Fraunhofer-Institut für Bauphysik IBP

Forschung, Entwicklung,
Demonstration und Beratung auf
den Gebieten der Bauphysik

Zulassung neuer Baustoffe,
Bauteile und Bauarten

Bauaufsichtlich anerkannte Stelle für
Prüfung, Überwachung und Zertifizierung

Institutsleiter
Prof. Dr. Philip Leistner
Prof. Dr. Klaus Peter Sedlbauer

Study Report

Towards an identification of European indoor environments' impact on health and performance

- Mould and Dampness -

Gunnar Grün
Susanne Urlaub

Holzkirchen, Stuttgart, 10. November 2016

Fraunhofer-Institut für Bauphysik IBP
Nobelstraße 12 | 70569 Stuttgart
Telefon +49 711 970-00
Telefax +49 711 970-3395
www.ibp.fraunhofer.de

Standort Holzkirchen
Fraunhoferstr. 10 | 83626 Valley
Telefon +49 8024 643-0
Telefax +49 8024 643-366

Standort Kassel
Gottschalkstr. 28a | 34127 Kassel
Telefon +49 561 804-1870
Telefax +49 561 804-3187

Introduction

This report aims at showing the impact of mould and dampness on the health of inhabitants. To achieve a magnitude about the effect of mould in homes on respiratory diseases, a meta-analytic synthesis has been performed. In a further step, a projection about the potential of modernizing the building stock and reducing mould sources on lowering the impact on the inhabitant's health has been made. Finally measures for improvement through renovation are outlined, which can lead to a higher quality of the indoor environment and thus improve the inhabitant's health.

The occurrence of dampness is one of the major defects in dwellings across Europe, which is typically a result of defective building structures and adverse occupant behaviour, e.g. by insufficient ventilation. As a consequence dampness is likely to lead to mould growth and other associated structural damages. Moulds are species of fungi and require mainly four prerequisites to grow: a substrate containing sufficient nutrient matter, a suitable surface temperature, sufficient moisture and of course enough time to grow under these circumstances. Amongst the parameters for mould growth the relative humidity indoors is the critical one which can be controlled for effective prevention. However, if the occupant misses to sufficiently remove the moisture produced indoors (e.g. by ventilation) or the building has a defective envelope causing wet walls or insufficient insulation (incl. thermal bridges), conditions supporting mould growth are likely to occur and mould will become visible sooner or later.

There is evidence that the occurrence of mould and dampness is associated with respiratory or allergic health effects. Amongst others it promotes the development of asthma and upper respiratory tract symptoms. For example the overall risk for developing asthma is reported as being approximately 50% higher as if no mould or dampness is detectable in a home [1]. Respiratory tract illnesses are forming one of the major shares of direct health service costs: e.g. in Germany these are around 5 %, which amounts to ca. 13.2 billion Euros per annum (data of 2008) [2]; and asthma costs for the European economy have been estimated at 19.5 billion Euros each year (data of 2011) [3].

This study concentrates on the link between moulds indoors and associated health effects in order to identify the risk of suffering from respiratory illnesses because of living in damp or wet dwellings. The investigation finally yields a number of 2.2 million Europeans, that have asthma because they live in damp and mouldy dwellings. As a consequence much more attention should be drawn to a high quality of the indoor environment and building fabric. The careful installation of building structures, especially while performing energetic modernisations, becomes more and more important, as buildings become more air tight with the constant efforts to improve energy efficiency. This finally also leads to higher importance of the occupant behaviour with respect to the removal of internal moisture production through ventilation and emphasizes the necessity to develop sufficient demand related ventilation concepts (natural, automated and/or mechanical) for dwellings.

Status quo

Population in wet dwellings

The share of population living in wet or damp dwellings ranges from 5% to over 30% in the different European countries, on average around 16% of the population was affected in recent years [4]. Projected onto the total population statistics (January 1st, 2013 [4]) of the European Union plus Iceland, Norway and Switzerland this affects an overall number of about 84 million people.

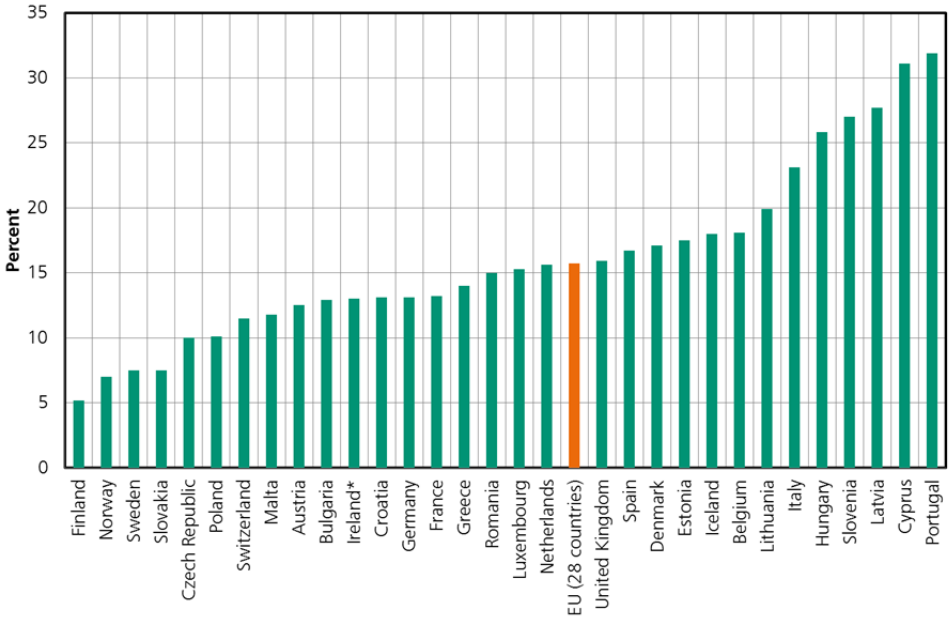

Figure 1:
Share of total population in European countries living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor – data of 2013, 2012 for Ireland [4].

Population suffering from respiratory illnesses

Respiratory diseases are of huge concern worldwide, as to a substantial portion they cause disability and premature deaths. Given this fact there are huge efforts to gain knowledge on the prevalence of such diseases. For the case of clinical asthma the most extensive investigation has been performed with the WHO world health survey [5], which has been analysed also in [6]. The available prevalence rates have been pooled onto the region considered in this study using sampling weights [7]. Using this method the prevalence rate of having asthma in the considered European countries can be estimated at being 7% (approx. 36.3 million people). This proportion has been taken as total prevalence rate for dwellings, regardless of whether they are damp and wet or not.

Besides the affliction they cause to patients, there are huge societal and personal cost to be associated with them, e.g. primary and hospital care, treatments or loss of productivity. About 7 % of all hospital admissions in Europe are caused by respiratory illnesses [3], across European countries on average 7.6 % of those are in-patients due to asthma, 18.8 % due to chronic obstruc-

tive pulmonary disease (COPD), 23.5 % due to acute upper and 50.1 % due to acute lower respiratory diseases. The largest amount of costs due to respiratory illnesses in Europe has been identified due to COPD and asthma [3]: While the inpatient costs related to COPD and asthma in Europe could be estimated at an annual amount of 7.3 and 4.8 billion Euros (data of 2011), the overall direct costs (drug, outpatient and inpatient costs) are at 23.3 and 19.5 billion Euros.

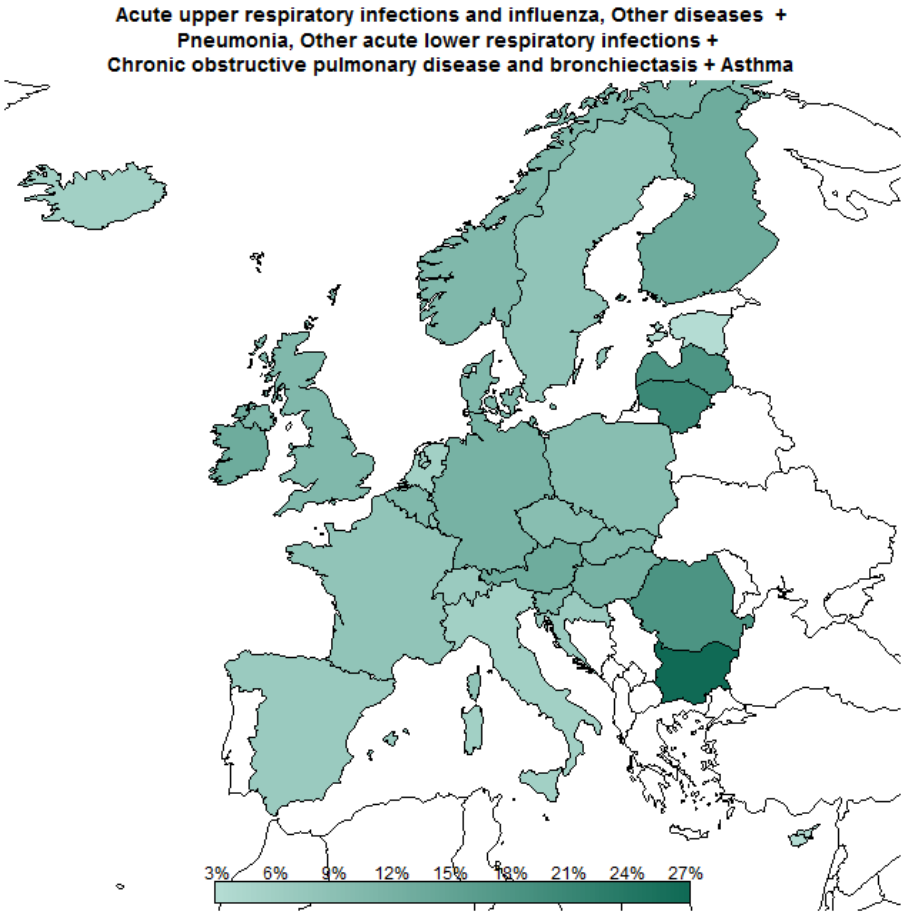

Figure 2:
In-Patients because of respiratory illnesses per 1000 populations [8].
ISHMT = International Shortlist for Hospital Morbidity Tabulation.

In summary we know, that mould growth is very dependent on the indoor climate available in dwellings [9]. Basically with ca. 16% a large quantity of Europe's population lives in wet or damp dwellings [4]. At the same time there is evidence, that mould is associated with respiratory tract symptoms [1] and a large quantity of the population is affected by respiratory tract illnesses [3]. Still, the question is to be answered: what percentage of the population is afflicted with respiratory illnesses because they live in damp or wet dwellings?

Study Results

Within this study a huge amount of scientific peer-reviewed literature was reviewed, using over 200 publications dated from 1986 to 2015 [7]. Again it can be confirmed that there is a relation between respiratory tract infections and damp and mouldy indoor environments. However, regarding this association there is still uncertainty, how many people are suffering respiratory tract infections because they live in damp or wet dwellings. With the chosen approach of a meta-study this investigation used the odds ratios calculated from the literature in order to derive an indication of a magnitude for this number.

Literature Research

A meta-study uses statistical methods to combine results from different studies in order to identify patterns among those study results. For small odds ratios (smaller than 0.1) they are approximately equal to the so called risk ratios, which quantify how strongly the presence or absence of one property (e.g. mould) is associated with the presence or absence of another property (e.g. asthma) in a given population. Given the number of people suffering from respiratory infections (like asthma), which are not living in a damp or wet dwelling from the literature review, the number of people that are impaired in this respect because they live in wet or damp dwellings can be estimated.

The studies which were used to evaluate the influence of mould and dampness on health are observational in their character, experimental studies like clinical trials were not used in this context. In total, the literature search identified 172 scientific studies, of these 99 were conducted as a cross-sectional design, 31 were case control studies and 40 were cohort studies [7]. Not all of them were eligible for meta-analysis for different reasons.

To evaluate mould or dampness in buildings by questionnaires, different indicators have been identified: visible mould spots, dampness, mould or dampness, mouldy odour, water leakage/damage, condensation, moisture.
For the health outcomes asthma, wheeze, cough, rhinitis, bronchitis, allergic rhinitis, nasal symptoms, eye symptoms, throat symptoms, skin symptoms and common cold, enough studies were available. This study focused on the influence of mould and dampness and their different indicators; additional phenomena that may be caused by or aggravate the influence of mould and dampness (e.g. house dust mites) have been excluded.

Outcomes

The trends identified by the analysis with respect to mould and health indicators all point in the same direction: all of the odds ratios of different respiratory tract illnesses are above 1, mostly around 1.5.

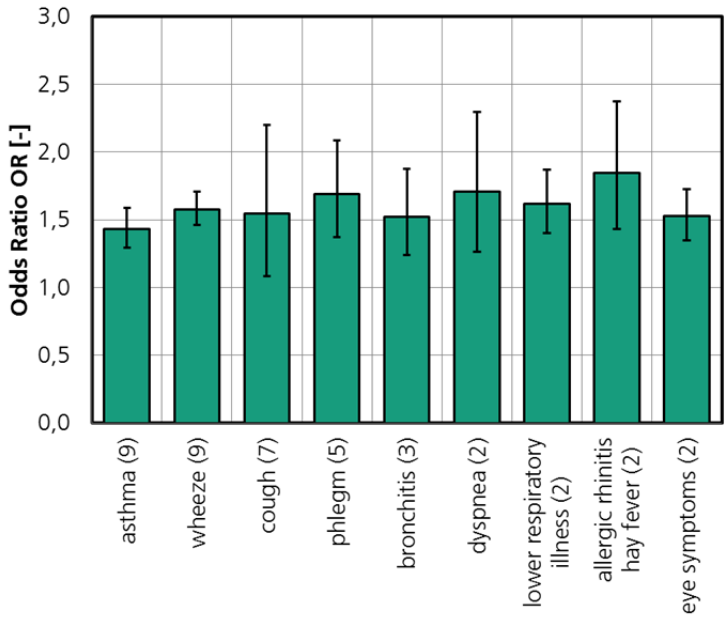

Figure 3:
Relationship between the prevalence of the different health outcomes in cross-sectional studies when the indicator "mould or dampness" is present.

In the case of asthma the odds ratio of having asthma in a damp and mouldy dwelling is significant and data of cross-sectional studies yields a value of 1.4 - i.e. it is 40 % more likely to have asthma when living in a damp and mouldy dwelling compared to dwellings that are not damp and mouldy.

Projection on Population

Together with the figures outlined above, that 16.1 % of the European population live in wet or damp dwellings (approx. 83.5 million people), 7% is the prevalence rate of having asthma in Europe and the risk ratio of having asthma in a damp or mouldy dwelling is 1.4 (cross sectional data) the fraction of the population, who lives in damp or mouldy dwellings and has asthma can be solved. This yields approximately 7.7 Million people who do live in a damp or mouldy dwelling and have asthma, which is a prevalence rate of 9.2% of the population living in damp or mouldy dwellings. As the fraction of the population not living in damp or mouldy dwellings is 6.6%, there are 2.6 % more people having asthma in damp or mouldy dwellings than if they would not live in such dwellings. Thus it can be concluded, that this share of a higher prevalence of having asthma is due to the circumstance of living in damp or mouldy dwellings. Related to the absolute number of people, there are thus approximately 2.2 million people across Europe having asthma because of living in damp or mouldy dwellings.

Impact and Improvements

Respiratory illnesses are to a significant amount related to the indoor environment - which is in turn determined by the available building fabric. Therefore much focus should be laid on the adequate modernisation of the building stock including improving ventilation.

Trend analysis on modernisation of wet or damp dwellings

With the societal challenge to encounter climate change there are various ambitions to accelerate the modernisation of the existing buildings, which contributes significantly to energy consumption. With the objective to reach carbon neutral building stock until 2050 e.g. the German federal government has set out the aim to achieve a modernisation rate of approximately 2% [10]. Based on this figure a trend analysis has been performed considering the situation of an average share of population living in wet or damp dwellings of ca. 16% [4]. Different scenarios have been elaborated assuming that this number remains stable for non-modernised buildings and that modernised buildings are in a better condition after retrofit than they were before, i.e. that afterward there would be a smaller share of population living in wet or damp dwellings.

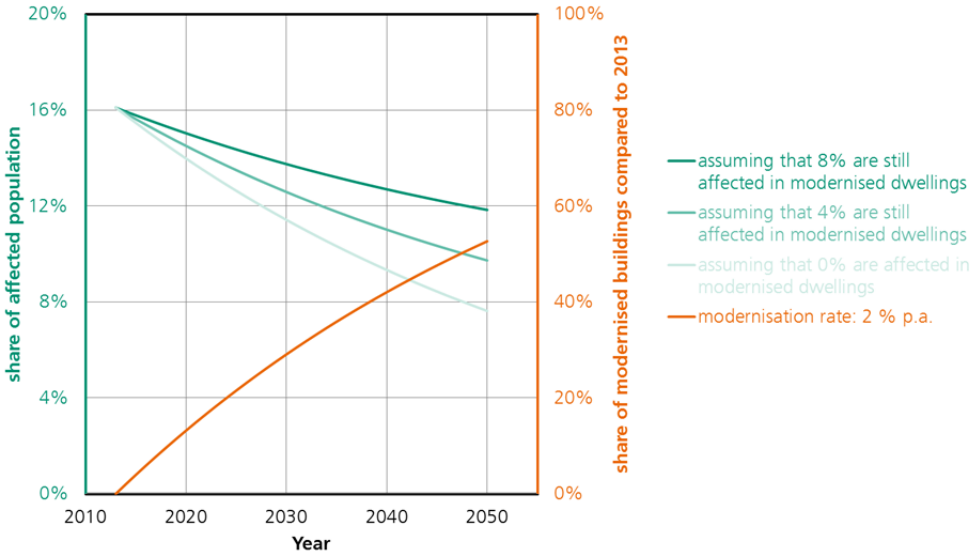

Figure 4:
Projection of the share of the population affected by wet or damp dwellings with a modernisation rate of 2% p.a. and different qualitative levels of modernised dwellings.

Thus if we would achieve an improved building stock, which halves the number of affected people due to damp and wet dwellings from approximately 16% to 8%, with a modernisation rate of 2% p.a. the adverse living conditions of wet or damp dwellings and the share of affected population would reduce by approximately 25% until 2050. Consequently the associated respiratory illnesses can be expected to reduce accordingly, accompanied by a decrease in the related public health costs. In the case of asthma this reduction by 25% would mean a reduction of approximately 550.000 affected persons in 2050, when using the same projections as described above (assuming, that prevalence rates do not change over time and risk factors are independent).

Measures for improvement

Consequently the defect-free modernisation of dwellings is key – not only to the owners personal economic benefit but also to their health and the socio-economic aftereffects. Still: Mould related damage in buildings is frequent, e.g. in Germany nearly 10% of all building damage is mould related. The figure improves only slightly for modernised buildings (modernised after 1995). In these buildings around 35% of damage occurs due to insufficient thermal insulation, 33% due to insufficient ventilation, 22% due to defective installations and 10% due to problems in sanitary areas [11].

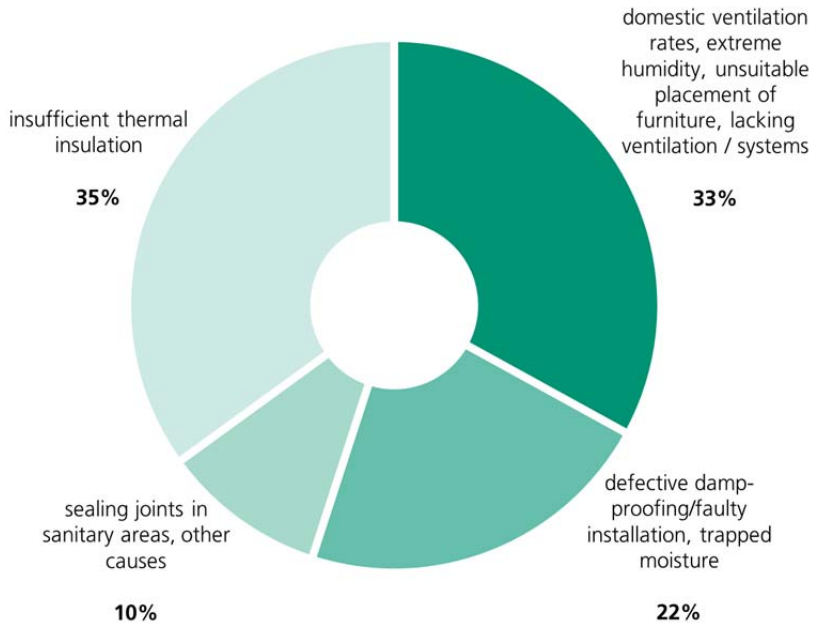

Figure 5:
Causes of mould-related damage in highly insulated buildings (from [11]).

Mostly the repair of moisture related damages can be performed promptly, however their success should be assessed thoroughly. In general moisture tolerant constructions should be preferred, that have a high drying potential in order to avoid moisture accumulation and finally damage. Typical areas of improvements of the building fabric with respect to mould and dampness are:

- Avoiding leakages in roofs and installation faults of windows
- Avoiding moisture penetration: horizontally due to driving rain, vertically from building components in contact with ground and in chimneys
- Avoiding installation faults of sanitary facilities and plumbing damages
- Avoiding improper installation of insulation (esp. interior insulation)
- Reduction of constructive and geometrical thermal bridges, especially in combination with minor insulation and/or modernisation of windows
- Reduction of building moisture during construction
- Developing sufficient demand related ventilation concepts (natural, automated and/or mechanical) to enable adequate air exchange
- Particularly ensure sufficient air exchanges after modernisation, which lead to improved air tightness
- Modernisation of insufficient heating systems

Parallel to addressing these improvements of the building fabric a proper quality assurance during planning and construction as well as the proper and timely conduction of maintenance is required. Such procedures have already been implemented for selected measures and should be further elaborated (e.g. [12]) – especially in view of future regulatory frameworks, such as the Energy Performance of Buildings Directive. Consequently renovation measures should be designed and realised in a high qualitative manner as to prevent damages due to mould and dampness and to achieve a healthy living environment.

References

[1] Mendell, M.J., Mirer, A.G., Cheung, K., Tong, M., Douwes, J.: Respiratory and allergic health effects of dampness, mold and dampness-related agents: a review of the epidemiologic evidence. Environmental Health Perspectives, 119 (2011), p. 748-756.

[2] Statistisches Bundesamt: Gesundheit – Krankheitskosten – 2002, 2004, 2006 und 2008. Fachserie 12, Reihe 7.2, Wiesbaden, 2010.

[3] European Respiratory Society: European Lung White Book, accessed at: http://www.erswhitebook.org, 2.4.2016.

[4] Eurostat: EU Statistics on Income and Living Conditions, 2009-2013.

[5] WHO: World health survey, accessed at: http://www.who.int/healthinfo/survey/en/, 3.10.2016.

[6] To, T., Stanojevic, S., Moores, G., Gershon, A.S., Bateman, E.D., Cruz, A.A., Boulet, L.-P.: Global asthma prevalence in adults: findings from the cross-sectional world health survey. In: BMC Public Health 2012, 12: 204.

[7] Urlaub S, Grün G: Mould and dampness in European homes and their impact on health. IBP-Report EER-058/2016/950.

[8] WHO: European Hospital Morbidity Database (HMDB), accessed at: http://data.euro.who.int/hmdb/, 2.4.2016, Last updated: January 2015.

[9] Sedlbauer, K.: Vorhersage von Schimmelpilzbildung auf und in Bauteilen. Dissertation, University of Stuttgart, 2001.

[10] BMWi, BMU: Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung, 28.9.2010.

[11] Oswald, R., Liebert, G., Spilker, R.: Schimmelpilzbefall bei hochwärmegedämmten Neu- und Altbauten. Bauforschung für die Praxis, Band 84. Fraunhofer IRB Verlag, Stuttgart, 2008.

[12] QualiCheck: Towards better quality and compliance, accessed at: http://qualicheck-platform.eu/, 3.10.2016.

Acknowledgement

The authors express their gratitude to the graduate program "People Inside" at the Chair of Building Physics, University Stuttgart, Germany and Velux A/S, Denmark for a fruitful cooperation and support of this study. This work is benefitting from the research project Building I conducted at the Energy Campus Nuremberg, funded by the Bavarian State Government. The authors are responsible for the content of this publication.