved since the last survey, table 1. In the final case-control cohort, there were 10 siblings, which resulted in 390 dwellings and 400 children included in the study population.

Table 1. Case and control criteria

Cases, n=198	Controls, n=202
Questionnaire 2000 At least two symptoms of: • Wheezing last 12 months • Rhinitis last 12 months • Eczema (itching) last 12 months	Questionnaire 2000 No asthmatic or allergic symptoms from the questionnaire 2000
Invitation/questionnaire 2001 • Not moved – the same dwelling as by the questionnaire 2000 • No extensive renovations since the time of the questionnaire 2000 • At least two symptoms (above)	Invitation/questionnaire 2001 • Not moved – the same dwelling as by the questionnaire 2000 • No extensive renovations since the time of the questionnaire 2000 • No asthmatic or allergic symptoms

Between October 2001 and April 2002, ocular inspections and indoor air quality (IAQ) assessments were made in the 390 dwellings parallel to medical examination of the children. Measurements of ventilation rate, relative humidity and temperature, as well as dust- and air samples for analyses of microbiological and chemical agens were carried out. The inspectors were building engineers who in their daily work investigate buildings with moisture problems.

Initially the inspectors simultaneously investigated the dwellings, in order to calibrate sampling techniques, and assessments of dampness and perceived IAQ. During the study period, regular meetings for the inspection team were held, in order to standardize procedures and judgments. One inspector visited two houses per day; each inspection took 3-4 hours where most of the time was spent to collect dust (n=7) and air samples (n=9). The specific time for the ocular inspection on building characteristics, dampness indication and odor assessments was normally about 30 minutes.

In the Nordic Countries, visible mold on the inside wall is very rare, the damage is more often within the constructions, and is not detected without making holes in the constructions. The inspection for indications of dampness was performed without such destructive sampling or measurements. Crawlspaces and attics were not visited, due to time constraints. A moldy smell is often a good proxy for non-visible damages. The investigators used checklists for e.g. building characteristics and signs of moisture and mold damages Visible signs of dampness and assessments of odors were classified in 4 different categories depending on grade of severity, table 2. For example, a damp stain under a window may be due to an accident while watering the plants on the window-sill (grade 1=no effect on the IAQ) while damp stains due to leakage can indicate potential moisture damage behind the wall.

Table 2. Classification of odor and visible signs of dampness regarding to severity

Odor	Visible signs of dampness
0. No remarks	0. No remarks
1. Possible smell, very slight	1. Local indication, not active, no effect on the IAQ
2. A slight odor	2. More spread damage, possible active
3. Strong odor	3. Obvious damage with extensive effect on the IAQ

It is beyond the scope of this paper to present all the variables studied during the inspection. All variables in the checklist had preprinted questions and answering alternatives. Data is presented here for indexes of single observations from the inspections and from the questionnaires.

Six professional inspectors conducted the work. The database from the inspections was slightly adjusted for one inspector who used the odor scale wrongly.

Data analysis

The correlation between building characteristics, dampness indications and perception of moldy odor between the resident's questionnaire response, and the inspectors reports were measured with their kappa-status calculated in SPSS.

Kappa is often used as a measure of agreement between two binary variables that measure the same thing. Kappa measures the percentage of data values in the main diagonal of the 2x2 table and then adjusts these values for the amount of agreement. Kappa is always less than or equal to 1. A value of 1 implies perfect agreement. In rare situations, Kappa can be negative. This is a sign that the two observers agreed less than would be expected just by chance. It is rare with perfect agreement. Practical Statistics for Medical Research (1991) England by Chapman and Hall give suggestions how to interpret the score of kappa:

- Poor agreement = Less than 0.20
- Fair agreement = 0.20 to 0.40
- Moderate agreement = 0.40 to 0.60
- Good agreement = 0.60 to 0.80
- Very good agreement = 0.80 to 1.00

RESULTS

There was a good correlation between self-reported data on technical parameters in the dwelling and data from inspections. However, the correlations regarding moldy odor and visible dampness were lower. There was a considerable difference in judgments made by different inspectors. The kappa-value was high for some investigators regarding visible dampness; other inspectors had higher kappa-score for the perception of moldy odor. The correlation between self reported and inspected building characteristics had kappa-scores between 0.76-0.94, table 3 There was a similar distribution of different dwellings and buildings characteristics between the six inspectors.

Indexes from questionnaire responses were constructed for both perceptions of moldy odor, and reporting of visible signs of dampness. The "moldy odor- index" embraces perceptions of moldy or earthy odor indoors or in the basement "sometimes or often (every week)". A corresponding index from inspector reports was constructed regarding "any notice of moldy odor" in any vital room indoor, in the basement or along walls. For visible signs of dampness, a number or questions from the questionnaire, and from the inspection checklist respectively, were combined for the following signs of dampness; visible mold, damp stains, detached floor covering (as bubbly, discolored or loosening PVC-flooring) or blackened parquet. Moisture damages or bad odor in bathroom was not included in the analyses.

Table 3: Kappa-scores for technical data and individual kappa-scores for inspectors A-F.

	All inspec.	A	B	C	D	E	F
Inspected dwellings n=	390	70	78	75	52	24	90
<u>Type of dwelling</u> Single family house (SH) row house (RH) or multi family house (MH)	κ=0.87	κ=0.78	κ=0.81	κ=0.89	κ=0.83	κ=0.88	κ=0.92
<u>Surroundings</u> Urban, sub-urban or country-side	κ=0.68	κ=0.79	κ=0.81	κ=0.77	κ=0.59	κ=0.72	κ=0.55
<u>Type of ventilation</u> Natural, exhaust or supply and exhaust ventilation	κ=0.68	κ=0.80	κ=0.70	κ=0.76	κ=0.64	κ=0.33	κ=0.81
<u>Type of foundation*</u> Concrete slab on the ground, crawlspace or basement.	κ=0.85	κ=0.80	κ=0.96	κ=0.79	κ=0.79	κ=0.66	κ=0.93

* Single family houses and row houses

Table 4. Visible signs of dampness. Kappa scores for total population, type of dwelling and for individual inspectors A-F.

Visible mold, damp stains, detached floor covering (as bubbly, discolored or loosening PVC-flooring) or blackened parquet (not bathroom). Questionnaire data vs. inspection data.												
	Total population n= 390 homes			Type of house*			Kappa scores for different inspectors					
	n	%	κ	SH	RH	MH	A	B	C	D	E	F
Inspection 2001/2002 Severity grading 2-3	87	22.3	**0.17** **	**0.21** ***	0.01	-	-	**0.32** **	**0.40** ***	0.03	0.18	0.05
Inspection 2001/2002 Severity grading 1-2-3	143	36.7	**0.20** ***	**0.21** ***	0.05	0.02	0.18	**0.20** *	**0.42** **	0.02	0.31	0.10

Table 5. Perception of moldy odor. Kappa scores for total population, type of dwelling and for individual inspectors.

Perception of moldy or earthy odor indoors or in potential basement. Questionnaire data vs. inspection data

	Total population n= 390 homes			Type of house*			Kappa scores for different inspectors					
	n	%	κ	SH	RH	MH	A	B	C	D	E	F
Inspection 2001/2002 Severity grading 3	75	19.2	**0.21** ***	**0.25** ***	**0.44** *	**0.20** *	**0.39** **	0.14	0.13	**0.33** *	-	0.15
Inspection 2001/2002 Severity grading 2-3	83	21.3	**0.27** ***	**0.22** ***	0.33	**0.28** **	**0.36** **	**0.23** *	0.13	**0.33** *	-	0.10

DISCUSSION

The time between the inspections and the questionnaire was between 1,5 to 2 years. According to the criteria for inclusion in the study, no major renovation had been made in the homes. However, minor changes may have been made, and damp stains or spots of mold could have been hidden behind e.g. furniture. This could be one, but not the only factor that can explain the low correlation regarding visible signs of dampness between questionnaire reports and reports from inspections. Professional inspectors have knowledge of risk structures and common localities for dampness, and besides this also a trained nose for the smells that are related to moisture damaged building materials. Questionnaire reports include, in general, perceptions for a longer time while observations from inspectors came from only one visit for a couple of hours.

Few studies in this field, to our knowledge, have studied the validity of self-reported questionnaire reports and inspected dampness indications. Nevalainen et. al. 1988 conclude that the higher prevalence of dampness indications reported by inspector's was the results of a "trained eye" and knowledge about critical problem spots. In Australia, 80 households were inspected and visible mould growth on indoor surfaces was found in every house, at some time during the time of the study, but only 23 % of the residents considered their house to be damp (Garrett et al. 1998). A case control study in Britain, 102 cases and 196 controls, with both inspections and questionnaires found an agreement between self-reported dampness and the inspector's findings in 139 out of 328 homes (Williamson et al. 1997).

Dales et. al. 1997 studied correlation between self-reported dampness and measurements of viable fungi and ergosterol. They found higher levels of fungi in living areas when the occupants reported mold, damp spots, and water damage. Inspectors did not validate the questionnaire data about dampness.

CONCLUSIONS AND IMPLICATIONS

Data from questionnaires and inspections have a good agreement for simple technical parameters. Perception of moldy odor and detection of visible signs of dampness showed on the other hand a low correlation between the self-reported questionnaire and the inspections by professional investigators. Future studies should focus more on calibrating inspectors, and use teams of two persons per inspection to minimize these biases. Analyses of subjectively collected data from different inspectors should in one way or another be controlled for the divergence.

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