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# Artificial light exposure at night: A hidden risk factor for type 2 diabetes

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ABSTRACT

This study examines the effect of nighttime light exposure on the risk of developing type 2 diabetes Mellitus (T2DM), highlighting an often-overlooked environmental factor. While lifestyle choices such as diet and physical activity have long been recognized as critical risk factors for T2DM, emerging evidence suggests that artificial light at night (LAN) may also play a significant role. LAN disrupts circadian rhythms, which regulate sleep cycles and glucose metabolism, leading to metabolic dysfunction. Using data from the UK Biobank, researchers assessed the relationship between personal light exposure patterns and T2DM risk. Findings revealed that for every 10-lux increase in LAN, the risk of developing T2DM rises by 30 %. The study underscores the importance of circadian alignment in metabolic health and suggests that mitigating nighttime light exposure, especially in urban environments, could be a practical strategy for reducing T2DM risk. Raising awareness about the health risks of light pollution and advocating for healthier lighting solutions in public spaces could play a crucial role in T2DM prevention. Further research is needed to confirm these findings and explore interventions that reduce nighttime light exposure and its impact on diabetes risk.

## 1. Background

Type 2 diabetes Mellitus (T2DM), formerly known as adult-onset diabetes, is a metabolic disorder characterized by high blood sugar in the human body, either due to insulin resistance or a relative lack of insulin due to impairment of its secretion by Beta cells [1]. People with T2DM are presented with polyuria, polydipsia, and unexplained weight loss. In addition, they may include increased hunger, tiredness, and sores.

The relative lack of insulin has reached epidemic proportions, affecting millions of people worldwide and posing significant public health challenges. According to a 2021 report by the International Diabetes Foundation (IDF), approximately 537 million individuals globally are affected by diabetes, constituting approximately 10.5 % of the world's population [1]. This rising incidence is due to lifestyle changes, including global population aging, decreased physical activity, increased obesity rates, sedentary behavior, and poor dietary habits.

While lifestyle factors such as diet and physical activity have long been acknowledged as pivotal contributors to diabetes risk, emerging research underscores an often-overlooked environmental element, which is the influence of artificial light exposure during nighttime on glucose metabolism and diabetes susceptibility [2]. Recent evidence indicates that exposure to light at night may disrupt circadian rhythms, thereby contributing to metabolic disorders [3–6].

One plausible mechanism through which nighttime light exposure affects glucose metabolism is via the disturbance of circadian rhythms, which are integral to the regulation of insulin sensitivity and glucose management. The presence of artificial light at night, specifically shorter wavelengths of light (blue light spectrum), can disrupt the natural light-dark cycle, which can suppress the production of melatonin, a hormone secreted by the pineal gland crucial for regulating sleep and wakefulness (Fig. 1). This suppression can lead to sleep disturbances, diminished sleep quality, and increased metabolic stress, potentially affecting overall health. It is well-documented that melatonin plays a crucial role in insulin regulation, and its disruption may heighten vulnerability to glucose intolerance [7]. Moreover, exposure to light during nighttime could augment appetite and alter eating patterns, subsequently promoting weight gain and insulin resistance, both of which elevate the risk for T2DM [8] As well as cancers, due to that melatonin suppression is related to several downstream activities, including reduced cellular

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anticancer and antimetastatic properties, as well as poor sleep quality and short sleep duration, are hypothesized risk factors for cancer development and progression [9,10]. And also, light at night may induce mechanisms conducive to cancer development. For example, Palomar-Cros et al. (2024) [10] In their systematic review and meta-analysis, they found that being exposed to higher levels of outdoor ALAN was associated with a higher risk of breast cancer, with outdoor ALAN exposure associated with prostate cancer risk, even though there was no significance [10].

Circadian rhythms are biological processes that adhere to a 24-h cycle, governing various physiological functions, including sleep-wake cycles and glucose metabolism. Disruptions to this circadian regulation, whether due to shift work, late-night eating, or genetic factors, can lead to impaired glucose control and an increased risk of T2DM [3].

Light at night (LAN) has been associated with poor health, including obesity and cancer risk [2]. Different studies have demonstrated a higher prevalence of obesity in individuals with bedroom LAN during sleep, both objectively and subjectively [2,4,6]. In a large prospective study of middle-aged women followed for over five years, self-reported LAN during sleep was significantly associated with an increased risk of weight gain and the development of obesity [11]. In Japanese older adults followed up for over 21 months, evening or nighttime light exposure was associated with a subsequent increase in obesity [5]. In addition, annual levels of outdoor LAN estimated from satellite data have been associated with a higher risk of coronary heart disease in older adults in Hong Kong over 11 years of follow-up [12]. And also there is an association between ALAN with mental disorders like depression, Bipolar disorders exacerbation, and others, as reported by Deprato et al. (2025) [13].

A significant study published in The Lancet Regional Health - Europe has underscored the importance of this issue, indicating that individual light exposure patterns may have a substantial impact on the incidence of T2DM. Windred et al. (2024) [14] Analyzed data from 84,790 participants in the UK Biobank, utilizing approximately 13 million hours of light sensor data to assess the relationship between light exposure and diabetes risk. Participants wore light sensors for a week, enabling researchers to model circadian amplitude and phase based on their light exposure. Over a follow-up period of approximately 7.9 years, researchers recorded 1997 cases of incident T2D [14].

The findings indicated that individuals subjected to increased brightness during nighttime exhibited a significantly elevated risk of developing diabetes, in comparison to those residing in darker night environments [14]. Specifically, the study demonstrated that for each increment of 10 lux in nighttime light exposure, the likelihood of developing T2DM rose by 30 % (hazard ratio [HR] 1.30, 95 % confidence interval [CI] 1.10–1.54; $p < 0.01$). Furthermore, participants categorized in the highest quartile of exposure exhibited a 50 % greater risk of diabetes than those in the lowest quartile (HR 1.50, 95 % CI 1.20–1.85, $p < 0.001$). The circadian amplitude was also found to be a significant factor; participants with lower circadian amplitude (mean Â ± SD: 1.5 ± 0.8) faced a 40 % heightened risk of diabetes (HR 1.40, 95 % CI 1.15–1.70; $p < 0.01$). Moreover, individuals with either early or late circadian phases demonstrated an increased risk, with a statistical significance indicated by a p-value of 0.005 [14].

## 2. The importance of circadian rhythms

Circadian rhythms, the body's internal clock that regulates sleep-wake cycles, and various physiological processes are profoundly influenced by light exposure [3]. Natural light during the day helps to synchronize these rhythms, promoting alertness and metabolic function. Conversely, exposure to artificial light especially Blue light at night can disrupt this delicate balance, leading to circadian misalignment [3,4]. This misalignment has been linked to a range of health issues, including obesity and cardiovascular disease, and as this study indicates, T2DM [14].

The mechanisms through which light exposure affects metabolic health are complex. Disruption of circadian rhythm can lead to impaired insulin sensitivity, altered glucose metabolism, and increased appetite, all of which are risk factors for diabetes [3,7,9]. The findings of this study suggest that nighttime light exposure may exacerbate these issues, particularly in individuals already predisposed to metabolic disorders.

### 2.1. *Significance of the study findings*

The significance of this study cannot be overstated. It highlights a critical yet often overlooked environmental factor that may contribute to the increasing prevalence of T2DM. The public health implications are substantial, indicating that minimizing nighttime light exposure could serve as an effective strategy for diabetes prevention, particularly

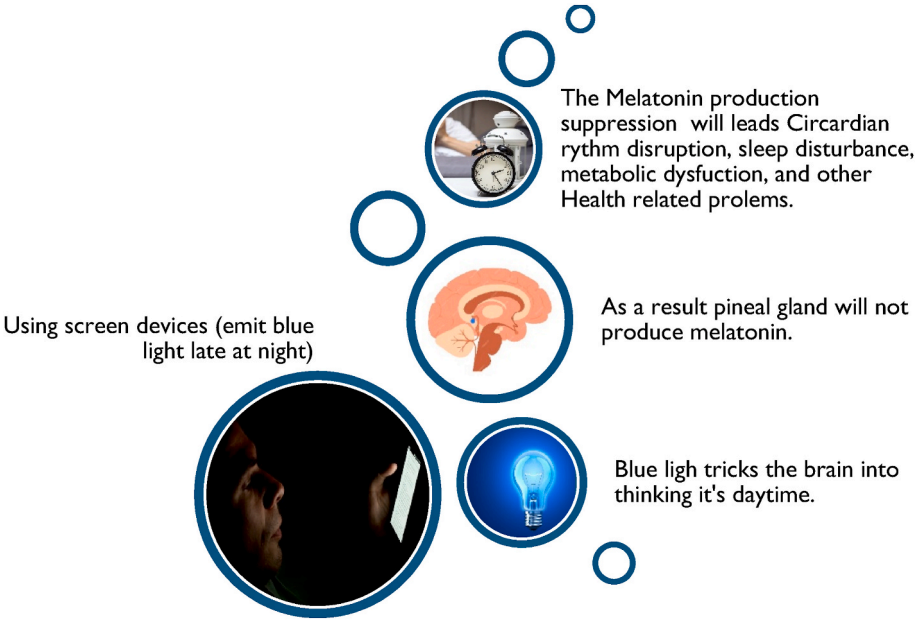


**Fig. 1.** Schematic depicting the effect of ALAN exposure and its adverse effects on the Circadian rhythm and T2DM.

in urban areas where light pollution is prevalent. This finding underscores the necessity for targeted public health campaigns to raise awareness of the associated risks. Furthermore, policymakers should prioritize regulations that promote healthier lighting solutions in public spaces, such as the implementation of "dark sky" initiatives to limit unnecessary nighttime illumination. From a healthcare perspective, incorporating light exposure into diabetes risk assessments could enable clinicians to offer more comprehensive lifestyle recommendations, enhance preventive measures, and improve overall patient outcomes.

### 2.2. A call for increased awareness

Despite substantial evidence linking exposure to artificial light during nighttime to an increased risk of diabetes, this critical issue is often overlooked in public health discussions. A significant number of individuals remain unaware of the potential health risks associated with nocturnal light exposure, frequently perceiving it as a harmless element of contemporary living. This gap in awareness also extends to healthcare professionals, who may not routinely evaluate patients' exposure to light when assessing their diabetes risk factors.

To bridge this awareness gap, it is imperative to inform the public about the potential health consequences of nighttime light exposure. Public health initiatives could play a pivotal role in educating individuals on the importance of minimizing artificial light in the hours leading up to sleep. Simple modifications, such as utilizing blackout curtains, reducing screen time prior to bedtime, and choosing dimmer lighting in the evening, can have a significant positive effect on circadian rhythms and, consequently, metabolic health.

## 3. Practical recommendations

Based on the findings of this study, several actionable recommendations can be proposed to assist individuals in mitigating their risk of T2DM through improved management of light exposure. Individuals are advised to take several steps to regulate their circadian rhythms. Reducing blue light exposure emanating from screens and artificial lighting using blue light filters or specialized glasses during the evening may prove beneficial. Additionally, creating a sleep-conducive environment by utilizing blackout curtains or eye masks to keep bedrooms dark can significantly enhance sleep quality. It is imperative to maintain a consistent sleep schedule, even on weekends, to regulate circadian rhythms effectively. Instead of engaging with electronic devices, individuals are encouraged to participate in relaxing evening activities, such as reading or meditating, which can further support the body's natural winding-down process. Furthermore, communities can advocate for healthier lighting policies in public spaces to diminish light pollution and its associated adverse health effects. Collectively, these strategies can promote better circadian alignment and reduce the risk of diabetes.

## 4. Future research directions

Although this study provides valuable insights into the relationship between light exposure and T2D, additional research is essential to establish causal relationships and explore the underlying mechanisms. Longitudinal studies that examine the effects of specific light exposure patterns on metabolic health are necessary to confirm these findings. Additionally, research should investigate the potential benefits of interventions designed to reduce nighttime light exposure and their implications for diabetes prevention.

## 5. Conclusion

The findings of this study act as a significant reminder concerning the concealed risks associated with light exposure during nighttime hours. As society continues to navigate an increasingly illuminated environment, it becomes crucial to acknowledge the potential health implications of such exposure. By raising awareness and implementing practical strategies to manage light exposure, proactive measures can be undertaken to mitigate the risk of T2D and enhance overall metabolic health. The intersection of light exposure and metabolic health is an emerging field of research that requires further exploration. In the endeavor to combat the diabetes epidemic, understanding and addressing the impact of contemporary lifestyles, particularly regarding light exposure, will be vital in the formulation of effective prevention strategies. It is essential to illuminate this hidden risk factor and pave the way for a healthier future.

## CRediT authorship contribution statement

**Izere Salomon:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Conceptualization. **Shema Sam:** Writing – review & editing. **Yahya Ur Rehman:** Writing – review & editing. **Intwari Munyaneza Hope:** Writing – review & editing.

## Ethical approval

Not applicable.

## Consent

Not required.

## Research registration unique identifying number

Not applicable.

## Guarantor

All authors.

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## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Abbreviations

| | |
|---|---|
| **T2DM** | Type 2 Diabetes Mellitus |
| **LAN** | Light at night |
| **CI** | Confidence Interval |
| **HR** | Hazard Ratio |

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