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Review Article

Bedrooms And Sleepers' Vulnerability To Extreme Heat Events.

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Abstract

Inadequate sleep has been linked to decreased health, well-being, and productivity. Sleep has been extensively studied in medical literature, but has gotten little attention in built environment journals. As the environment becomes more unpredictable and there are concerns about energy poverty, it's important to consider the suitability of dwellings, particularly bedrooms. This is especially important for vulnerable individuals, such as children, the elderly, and those with medical concerns, who may struggle to adjust their sleeping environment during extreme heat episodes. This narrative review aims to highlight the complex interaction between the sleeper and bedroom in household settings. This underscores the susceptibility of sleepers and the necessity for adaption measures to deal with intense heat without using mechanical air conditioning. This highlights the importance of interdisciplinary research to alert stakeholders about the implications of climate change on sleep quality and promotes health.

Keywords : *adaptability; bedrooms; extreme heat impacts; human health; sleep quality; thermal comfort; vulnerability.*

INTRODUCTION

The climate emergency highlights the urgent need to cut carbon emissions from buildings. The Intergovernmental Panel on Climate Change [1] highlights the susceptibility of communities to extreme weather, particularly heat events. Consider the ageing population, as older individuals are more vulnerable to protracted heat episodes [2]. Extreme heat occurrences have been linked to higher mortality. In 2003, Europe saw record temperatures, leading to nearly 35,000 heat-related deaths [3, 4]. Recent excessive heat occurrences emphasize the need for proper ventilation and cooling in bedrooms to ensure sleeper comfort [5]. Climate change is increasing indoor temperatures, with studies indicating that bedrooms experience higher temperatures at night than during the day [6]. Internal temperatures are expected to rise faster at night than during the day [7].Individuals are especially vulnerable while sleeping [2, 8, 9]. Maintaining thermal comfort and managing heat exchange while sleeping poses a difficulty for household properties in temperature zones without mechanical cooling in bedrooms, relying on windows for ventilation and cooling [10]. This applies to those sleeping alone, with a spouse, or on separate beds within the same room. Research suggests that a considerable number of household residences in many nations face this difficulty, regardless of climate or housing type [11]. Having air conditioning in a property does not guarantee good sleep quality [12].

METHOD

The study's goal was to increase awareness about the complicated relationships that occur between people and their bedroom environments. A narrative review was conducted to examine existing research on sleep quality and bedrooms in residential homes. Narrative reviews provide a thorough understanding of a complex topic [14-17]. This review is based on peer-reviewed journal publications written in English. Articles on domestic housing and aging facilities with similar qualities, such as care homes, were included. Articles about medical facilities, such as hospital wards, were excluded. Only a little amount of research has been conducted on the adaptability of hospital patients, which is similar to this study. This study focuses on bedrooms without mechanical air conditioning or when users are hesitant to use it owing to environmental and energy concerns. The narrative organizes and analyzes study findings from many knowledge sets under three categories: sleep, bedrooms, and adaptation. Conclusions are relevant to research and practice.

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SLEEP QUALITY

Sleep is essential for an individual's physical and mental well-being, with most people sleeping for about eight hours every day. Sleep studies have found elements influencing sleep efficiency and quality. Sleep efficiency and quality are influenced by factors such as age, mental health, physical health, food, alcohol usage, and drug dependency (18-19). Individual characteristics inform health interventions, including sleep management for those with long-term diseases like Parkinson's [20] and promoting excellent sleep health [21]. Poor sleep efficiency and quality can have detrimental effects on health, cognitive function, and productivity [22, 23-24]. Research on the impact of a sleep companion on poor sleep quality in the home is limited [25]. Climate change and rising nighttime temperatures in bedrooms increase the risk of poor sleep [26]. Individuals are particularly vulnerable to temperature changes when young, pregnant, elderly, or in poor health [27-29]. Climate change and high heat events are more likely to affect the most vulnerable elements of society, particularly during sleep. This could exacerbate health disparities and put further strain on healthcare providers and infrastructure.

Sleep quality refers to all facets of a person's sleep experience [30]. Although definitions differ, the goal is to understand an individual's sleep behaviour, typically in relation to sickness, with the findings informing intervention methods. Sleep quality is measured in controlled situations like sleep labs using polysomnography [31]. Although useful for examining sleep physiology, this artificial setting may not accurately reflect an individual's bedroom.

To assess sleep quality at home, self-reported questionnaires like the Pittsburgh Sleep Quality Index (PSQI) and sleep diaries are frequently used [32]. Smart sensors on the bed (e.g., under the mattress) and in the bedroom now allow for remote monitoring of sleep activity [33]. Researchers do not intrude on private spaces with these interventions. However, acceptability of sensor/smart technologies in the house is a barrier, as they must be demonstrated to benefit inhabitants [34]. Questionnaires and sleep diaries have limitations due to participant recollection and the need for daily completion. Actigraphy data collection can result in inaccurate measurements [31].

BEDROOMS

As temperatures rise and extreme heat events become more common, it's important to consider the adaptability of bedrooms. Are they suited for purpose? A recent evaluation of literature indicates that they are not [37]. Designers and engineers demand evidence-based assistance to make informed design decisions. Some of this can be found in country-specific guidance and legislation that attempt to prohibit high night-time temperatures in bedrooms [11], as well as guidance materials for assessing overheating [38] using dynamic thermal modeling.

While simulation and modeling are useful design tools, there is often a performance gap between design and reality, resulting in buildings and rooms not working as anticipated [39]. It is tough to predict and model individual behavior, bed occupancy, bedroom use, and sleepers' physical and mental wellbeing. The European Insomnia Network recommends sleeping during heatwaves [7]. They provide metrics primarily focused on individual behaviors. The recommended temperature for the bedroom is 19C, or 20-25C if that is not achievable. Indoor bedroom temperatures exceeding 25°C should be avoided. Building rules in many countries limit temperatures over 26-27C, with others setting a maximum of 30C as a performance criterion [11]. In extreme heat events, air conditioning equipment may be necessary to maintain a comfortable temperature, particularly at night. Heatwaves are likely to cause discomfort for inhabitants, especially when temperatures surpass the thermal comfort zone at night [40, 41].Sleepers need to be able to heat, cool, and ventilate their bedroom [42,43]. This applies to new properties and to the existing building stock. In Europe and many other parts of the world, there has been a drive to design buildings that consume no, or very little, energy. This has been achieved by constructing thermally efficient and airtight buildings, which in some cases has created residential properties that are prone to overheating in hot weather [6,11,44], including those designed for older people [45]. This relates to the orientation and thermal mass of the building, ventilation provision via windows and vents, and the ability to limit solar heat gain via passive shading and active interventions by residents (e.g., closing curtains, shutters, and window blinds).

Bedroom Size And Psychological Factors

Bedrooms with tiny dimensions have long been questioned for their functionality [49, 50]. Despite research indicating the psychological significance of bed orientation [51], most beds can only fit in one position in a room. Research suggests that sleepers prefer a bed facing the bedroom door [52]. A greater knowledge of how sleepers relate to their bed position and its impact on their sleep is necessary. This may relate to the sleeper's impression of safety. Bedroom design often fails to prioritize sleepers' safety [53]. Chronic overheating has been observed in high-density dwellings (40).

These were not opened at night due to security concerns and noise exposure, resulting in overheating. Opening windows at night for cooling raises safety concerns, since they may allow unauthorized entry by persons, animals, and insects. This is especially important in countries with high mosquito populations [54].

Indoor Environmental Quality (Ieq)

IEQ in bedrooms has received little attention [42, 55], despite the fact that the connection between IEQ components is known to influence sleep quality [56]. Balancing ventilation and noise pollution through open bedroom windows can be hard, particularly in densely populated areas [35]. Research on indoor environmental quality (IEQ) in bedrooms has primarily focused on air quality and ventilation [43, 53], as well as its impact on cognitive performance [57]. However, IEQ also encompasses indoor temperature, humidity, and noise pollution. The correlation between carbon dioxide levels and sleep quality extends to external meteorological events. Closing windows to retain heat in cold weather might lead to increased levels.

Thermal comfort research has been focused on workplace settings, which differ significantly from the bedroom environment [10]. Sleeping lowers an individual's metabolism compared to being awake. Small changes in temperature can have a significant impact on sleep quality [55]. Research on thermal comfort models for sleep and ageing is limited and requires additional development (10). A new review emphasizes problems in thermal comfort studies on sleep quality, which has primarily focused on healthy, young people (typically students) who sleep alone. According to a review [60], there is no direct evidence linking thermal comfort to improved sleep quality.Light and sound both have an impact on sleep. Control natural light via blinds, curtains, or shutters (both indoors and outdoors). When closed, they reduce airflow and ventilation rates. When open, they let unwanted sounds into the bedroom [35]. With a large proportion of people living in densely populated and developed urban and semi-urban areas, usually in multi-storey and row houses, noise pollution while trying to ventilate the bedroom at night is to be expected [61,62]. To reduce noise pollution, consider using portable fans that filter indoor air pollutants [63] and keeping windows closed. This has been shown to improve sleep quality [64]. Whether this is entirely down to air quality,

Sleeper Behavior And Adaptability

According to [34], the majority of residents live in homes they did not create or control, including their bedrooms. Sleepers may need to adjust their body temperature to cope with harsh weather conditions. To combat the impacts of high temperatures, individuals might adjust their sleeping habits, such as going to bed later [65] or altering their bedroom [66]. This may include upgrading outdoor shade devices and installing mechanical air cooling equipment. Interventions may incur costs for residents and building owners [66]. Sleepers can adjust their sleepwear (clothes) and bedding to increase thermal comfort [67], reducing their susceptibility to excessive nighttime temperatures. Sleepers may be able to alter their bed position, such as shifting it closer to a window for ventilation or away from a hot external wall. Small bedrooms and those with additional equipment, like a study desk and wardrobes, may not allow for this. Consider temporarily moving to a cooler room to escape the heat [9]. This may not be suitable for sleepers living in overcrowded or overheated properties. It does not consider the needs of those with disabilities or long-term illnesses who cannot relocate due to practical constraints. This defies the European Insomnia Network's recommendation to exclusively sleep in bed [7]. Sleepers are often more vulnerable to extreme weather events due to their proximity to the building.

DISCUSSION AND CONCLUSIONS

This research highlights the complicated relationship between the bedroom environment and sleepers' health and wellbeing, making it scientifically innovative. Interventions that increase sleep quality do not fully consider the physical bedroom environment. Design guidance does not fully examine the physical and psychological features of those who will sleep in bedrooms. These findings are relevant to both healthy individuals and those with medical issues, particularly those who are more susceptible to temperature changes due to aging. The analysis found less evidence on how sleepers adjust their bedrooms to maintain comfort under excessive temperatures.The impact of transitioning to a net zero economy on sleepers' health and wellbeing is uncertain. Better thermally insulated residential projects, as well as modifying existing buildings to improve thermal efficiency, should improve sleepers' thermal comfort during the colder months. This will improve sleep quality and limit inhabitants' exposure to extreme cold. There is currently insufficient evidence to determine the impact of thermally efficient buildings on sleep quality during hot weather. This review highlights the importance of understanding how structures behave during extreme heat.

The medical literature generally focuses on sleep and disease, limiting study on sleep quality. This corpus of knowledge focuses on the individual and their ailment, rather than the bedroom environment itself. Sleep research in the built environment primarily focuses on thermal comfort and indoor air quality. Unlike medical literature, this study has primarily focused on healthy, young persons. These two areas of research do not overlap. Interdisciplinary study has the potential to better understand the relationship between sleepers and how they respond to their environment, despite disciplinary barriers and financing constraints.

The research challenge must not be underestimated. Interdisciplinary research is needed to consider the bedroom's context, including orientation, size, function, thermal performance, and solar shading. It should also monitor air quality, temperature, humidity, carbon dioxide, light and sound levels, scent, ventilation, occupancy levels, occupant behavior, sleepwear and bedding, bed comfort and position, and sleep perception. Research should consider several factors such as sleeper age, socioeconomic status, and mental/physical health issues that may impact sleep quality. This raises practical and ethical concerns for research teams. Simulation, such as using a digital twin to test design modifications and their impact on the sleep environment, can provide insight on these difficulties. However, simulations require lacking study findings and may differ from actual results.Poor sleep quality is a public health issue that is expected to worsen as the world heats. The topic is especially important given the aging population's increased susceptibility to harsh weather events and the concentration of people in densely populated cities. To address climate change and create a useful, adaptive, and comfortable sleep environment, bedroom design and new household developments need to be reconsidered. Achieving this requires balancing thermal insulation, thermal mass, solar management, and providing enough ventilation and cooling (natural, mechanical, or mixed mode). To improve sleep quality [21], it's important to understand how sleepers interact with their bedroom and adapt to harsh weather conditions. Sensor technology and remote monitoring can provide strong evidence for policy and intervention development. This will help building designers, policymakers, and urban planners make more informed judgments. Raising awareness of sleepers' vulnerability to climate change can educate households on the importance of their bedroom environment. Sleepers are exposed to harsh weather occurrences due to their connection to the building where they live and sleep, which many occupants share.

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