Key factors to have a good sleep quality in bedrooms

Factori cheie pentru a avea o calitate bună a somnului în dormitoare

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Abstract. *The indoor air quality in bedrooms is one of the main factors that influence the human performance during these days. Throughout the years, a lot of studies described the relation between the climate comfort and the performance. This study presents the important factors to have a quality sleep with the main effect being daily productivity*

Key words: thermal comfort, productivity, performance, environmental quality, indoor air quality (IAQ)

1. Introduction

An important aspect that could help better inform designers and home builders is understanding sleep quality and our physical sleep environment. The houses should be designed and built that provide an adequate (comfortable) indoor environment for all rooms, but especially for the bedroom, which can be adjusted by the bedroom(s) to suit individual preferences and a lot of people spend up to 87% of their time in indoor environments, be it in residential, academic, or commercial buildings, and another 6% in their vehicles, and thus are continually being exposed to the indoor environment [1]. According to Wong et al. (2007) [2], the acceptance of an environment by its occupants depends on environmental parameters, namely thermal comfort, indoor air quality (IAQ), sound and visual comfort, which are identified to determine indoor environmental quality. In many studies it has been proven that poor IEQ may cause diseases, negatively affecting the workers well-being and reduce its productivity [3]. Many studies held in the last decades have reported the connection between thermal environment and the performance of its occupants [4]. The thermal environment may vary and may affect the performance of workers, affecting their productivity. Sleep is an important factor that affects a person's health and performance. The quality of sleep is very important to perform well at work but also in other daily situations. A good sleep improves our performance, health, and mood.

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2. Content of the paper

A large part of the time we spend indoors is related to relates to the sleeping environment. Sleep is an important factor that affects people performance and health. A good night's sleep is commonly accepted as a significant factor in allowing adequate daytime functioning such as concentration and alertness. The quality of sleep is very important to perform well at work. today there is no clear definition of sleep quality. To understand the significance of sleeping well, a distinction must be made between sleep duration and sleep quality. These two aspects of sleep are uncorrelated and may have different effects on daily functioning. In simpler terms, it means that having longer sleeping duration does not necessarily indicate that sleep quality is good. Similarly, if a person has poor sleep quality, it does not imply that his sleep duration is short [5]. Someone can have short sleep duration with high sleep quality at the same time. In the studies carried out so far, sleep duration is defined as the sleep period from going to bed to waking up in the morning. We can also define it as "time in bed". As for the quality of sleep, the literature frequently cites criteria such as early onset, fewer interruptions, and fewer early awakenings. In other words, sleep quality is correlated with measures of sleep continuity but not with the content (stages) of sleep. As for the quality of sleep, the literature frequently cites criteria such as early onset, fewer interruptions, and fewer early awakenings. In other words, sleep quality is correlated with measures of sleep continuity but not with the content (stages) of sleep. [6] There have been identified a variety of sources that affect sleep quality that include psychological and environmental factors. Psychological factors, often referring to mental health problems, include Autism Spectrum Disorder (ASD), depression, anxiety, ADHD and panic attacks [7]. Life events such as work stress, relationship problems and financial worries can lead to negative thoughts and excessive anxiety, causing one to have difficulty falling asleep. Environmental factors include noise, unfamiliar environments, uncomfortable beds, and pillows, high or low temperatures, bright lights, and nursing at night [8].

The categories of comfort in terms of sleep quality related to the level of expectations the occupants may have been presented in Table 1. A higher level may be selected for occupants with special needs (children, elderly, handicapped, etc.). A lower level will not provide any health risk but may decrease comfort. An optimal level expectation is considered to be IEQIII, representative for an "medium" level of expectation, with heating season temperature with values between 20.0 - 24.0 °C and cooling season temperature with values between 23.0 – 26.0°C. Conform ISO 17772-1 and pr EN 16798-1 minimum total ventilation rate for health is 4 l/s person. This will work for establishing design values for dimensioning of heating and cooling systems by using the lower value in heating season for the heating system and the upper value in cooling season for the cooling system.

Table 1

Categories of optimal comfort in terms of sleep quality related to the level of occupant's expectations

Category	Level of expectation	Heating season (1.0 clo)°C	Cooling season (0.5 clo)°C	Low polluting building l/(s m2)	Minimum total ventilation rate for health l/s person
IEQI	High	21.0 - 23.0	23.5 - 25.5	1,0	4
IEQII	Medium	20.0 - 24.0	23.0 - 26.0	0,7	4
IEQIII	Moderate	19.0 - 25.0	22.0 - 27.0	0,4	4
IEQIV	Low	17.0 - 25.0	21.0 - 28.0	0,3	4

Natural home ventilation uses all the gaps and cracks in the home, along with windows and other passive openings, such as the spaces under doors or those between doors and frames, to allow air to move uncontrollably into the home. These are found in older houses, being most of the time sufficient to dilute the atmospheric pollutants in the rooms and maintain the environment suitable for sleeping. The main advantage of this type of ventilation is the low cost and the fact that they are already present in most homes right from the design stage. However, the disadvantages are many, starting with the fact that this ventilation is uncontrolled, and the ventilation is not uniform. When it comes to room temperature control the system can become particularly expensive. Moreover, the system is not enough to remove pollutants from the air. There is a significant difference between naturally ventilated bedroom and the case when the ventilation is not realized in the room. A comparation between these two cases are presented in the Table 2 below, to see the difference between these two options and which one is more reliable. The option in which a room is naturally ventilated shows a qualitative improvement of the air in the bedroom.

Table 2

A comparation between a naturally ventilated bedroom and without ventilation case

CO_2 level	**Measured outside (ppm)**	**Measured inside**	
Evening		Naturally ventilated (ppm)	Without ventilation (ppm)
	400	530	750
Morning	380	1230	1850

Mechanical ventilation uses equipment such as fans, air conditioners, hoods and ventilation systems installed throughout the building to move air around the home. Since a large part of new homes, designed on the principles of energy efficiency, are built airtight to ensure energy savings, the need arises to install mechanical ventilation systems. Mechanical ventilation systems ensure uniform ventilation of the entire home, while the air is purified by filters. Also, a very big advantage is that you can opt for integrated systems at the level of the entire house or for the ventilation of a single room. Moreover, mechanical equipment can be integrated into heating and cooling systems, such as air conditioning units. The main disadvantage of these equipment is

their relatively large volume and significant energy consumption, being more expensive than natural ventilation. Another aspect that many people forget to take into account is the air conditioner, because over time a thick layer of dust and dirt is deposited on the internal components of the air conditioner, a very favorable environment for the development of bacteria, fungi and molds. With increasing living standards and expectations for better thermal comfort, more residential homes have air-conditioning systems installed in each bedroom. Primarily, the bedroom air conditioning is to maintain an appropriate thermal sleeping environment by providing a cooling sensation to the occupants. Room temperature that is too hot or too cold can also be disruptive to one's sleep [9].

Another objective of air-conditioning is to dilute the indoor air pollutants by introducing conditioned outdoor air into the room. If there is insufficient outdoor air to dilute the room, the concentration of indoor pollutants will be increased. Thus, enough fresh air intake is critical, but this could in turn affect the energy efficiency of the building. There are not many studies reported regarding the thermal comfort and IAQ issues in bedroom environments.

Sleep quality is closely related to outdoor air pollution, because together with natural ventilation, part of the pollutants is introduced into the bedrooms. Along with the penetration of outside air pollutants, air quality can be indicated by the number of certain pollutants in the air. Air pollution is a complex mixture of solid particles, liquid droplets, as well as gases. It can come from many sources for example: household fuel burning, industrial chimneys, traffic exhausts, power generation, open burning of waste, agricultural practices, desert dust and many other sources.

World Health Organization (WHO) guidelines values for indoor and outdoor air pollutants are presented in Table 3. A few adverse health effects have been associated with exposure to both PM2.5 and PM10. For PM2.5, short-term are associated with premature mortality, increased hospitalizations for cardiac or pulmonary causes, acute and chronic bronchitis, asthma attacks, emergency room visits, respiratory symptoms and restrictions, days of inactivity. Additionally, of all common air pollutants, PM2.5 is associated with the highest proportion of air pollution-related adverse health effects, both in the United States and worldwide, according to the World Health Organization. [10] Short-term exposure to PM10 has been primarily associated with worsening respiratory diseases, including asthma and chronic obstructive pulmonary disease (COPD), leading to hospitalization and emergency department visits. Long-term exposure (months to years) to PM2.5 has been linked to premature death, especially in people who have chronic heart or lung disease, and reduced lung function growth in children. The effects of long-term exposure to PM10 are less clear, although several studies suggest a link between long-term exposure to PM10 and respiratory mortality [11]. Research shows that older adults with chronic heart or lung disease, children and asthmatics are the groups most likely to experience adverse health effects from exposure to PM10 and PM2.5. Children and infants are also likely to be affected by inhaling pollutants such as particulate matter because they inhale more air per kilogram of body weight than adults – they breathe faster, spend more time outdoors

and have smaller body sizes. In addition, children's immature immune systems may cause them to be more susceptible to PM than healthy adults [12], [13].

Table 3

WHO guidelines values for indoor and outdoor air pollutants

Pollutant	WHO Indoor Air Quality guidelines 2010	WHO Air Quality guidelines 2005
Carbon monoxide	No safe level can be determined	-
Formaldehyde	30 min. mean: 100 µg/m3	-
Naphthalene	Annual mean: 10 µg/m3	-
Nitrogen dioxide	1h mean: 200 µg/m3 Annual mean: 40 mg/m3	-
Polyaromatic Hydrocarbons (e.g. Benzo Pyrene A B[a]P)	No safe level can be determined	-
Radon	100 Bq/m3 (sometimes 300 mg/m3, country-specific)	-
Trichlorethylene	No safe level can be determined	-
Tetrachloroethylene	Annual mean: 250 µg/m3	-
Sulfure dioxide	-	10 min. mean: 500 µg/m3 24h mean: 20 mg/m3
Ozone	-	8h mean:100 µg/m3
Particulate Matter PM 2.5	-	24h mean: 25 µg/m3 Annual mean: 10 µg/m3
Particulate Matter PM 10	-	24h mean: 50 µg/m3 Annual mean: 20 µg/m3

Conclusions

The characteristics of thermal comfort and indoor air quality (IAQ) in bedrooms, occupants' perceptions and their impact on sleep quality are not often studied.

Understanding sleep quality and our physical sleep environment is an important aspect that could help to better inform designers and housebuilders.

To improve the quality of sleep increases people's productivity during the day. Societies should be designing and building homes that provide an adequate (comfortable) interior bedroom environment that can be adjusted by the sleeper to suit individual preferences and temperature events.

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[13] EEA, NMVOC: non-methane volatile organic compounds; NOX: nitrogen oxides; PM2.5: particles with a diameter smaller than 2,5 microns; PM10: particles with a diameter smaller than 10 microns; SO2: sulphur dioxide, 2022.