# Light and Health

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Light is important for visual performance and safety, and also plays a vital role in regulating human physiological functions. Poor housing is an important determinant of poor health. One key aspect of housing quality is lighting.

Keywords: Light ; Health ; Housing

## 1. Introduction

The right to adequate housing is a recognized international human right [1]. The World Health Organisation (WHO) defines healthy housing as one that encourages a state of complete physical, mental and social well-being [2]. People living in inadequate housing are at greater risk of ill health [3][4][5] and inadequate housing conditions are one of the main drivers of health inequalities [2]. Adequate housing is commonly assessed based on housing quality [4][5] which encompasses a wide variety of factors including: crowding and home safety, mould and dampness; temperature and humidity; ventilation and insulation; sanitation; indoor air and noise pollution; radon, asbestos and lead exposure; and lighting [2][4]. Many housing quality factors co-exist within the home, placing occupants at a greater risk of multiple health problems. Housing quality is associated with different health outcomes including developmental, chronic and acute conditions [5][6]. Many housing quality factors are widely studied, for example, mould and dampness [7]; crowding [8]; and lead exposure [5]. Others, however, are understudied despite their potential to impact health. One of the less studied housing quality factors is lighting in the home.

Adequate lighting is needed for visual performance and safety, and to reduce falls and injuries. Light is also highly essential for health and well-being [9][10][11] through the regulation of bodily functions [12]. Light plays an important role in the function of the nervous and endocrine systems and the secretion of hormones such as melatonin. Melatonin is released by the pineal gland in a 24-h cycle according to how much light is received, regulating the body's circadian rhythm. In regular sleep-wake cycles, the hormone is highest at night in the dark promoting healthy sleep and lowest during daylight promoting alertness. Disruption to these rhythms caused by a lack of daylight exposure during the day and exposure to bright lights during the night constitutes as improper light exposure which affects health [9][13].

The importance of light on health is further demonstrated through its therapeutic effects. Symptoms of seasonal affective disorder and other types of depression have been shown to be effectively reduced by both natural and artificial light therapy [14][15][16][17]. Before the discovery of antibiotics, sunlight played a significant role in infection control and preventing the spread of disease in buildings [18][19]. Even today, forms of artificial light are effectively being used in hospital settings to reduce infection transmission [20][21].

Lighting within the home encompasses different types of light. For instance, homes may be illuminated by natural light through windows and supplemented with artificial light sources during the day, with artificial lighting continuing into the night. As such, there is a need to understand the impact of the various types of lighting in the home on the health of residents. A limited number of systematic reviews have previously explored the impact of lighting on the elderly [22] and the effects of sunlight [23] and light at night [24] on health in certain settings such as care homes. A systematic review that synthesises the evidence of health impacts from different types of lighting in the home is lacking.

## 2. Impact of Lighting in the Home on Health

This systematic review synthesised the existing evidence on links between lighting in the home and health. Though limited in number, the available studies evaluated a range of lighting types (natural light, artificial light and light at night) across twenty-two specific health outcomes. Of the twenty-eight studies included in this review, twenty-five studies observed an association of lighting exposure on at least one health outcome; five of these studies investigated natural light, ten artificial light and ten light at night.

## 2.1. Natural Light

In general, the included studies showed positive associations of natural light exposure and improved health across all health domains (physical, mental and sleep health). Adequate natural light at home has been found to be protective for various health outcomes including tuberculosis, leprosy, depression, mood, falls and sleep. These findings are in line with previous studies conducted in settings other than the home, including offices and hospitals. For instance, in offices, evidence suggests workers with less sunlight exposure have worse self-reported sleep quality [25] and mood [26]. Three systematic reviews focusing on hospital settings identified positive effects on depression in patients with diagnosed depressive illnesses attributable to increased sunlight exposure [27][28][29]. Findings also suggest that exposure to sunlight can improve sleep amongst all hospital in-patients [27][29].

Our systematic review also identified protective effects of natural light with respect to infectious diseases, possibly due to sunlight's ability to kill bacteria [30]. Ultraviolet light might act as a natural disinfectant, by weakening and damaging bacteria, causing mutations that limit their ability to reproduce and survive [31]. This disinfectant effect has been found to persists via indirect sunlight exposure through glass [18][32] and windows in homes [33].

## 2.2. Artificial Light

Studies included under the artificial light category used a diverse range of methods to measure exposure to artificial lighting. Methods varied from different sources of artificial lighting (e.g., fuel based, electric, and solar), different electrical lighting equipment (e.g., light bulbs, LED), the adequacy of the lighting available and adjustments to existing electrical lighting (e.g., provision of additional lamps to the living room), all of which showed an impact on health. The majority of studies focused on differential effects on health due to different sources of artificial lighting in the home. There is clear evidence that use of fuel based light sources negatively impact health. In the developing world, 860 million people lack access to electricity [34], as such fuel-based lighting is the common method to illuminate the home. Our review included five studies which evaluated fuel-based lighting compared to electric/solar lighting which were carried out in LMICs. Of those, four showed that individuals using fuel-based lighting compared to electric or solar lighting are more likely to suffer from respiratory diseases and burns. This is consistent with a comprehensive review by Mills et al. on the health impacts of fuel-based lighting [35][36]. Studies have shown that fuel-based indoor lighting choices significantly contribute to the level of indoor air pollution [37]. Fuel based lighting releases particulate matter, volatile organic compounds and other harmful pollutants when burned, and inhalation of these particles into the lungs results in respiratory disease such as acute respiratory lung infections and lung cancer [38][39][40], especially in homes with poor ventilation.

Burns are one of the top causes of non-fatal injury in children [41]. The use of fuel-based lighting sources can result in burn injuries, for example via overturned kerosene lamps, with a significant proportion of burns occurring amongst children. The placement of lamps is, therefore, an important consideration.

The type of electric lighting (bulb type and colour temperature) in the home can also impact health. One of the studies on light bulb types included in this review [42] reported worse sleep quality for a light bulb versus LED lighting. It is worth noting, this study did not classify what specific light-bulb types were considered under "light bulb". However, in Japan, where the study took place, this term is often used to reflect incandescent light bulb [43].

Only one study reported on colour temperature. Worsened sleep quality but lower daytime anxiety levels were reported when exposed to cooler lights compared to warmer light during the 12-week cross-over study [44]. Light naturally contains a spectrum of colours. The light falling on the eye has an important role in regulating the circadian rhythm. Melanopsin, a photoreceptor in the eye, responds to rich blue light and signals the suppression of melatonin [45]. Sunlight has lower wavelengths during the day corresponding with a bluer light [46]. This exposure to daylight helps to stay alert, while evening exposure to light bulbs containing high levels of blue light signals processes affecting melatonin release and negatively impact sleep [9][47][48]. However, in the study only overhead lights in communal areas (lounge and dining room) were adjusted, and although only residents that frequented these areas were eligible, participants were not be exposed to the intervention in the evening upon returning to their bedroom [44].

## 2.3. Light at Night

Effects of light at night were generally consistently associated with the analysed health outcomes. The majority of the evidence came from the HEIJO-KYO cohort. Results consistently showed high levels of indoor light at night was associated with negative health outcomes (including sleep and metabolic disorders such as obesity, diabetes and dyslipidaemia). The studies conducted on the HEIJO-KYO cohort were of good quality with rigorous methodology, including objective measures of evening and bedroom night-time light intensity with a light meter. Although these results are restricted to a sub-population of home-dwelling Japanese elders, they are in line with the findings of another review

[24]. Cho et al. reviewed the effects of artificial light at night across the general population and identified that chronic light at night exposure could negatively impact sleep and other physiological functions [24]. Their review, however, incorporated studies using satellite imagery to measure the outdoor night-time light level. Studies using this measurement method were not eligible for inclusion in our systematic review as it lacks consideration for individual level factors, like window covering practices with blinds and location of the bedroom in relation to streetlights, and as such is not always reliable to represent an individual's exposure to light within the home [49][50]. Nonetheless, there is still further evidence available supporting the negative impact of light at night within the home on health and sleep in particular [22][47][51][52]. A clear biological explanation for this association exists. Bright light during the night is ill-timed, causing disruptive effects on the circadian rhythm, through suppression of melatonin and subsequently affecting sleep and other metabolic processes [53]. Although this systematic review, sought to evaluate the effect of lighting in the home on melatonin itself in addition to all health outcomes, no studies evaluating the effects of lighting in the home with melatonin were identified or eligible.

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