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White Paper

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

- homes and schools -

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Introduction

Today most of us live indoors a large portion of our lives - as a good estimate it is around 90%, which we try to shape as comfortable as possible. Thus the indoor environment is a crucial factor for our future development towards a healthy society reaching from childhood to the oldest old.

As we try to shape our indoor environment as comfortable as possible we are using resources – mostly energy: for heating, ventilating, cooling, lighting. In the recent years against the background of climate change and energy savings the focus of research and building regulations has been laid primarily on energy efficiency. This has eclipsed the main purpose of indoor environments. A healthy environment contributes much to our societal development: the way we live, learn, work and relax; with all the consequent socio-economic effects on our education, health care and productive working life.

This paper pinpoints key findings from a large literature screening of research on the European indoor environments' impact on health and performance in homes and schools. The aim is to analyse the relations of indoor environmental effects in homes and schools to health and performance aspects. This serves as basis for a detailed study of the socio-economic impact of the indoor environment as the next step.

Indoor climate in European homes and schools

With the variety of occupants and the many different types of dwellings also the indoor climate in European homes covers a wide range. One of the major problems in dwellings in Europe is the occurrence of dampness, which is likely to lead to mould growth and other associated structural damages. The share of population living in such dwellings differs quite between European countries, on average 15-16% of the population was affected in recent years [1]. Projected onto the total population statistics (January 1st, 2012 [1]) of the European Union plus Iceland, Norway and Switzerland this affects an overall number of about 77,6 million people.

There is evidence that the occurrence of mould and dampness is associated with several 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 approximately twice as high as if no mould or dampness is detectable in a home [3].

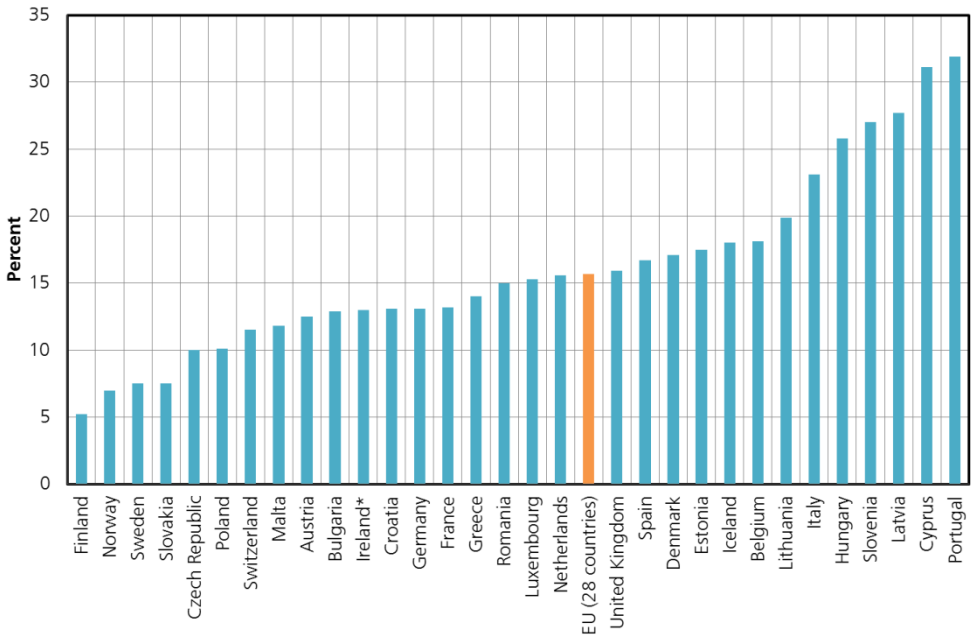

Figure 1: Share of total population in European countries living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor – data of 2013, 2012 for Ireland [1].

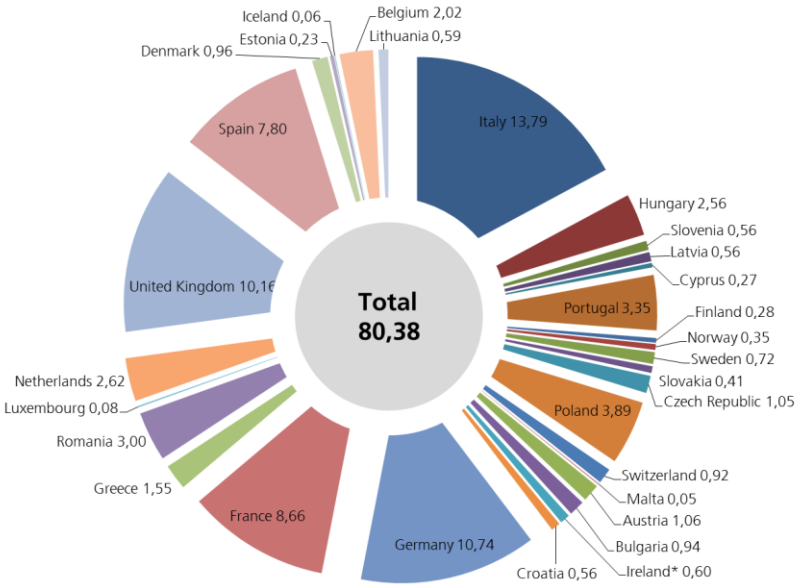

Figure 2: Total population (in millions) in European countries living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor – data of 2013, 2012 for Ireland, population statistics for January 1st [1].

Closely related to the humidity inside homes, but also to the energy consumption required to maintain a comfortable and healthy indoor environment is the ventilation rate. Frequently used in National standards in European countries are values between 0.35 and 0.5 air changes per hour. The Nordic countries are reported to be below their target value in ca. 40-60% of the dwellings [4].

Low ventilation rates in buildings are associated with an increased risk for respiratory infections, especially when mould is additionally detected inside the buildings. No explicit relation of the type of ventilation system (mechanical or natural ventilation) to maintaining or increasing the health status of occupants could be identified. The ventilation rate itself can have a significant effect on health symptoms, e.g. at low ventilation rates the risk for symptoms like wheezing and dry cough is approximately twice as high as with recommended ventilation rates [5]. Low ventilation rates are also associated with an approximate one and a half times higher risk for developing allergy symptoms [3].

The indoor environment in schools is typically dominated by poor ventilation rates, while 8 l/s per person is the recommended standard. Lower ventilation rates are reported frequently, e.g. the study in [6] found 87% of the investigated classrooms being below this standard. As classrooms are densely occupied spaces high CO_2-levels can be reached quite quickly with insufficient ventilation – reported values are frequently higher than 2100 ppm and up to 4000 ppm, which are beyond typically recommended values of around 1500 ppm. Every increase of ventilation by 1 l/s per person leads to a considerable increase in perceived air quality and mental performance of pupils [6]. Beyond that [8] reports that performance increases of up to 14.8% are possible depending on task. Moreover, poor air quality is not only associated with reduced performance but also with an increasing absence rate [9]. Both consequences are adverse conditions for a good academic achievement of pupils.

Daylight has a fundamental influence on human physiology and behaviour. As it influences our hormone and vitamin balance and determines the circadian rhythm including our sleep/wake-cycles, it is recommended to experience sunlight for a dedicated time of the day [10]. Additionally, it is known that low levels of daylight illumination may have negative effects on mental health and it seems that higher levels of daylight could shorten the stay in hospitals due to its influence on healing [11].

A good sleep is known to be important for good health and a good next-day performance, so the indoor environment in bedrooms should not hinder restitution during sleep. Ambient room temperature is associated with the sleep quality of occupants. Increased room temperatures decrease the duration of slow wave sleep (important for physical restoring) by ca. 15% per a 5°C increase. Analogous the REM sleep phases (relevant for mental relaxation) are reduced and wakefulness increases [12]. The situation in cold environments shows similar effects.

High temperatures due to overheating during heat waves have been found to be associated with an increase in mortality and affect especially those at poor health. If the apparent temperature during a heat wave rises 5°C above a regional threshold it can be estimated that between 9% and 15% of natural mortality can be linked to these untypically high apparent temperatures [13]. Especially the incidence of respiratory diseases is linked to heat waves and people suffering of them have a higher risk of mortality.

Conclusion

The results of this first screening of reviewed scientific literature show that the indoor environments in European homes and schools have a significant impact on public health and learning, and that the indoor environmental conditions of the current European housing building stock has substantial shortcomings. This calls for further action to improve the indoor climate where people live and learn, and it should also be reflected in National building codes.

Methodology

The literature screening for this white paper used a search of scientific, technical and medical databases, specific peer-reviewed journals as well as independent scientific reviews. This screening lead to the following number of studies of which only those matching predefined quality criteria, such as statistical information, complete description of study design etc., were included (number given in brackets): mould and dampness: 438 (174), ventilation: 90 (55), daylight: 55 (8), sleep quality: 41 (26), overheating: 30(23).

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