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Sleep, circadian disruption and breast cancer risk in working women: A narrative review

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Abstract

Introduction: Circadian rhythms play a key role in regulating hormonal secretion, immune function, metabolism, and cell-cycle control. Disruption of these rhythms due to artificial light at night (ALAN), sleep disturbances, and shift work has been increasingly implicated in breast cancer risk, particularly among working women.

Objective: This narrative review summarizes current evidence on the association between circadian rhythm disruption, sleep disturbances, and breast cancer, with emphasis on biological mechanisms and public health relevance.

Methods: A narrative review of English-language literature published between 2015 and 2025 was conducted using PubMed and Google Scholar. Epidemiological, clinical, and experimental studies examining ALAN exposure, shift work, sleep characteristics, circadian misalignment, and breast cancer outcomes were included.

Results: Most epidemiological studies report a positive association between night shift work, prolonged ALAN exposure, poor sleep quality, and increased breast cancer risk. Proposed mechanisms include melatonin suppression, dysregulation of estrogen signaling, altered clock gene expression, immune dysfunction, and impaired DNA repair. Experimental evidence supports the oncostatic role of melatonin through estrogen receptor modulation, cell-cycle arrest, apoptosis induction, and immune enhancement. However, heterogeneity in study design, exposure assessment, and outcome measures, along with reliance on observational data, limits causal interpretation.

Conclusion: Circadian disruption and sleep disturbances may represent modifiable risk factors for breast cancer, especially in occupational settings involving night work. Strategies to improve circadian hygiene, optimize shift schedules, and reduce ALAN exposure could contribute to breast cancer prevention. Further well-designed longitudinal and mechanistic studies are required to strengthen causal inference and guide targeted chronopreventive and chronotherapeutic approaches.

Keywords: Breast Neoplasms; Circadian Rhythm; Artificial Light at Night; Shift Work Schedule; Sleep Disorders; Melatonin

1. Introduction

Breast cancer is the most commonly diagnosed type of cancer among women. [1–3] In 2022, an estimated 670 000 women died of breast cancer globally. [1] The incidence rate is higher in countries with a low human development index (HDI), such as those in the African and North American regions. [2,4] Some of the major risk factors include use of oral

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contraceptives, aging, family history, reproductive factors, estrogen, lifestyle, urbanization.[2,5,6]Awareness, availability, and use of breast cancer screening methods can also contribute to a higher incidence rate. [2]

In 2007, the International Agency for Research on Cancer (IARC) recognized night work as a probable carcinogen. The IARC's decision was based on evidence from animal studies and a few epidemiological studies. [7] Following this, many case-control and epidemiological cohort studies have revealed an association between night shift work and increased risk for breast cancer. [3,8,9]

The circadian rhythm disruption is one of the primary mechanisms underlying increased risk for breast cancer in night shift workers. [5,10] The circadian rhythm includes a master clock - the Supra-Chiasmatic Nucleus (SCN), located in the hypothalamus, and peripheral clocks in various tissues. All peripheral clocks work in synchronisation with the SCN, spanning over 24 hours, and regulate physiological and behavioral processes. The master clock is reset every day to align with the solar period of 24 hours.

Environmental light signal is a key cue that helps reset the circadian rhythm. Light sensed through the retina and conveyed to the SCN during night, dawn, and dusk signals the circadian rhythm to initiate or turn off neuroendocrine processes. [11]

During dusk, the circadian system promotes melatonin secretion, a hormone that regulates the sleep-wake cycle. [7] However, exposure to artificial light at night (ALAN) in night shift workers suppresses melatonin secretion. [10,12,13] The blue light of ALAN from sources like streetlights, TVs, smartphones, and laptops can cause phase delays in the sleep-wake cycle. [10] This leads to increased alertness, poor sleep quality, and poor cognitive performance. [6,7]

Further, low melatonin levels at night alter its repressor role in regulating ovarian estrogen synthesis. As a result, high levels of estrogen build-up continues, increasing the risk for breast cancer. [10,13]

Modulating the immune system response is another way the circadian disruption increases the risk of breast cancer. Desynchronized circadian clocks affect activation of toll-like receptors (TLR's), maturation of dendritic cells, T cell proliferation, and Natural killer (NK) cells receptor expression. [14] Further, the shift in cytokine and Interleukin-2 (IL-2) production, and other tumor immune response mechanism drive tumor progression. [6,11,15]

This review has 2 main objectives:

- To identify potential biological mechanisms linking altered sleep patterns to breast cancer development, such as hormonal imbalances, melatonin suppression, and immune system modulation.
- To highlight gaps in current research and suggest directions for future studies aimed at understanding and mitigating the breast cancer risk associated with sleep disturbances in working women.

2. Methods

A literature search was conducted using PubMed and Google Scholar databases to identify manuscripts published from January 2015 to June 2025. We used keywords and Medical Subject Headings (MeSH) related to breast cancer (breast cancer, breast carcinoma, breast tumor, breast neoplasm, mammary cancer, breast cancer risk) and sleep-related variables (sleep disorders, sleep quality, sleep duration, sleep latency, sleep disturbance, sleep efficiency, insomnia, circadian rhythm, night-shift work, artificial light at night, melatonin).

Boolean operators were applied in various combinations to maximize the retrieval of relevant studies.

2.1. Inclusion Criteria

- Studies carried out over the last 10 years (January 2015- June 2025).
- Original research articles, narrative reviews, systematic reviews, and meta-analyses published in peer-reviewed journals and available as full text.
- Articles published in English.
- Studies in human females.
- Articles focused on epidemiological evidence or explaining mechanistic pathways i.e. melatonin suppression, immune dysfunction, circadian dysregulation.
- Studies focusing on risk of breast cancer in working women.

2.2. Exclusion Criteria

- Commentaries, essays, letters to the editor, case reports, conference reports, proceedings, opinion articles, and studies focused on cancers other than breast cancer.
- Animal studies, laboratory-based experimental studies, cell studies were also excluded.
- Studies reporting only mortality and benign breast diseases.
- Studies mentioning breast cancer survivors undergoing treatment.
- Articles that have no relation to the scope of the review.

Duplicate articles were identified and excluded.

The article titles were screened and the abstracts of relevant articles were then reviewed to identify eligible papers.

A total of 52 articles were then selected.

3. Results

The International Agency for Research on Cancer (IARC) has classified shift work that involves circadian rhythm disruption as a potential human carcinogen (Group 2A), linking circadian misalignment with increased cancer risk, particularly breast cancer. [16],[17]

At the molecular level, circadian rhythms are maintained through transcriptional-translational feedback loops (TTFLs) involving CLOCK\: BMAL1 heterodimers and their downstream targets (Per1/2, Cry1/2, ROR, and Rev-erbα). These core clock genes regulate a wide range of clock-controlled genes (CCGs), many of which influence the cell cycle, proliferation, and apoptosis, thereby linking circadian regulation with tumorigenesis. [16]

Role of Melatonin in circadian rhthym:

- **Anticancer effects:** Melatonin exhibits strong anti-proliferative and oncostatic effects in breast cancer. These effects are mainly mediated through activation of the MT1 receptor, which suppresses estrogen receptor-α (ERα) activity, inhibits calcium-calmodulin signaling, and induces tumor suppressor proteins such as p53 and p21, leading to G1 cell-cycle arrest.
- **Estrogen regulation:** Melatonin reduces circulating estrogen levels by inhibiting gonadal steroidogenesis and suppresses local estrogen synthesis through downregulation of aromatase, sulfatase, and aldo-keto reductase (AKR) enzymes.
- **Nuclear receptor modulation:** It downregulates glucocorticoid receptor (GR) and RORα signaling, while enhancing retinoic acid receptors (RARα, RXRα), vitamin D receptor (VDR), and PPARγ activity, thereby inhibiting cell growth and promoting apoptosis.
- **Gene regulation:** Melatonin represses tumor-promoting genes (e.g., FN1, BMP7, AREG, IGF1R, S100P, Ki-67) and upregulates tumor suppressor genes (e.g., p21, NUCB2, CALR, TIMP3).
- **Dose-dependent effects:** At physiological concentrations, melatonin mainly induces p53/p21-mediated cell-cycle arrest, while at pharmacological doses, it can trigger apoptosis.
- **Immunomodulatory role:** Melatonin enhances anti-tumor immune surveillance by stimulating T-helper cell activity and increasing cytokine secretion, including IL-2, IL-10, and IFN-γ, thereby promoting cytotoxic T-cell responses and tumor cell apoptosis. [18]

The exposure to artificial light at night (ALAN), both indoors and outdoors, may increase breast cancer risk by disrupting the circadian rhythm. The combined ALAN exposure and night-shift work are associated with reduced melatonin secretion. Bright light and blue enriched light exposure at night, even at low-intensity can significantly disrupt sleep architecture. The delayed sleep timing has been linked to altered sex hormone profiles, including elevated estradiol levels and diminished melatonin concentrations. [19]

Mechanistic Pathways associated with Circadian rhythm and Sleep Disruption to breast cancer.

3.1. Sleep and Immunity

Sleep deprivation triggers activation of both the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic-adrenal-medullary (SAM) system, resulting in elevated cortisol and catecholamine levels. These neuroendocrine changes suppress immune surveillance, particularly by impairing NK cell activity, and simultaneously promote

angiogenesis and tumor cell migration. Over time, chronic stress and persistent sleep loss promotes systemic inflammation, ultimately creating a pro-carcinogenic environment. Sleep disturbances also shift cytokine production from a T-helper 1 (Th 1) to a T-helper 2 (Th 2) dominant profile, increasing Interleukin-10 (IL-10) and facilitating immune evasion.

Sleep plays a vital role in regulating neuroendocrine activity and glucose metabolism. Disturbed sleep compromises metabolic homeostasis, creating conditions that favour tumor initiation and progression. [16],[18],[20]

In shift workers, repeated sleep restriction and recovery patterns affect how the immune system responds to inflammation, infection, stress, and other pain-related symptoms. The levels of immune biomarkers like T-Cells, T-Helper Cells, T-Cytotoxic Cells, B-Cells were found to be lowest in the evening and highest at the end of the shift in the morning. This is contrary to normal circadian changes reflecting phase shift in people working in the night shift. [21]

Other studies have noted that sleep disruption elevates circulating immune cells like granulocytes, T cells, and B cells, indicating systemic inflammation. High levels of IL-6, and TNF-α have been indicated. Evidence suggests activation of the hypothalamic-pituitary-adrenal (HPA) axis which influences metabolic, immune, and neurological systems increasing vulnerability to cancer. Dysfunction of the blood-brain barrier (BBB) and the subsequent increase in the BBB's ability to allow proinflammatory cytokines (such as Tumor Necrosis Factor-α) and immune cells to pass through is also noted. [22]

3.2. Sleep and Oxidative Stress

Sleep deprivation increases the generation of reactive oxygen species (ROS), leading to DNA strand breaks. Oxidative stress interferes with the apoptosis of mutated cells and is closely associated with circadian genes such as Per1, Per2, and RORα, which are tumor suppressors but are frequently dysregulated in cancer. [16]

The Light exposure at night (LEN) suppresses melatonin secretion and compromises DNA repair pathways, resulting in genomic instability. LEN also downregulates PER2, a tumor suppressor gene, impairing cell-cycle control and apoptosis. [23]

3.3. Role of Melatonin in Estrogen Signaling

Melatonin serves as a potent free radical scavenger by inducing antioxidant enzymes such as glutathione and glutathione S-transferase (GST). It downregulates estrogen receptor α (ERα) activity, modulates growth factor signaling, and promotes apoptosis in breast cancer cells. [16] Estrogen directly regulates core clock genes, including Bmal1, Per1, Per2, and Clock. [18]

Shortened or fragmented sleep elevates circulating levels of estradiol, luteinizing hormone (LH), progesterone, and prolactin, whereas prolonged and consolidated sleep enhances melatonin secretion and is associated with reduced breast cancer risk. [16]

3.4. Association of Sleep with Metabolic Dysfunction

Short sleep duration causes circadian misalignment which contribute to obesity, impaired glucose tolerance, insulin resistance, and reduced leptin levels, all of which are established risk factors for breast cancer. [16], [20]

Possible mechanisms underlying the association include hyperinsulinemia, chronic inflammation, antihyperglycemic medicines, and common risk factors. [24]

Hyperinsulinemia is linked to 7.2% of breast cancer cases. Obesity is also related to higher risk of cancer mortality. [25]

People with insomnia are at higher risk of metabolic dysfunction - reduced levels of high-density lipoprotein cholesterol (HDL), cholesterol and elevated levels of triglycerides (TG) compared to individuals without insomnia. High waist circumference, low HDL, and high low-density lipoprotein (LDL), increased triglycerides (TG), and fasting plasma glucose were noted in insomniacs. [22]

Circadian misalignment is associated with decreased leptin, increased glucose and insulin levels, an increase in mean arterial blood pressure, and reduced sleep efficiency. It was shown that women shift workers with excessive daytime sleepiness have lower levels of leptin than those without sleepiness. Further, the disruption of the normal diurnal sleep

pattern and long working hours are also associated with unfavourable lipid profiles and reduced consumption of healthy foods that predispose shift workers to obesity and other metabolic disorders. [26]

3.4.1. Circadian Genes and Breast Cancer

The circadian rhythm is primarily governed by core clock genes, including CLOCK, BMAL1, PER, and CRY. BMAL1 expression is tightly regulated by the nuclear receptors ROR and Rev-erbα, which help sustain circadian cycles. Epigenetic modulation to clock genes CLOCK, PER, and CRY are suggested to be the underlying mechanism of increased breast cancer risk in women who are shift workers. [7]

- CLOCK: Elevated CLOCK expression has been observed in breast cancer tissues. CLOCK knockout reduces cancer cell proliferation and downregulates metastasis-associated genes such as BDKRB2, SP100, and CCL5.
- PER genes: PER1 and PER2 act as tumor suppressors by inhibiting cell growth and promoting apoptosis. PER2 links the circadian system with estrogen receptor α (ERα) activity and suppresses tumor progression. Loss of PER2 promotes invasion and metastasis through suppression of epithelial-mesenchymal transition (EMT)-related genes.
- CRY Genes: CRY2 functions as a tumor suppressor, the knockdown of CRY2 alters pathways regulating differentiation, proliferation, motility, angiogenesis, and apoptosis in breast cancer cells.
- CLOCK/BMAL1 Heterodimer: This transcriptional complex has both oncogenic and tumor-suppressive roles. It enhances DNA repair via WEE1 kinase and inhibits CDK1. It can also exert anti-tumor effects by suppressing c-MYC expression, reducing proliferation, and promoting apoptosis.
- Other Circadian-Related Pathways: The Nrf2/ARE pathway, which is under circadian control regulates the oxidative stress. Silencing Nrf2 reduces proliferation and migration in breast cancer cell lines such as MCF-7 and MDA-MB-231. [17]

4. Discussion

Circadian rhythms are essential for maintaining physiological homeostasis and overall health. Behavioral circadian disruption has been linked to adverse health outcomes, including cancer progression and poorer prognosis. [18]

Night work remains essential in sectors such as healthcare, law enforcement, trade, and industry. Additional risk factors, including family history of cancer, hormone therapy use, and smoking, may further increase susceptibility. [27]

The growing evidence linking light at night (LAN) to cancer highlights the need for improved assessment methods in shift workers. Personal light exposure should be measured using calibrated devices that reflect circadian, rather than visual responses. [28]

Behavioral interventions and patient engagement in circadian health, supported by digital tools such as sleep and activity trackers, enable personalized strategies to improve sleep and circadian alignment. Circadian disruption and insufficient sleep contribute to increased healthcare costs and reduced productivity. [20]

4.1. Sleep duration and risk of breast cancer

A large prospective cohort study involving over 34,000 women aged 40-79 years evaluated the association between sleep duration and breast cancer risk over a median follow-up of 19 years. The findings revealed that shorter sleep duration was linked to a higher incidence of breast cancer. Compared with women reporting ≥8 hours of sleep, those sleeping 7 hours or ≤6 hours per night had an elevated risk, with the strongest association observed in postmenopausal and nulliparous women. [29]

Song S et al. also found that short sleep duration was strongly associated with a higher risk of breast cancer (OR = 4.86; 95% CI: 1.73-17.33). In contrast, longer sleep duration showed only a weak and uncertain link to breast cancer risk (OR = 1.16; 95% CI: 0.88-1.53). [30]

Lu et al. conducted a study to examine how sleep duration affects the risk of breast cancer. Their analysis of 415,865 participants from 10 studies showed a J-shaped nonlinear relationship between sleep duration and breast cancer. Using 6-7 hours of sleep as the reference, they found that breast cancer risk gradually increased with longer sleep durations. Women who slept more than the recommended range had a clearly higher risk of developing breast cancer. [31]

However, few studies indicate that sleep duration does not influence breast cancer risk. The Million Women Study, which followed over 713,000 women for 14.3 years, found no meaningful association between sleep duration and breast cancer risk after excluding the first five years of follow-up. Women sleeping fewer than 6 hours, 9 hours, or more than 9 hours had risks comparable to those sleeping 7-8 hours. A pooled analysis of this cohort with 14 other prospective studies, comprising more than 65,000 cases, likewise showed no significant link between short or long sleep duration and breast cancer. [32]

4.2. Duration and timing of light at night exposure and breast cancer risk

Light exposure during sleep rapidly suppresses melatonin, increases sleepiness, and delays sleep onset, with longer exposure producing stronger effects than higher brightness alone. Continuous nocturnal light also heightens alertness and induces larger circadian phase shifts, particularly when exposure occurs in the evening. Short-wavelength blue light (~460 nm) and high color temperature light (6500 K) are especially disruptive, causing greater melatonin suppression, circadian disruption, and hormonal changes than longer wavelengths or lower color temperatures. Such patterns of nighttime light exposure have been linked to elevated cancer risk, and night-shift or rotating-shift workers commonly show reduced or irregular melatonin secretion due to inconsistent nocturnal lighting. [19]

Keshet-Sitton et al. (2016) conducted a case-control study of 93 breast cancer cases and 185 controls to assess the impact of artificial light at night. Retrospective data on indoor and outdoor light exposure 10-15 years earlier were collected. Longer sleep duration was associated with reduced breast cancer odds (OR = 0.74, 95% CI: 0.57-0.97), and moderate indoor light exposure such as bedside-lamp use or sleeping in darker rooms showed similar protective associations (OR = 0.81 and 0.82). In contrast, residence near strong outdoor lighting increased risk (OR = 1.52, 95% CI: 1.10-2.12). These findings suggest that limiting nighttime light exposure may help reduce breast cancer risk. [33]

A meta-analysis by Luo et al. (2023), which evaluated 21 studies (13 case-control and 8 cohort) involving 734,372 participants worldwide, reported that exposure to light at night (LAN) is associated with an elevated risk of breast cancer, with the most pronounced effect observed among Asian women. Overall, LAN exposure was linked to a higher breast cancer risk (RR = 1.12; 95% CI: 1.06-1.17).

Subgroup findings indicated a stronger association in case-control studies (RR = 1.16) compared with cohort studies (RR = 1.08). Outdoor LAN exposure also showed a significant positive association (RR = 1.07). The highest risk estimates were noted in Asian populations (RR = 1.24). [34]

In a retrospective matched case-control study, researchers examined the potential link between exposure to blue light from mobile phone screens and the risk of breast cancer in women. The study included 301 breast cancer patients (cases) and 294 controls, who completed a standardized questionnaire, with subsequent data analysis. Heavy users in the case group had a significantly higher mean cumulative screen exposure over 10 years compared with controls. Nonetheless, no strong overall association was found between high-energy visible (HEV) blue light also known as artificial light at night (ALAN) and the development of breast cancer. [35]

Ritonja et al. (2020) conducted a population-based case-control study in Vancouver and Kingston, Canada, to assess whether residential outdoor light at night (LAN) influences breast cancer risk. The study included 844 cases and 905 controls and incorporated lifetime residential histories along with satellite-derived LAN levels from 5-20 years prior to enrolment. The analysis showed no meaningful association between outdoor LAN exposure and breast cancer. The findings were consistent regardless of menopausal status, night shift history, or residential movement, indicating that outdoor LAN likely has minimal effect on breast cancer risk. [36]

Song et al. (2023) reported that exposure to outdoor light while sleeping was linked to a modest, but non-significant, increase in breast cancer risk (OR = 1.15; 95% CI: 0.78-1.71). Similarly, women who kept lights on during sleep had a slightly elevated adjusted odds ratio of 1.26 (95% CI: 0.67-2.41). Overall, the study did not find a statistically meaningful association between indoor nighttime lighting and breast cancer risk. [30]

4.3. Shift work and risk of breast cancer

In a nested case-control study of Norwegian nurses (563 cases and 619 controls), Erdem et al. (2017) found that more demanding night shift schedules were associated with shorter telomere length. Nurses who worked six consecutive night shifts for more than five years showed a significant reduction in telomere length (−3.18; 95% CI: −6.46 to −0.58; P = 0.016). These results indicate that both the duration and intensity of night work may contribute to telomere shortening, potentially playing a role in increased breast cancer risk among female shift workers. [37]

He et al. (2015) conducted a meta-analysis of 28 studies and found that women exposed to circadian disruption had a 14% higher likelihood of developing breast cancer. Shift work was linked to a 19% increase in risk, light-at-night exposure to a 12% increase, and working as a flight attendant to a 56% increase. In contrast, short sleep duration did not show a meaningful association with breast cancer risk. [38]

Schernhammer et al. analysed data from 5,781 female twins in the Finnish Twin Cohort (1990-2018), identifying 407 breast cancer cases. Night shift work was associated with a higher breast cancer risk (HR = 1.58; 95% CI: 1.16-2.15). No increased risk was observed among two-shift workers without night duties. The association was most pronounced in women sleeping more than 8 hours per night (HR = 2.91; 95% CI: 1.55-5.46) and did not differ by chronotype. Co-twin analyses indicated that the findings were not explained by shared genetic or early-life factors, supporting a causal link between night shift work and breast cancer. [39]

In the multivariate logistic regression analysis by Song et al. (2023), adjustments were made for age, BMI, smoking, alcohol consumption, menopausal status, family history of breast cancer, breastfeeding duration, age at menarche, parity, age at first full-term pregnancy, and use of estrogen or oral contraceptives. After controlling for these factors, night or shift work showed no significant association with breast cancer risk. [30]

Sweeney et al. (2020) analysed data from 48,451 participants in the Sister Study, identifying 3,191 breast cancer cases over a mean follow-up of 9.1 years. The study found no significant overall association between night shift, rotating shift, or irregular work schedules and breast cancer. A modest increase in risk was observed among women with short-term (≤5 years) night or rotating night shift work, whereas longer-term exposure (>5 years) was not linked to elevated risk. The results provided limited support for a relationship between shift work and breast cancer, suggesting any potential risk may be restricted to shorter durations of night work. [40]

Travis et al. (2016) evaluated data from the Million Women Study, EPIC-Oxford, and UK Biobank, comprising more than 795,000 women with reported shift-work histories and subsequent cancer follow-up. Cox regression analyses showed no meaningful increase in breast cancer risk among women who had ever worked night shifts, including those with over 20 years of exposure. A pooled meta-analysis incorporating these findings with seven additional prospective studies encompassing 1.4 million women and 4,660 breast cancer cases among night-shift workers also demonstrated no significant association. The data indicated that night-shift work does not materially affect breast cancer risk, even with prolonged duration. [41]

Wegrzyn et al. (2017) analyzed data from the Nurses' Health Study and Nurses' Health Study II, encompassing more than 193,000 women with 24 years of follow-up and documenting 9,541 invasive breast cancer cases. In the original Nurses' Health Study, long-term rotating night-shift work (≥30 years) was not associated with increased breast cancer risk. In contrast, the younger Nurses' Health Study II cohort demonstrated a clear elevation in risk: women with ≥20 years of rotating night-shift work had substantially higher breast cancer incidence, particularly when exposure occurred in early adulthood. The findings suggested that prolonged rotating night-shift work may contribute to breast cancer risk primarily when initiated at younger ages, underscoring the relevance of exposure timing in assessing shift work-related risk. [42]

Samuelsson et al. (2018) reported mixed evidence regarding the relationships among night work, melatonin levels, and breast cancer risk. Night shift workers generally exhibited reduced melatonin secretion, indicated by lower first-morning urinary aMT6s concentrations compared with day workers. Several case-control studies have identified elevated breast cancer risk in women with night-shift exposure, including those who had ever worked night shifts, frequently rotated schedules, or worked during the circadian-sensitive early-morning window (12:00-5:00 a.m.). In contrast, a large prospective Dutch cohort found no association between night work and breast cancer, although the use of hospital admissions as the outcome measure limits the interpretability of this null finding. [16]

4.4. Sleep quality and risk of breast cancer

Li et al. (2023) conducted a prospective cohort study involving 78,232 participants, assessing sleep characteristics such as insomnia, daytime sleepiness, snoring, and sleep duration through self-reported questionnaires. Over a median follow-up of 5.67 years, 1,266 incident cancer cases were identified. Participants with the poorest overall sleep-quality scores had a higher risk of developing cancer overall, as well as colorectal, breast, uterine or cervical, prostate, kidney, and bladder cancers. [43]

4.5. Chronotype and breast cancer risk

Richmond et al. (2019) used Mendelian randomisation with UK Biobank and Breast Cancer Association Consortium (BCAC) data to assess causal links between sleep traits and breast cancer. In the UK Biobank, a stronger morning chronotype was associated with lower risk (HR = 0.95; 95% CI: 0.93–0.98), while sleep duration and insomnia showed no clear associations. Mendelian randomisation (MR) analyses indicated a protective effect of morning preference and suggested that longer sleep duration may increase risk. Two sample MR in BCAC confirmed these patterns, showing an inverse association for morning chronotype (OR = 0.88; 95% CI: 0.82–0.93) and a positive association for longer sleep duration (OR = 1.19; 95% CI: 1.02–1.39). Overall, the findings supported a protective role of morning chronotype and a potential adverse effect of prolonged sleep duration. [44]

Behren et al. (2024) analyzed data from the California Teachers Study, including 1,085 postmenopausal women who developed breast cancer and 38,470 cancer-free participants between 2012 and 2019. Using Cox regression models adjusted for major breast cancer risk factors, the investigators evaluated sleep quality, latency, duration, disturbances, use of sleep medications, and chronotype. No sleep quality or duration measures were significantly associated with subsequent breast cancer risk. However, an evening chronotype was linked to a modest increase in risk compared with a morning preference (HR = 1.19; 95% CI: 1.04-1.36). Overall, the findings indicated that poor sleep quality does not predict postmenopausal breast cancer, although evening chronotype may confer a slightly elevated risk. [45]

4.6. Insomnia and breast cancer risk

Liu et al. (2021) reported that women with insomnia had an elevated risk of breast cancer, with an adjusted hazard ratio of 1.16 (95% CI: 1.07–1.27; $p < 0.001$). [46]

Sen et al. (2017) evaluated insomnia symptoms in a prospective cohort of 33,332 Norwegian women followed for an average of 14.7 years, during which 862 invasive breast cancer cases were identified via the national cancer registry. Sleep difficulties including problems initiating sleep, maintaining sleep, and experiencing nonrestorative sleep were self-reported. While individual insomnia symptoms showed no consistent association with breast cancer, women reporting all three concurrently had a significantly elevated risk (HR = 2.38;95%CI:1.11-5.09). The findings indicated that isolated insomnia symptoms may not influence breast cancer risk, but combined sleep disturbances could markedly increase it. [47]

4.7. Light intensity and breast cancer risk

Samuelsson et al. (2018) provided strong evidence of an association between nighttime light exposure and breast cancer in a case-control study of 1,679 women. Higher bedroom light levels during sleep were linked to an increased breast cancer risk (OR = 1.22; 95% CI: 1.12-1.31). [16]

This review has several limitations that should be considered when interpreting the findings. Sleep disorders such as obstructive sleep apnea were not specifically assessed, despite their potential role in increasing breast cancer risk through intermittent hypoxia and immune suppression. As this was a narrative review rather than a meta-analysis, causal associations between artificial light at night (ALAN), circadian disruption, and breast cancer risk cannot be established, and pooled effect estimates were not generated.

Considerable heterogeneity among studies in design, exposure assessment, definitions of shift work and ALAN exposure, outcomes, and analytical methods limited comparability. Most evidence was derived from observational studies, making results susceptible to residual confounding, reverse causality, and selection bias. Reliance on self-reported light exposure and sleep measures may have introduced recall bias and exposure misclassification.

The review was restricted to English-language studies published between 2015 and 2025 and selected databases, potentially excluding relevant research. Small sample sizes and inconsistent reporting of confounders such as diet, body mass index, and lifestyle factors further limited generalizability. Additionally, many studies focused on specific populations, particularly nurses and Asian cohorts, which may restrict applicability to other occupational and ethnic groups. Limited reporting of prognostic outcomes, including overall survival, precluded assessment of long-term clinical impact.

Emerging technologies, including wearable devices and artificial intelligence-based applications, offer opportunities to monitor circadian rhythms and deliver tailored interventions relevant to breast cancer risk and outcomes. [20]

Preventive strategies to mitigate circadian disruption include optimizing shift work schedules, adopting lighting systems that minimize circadian disturbance, and reducing unnecessary light exposure at night. Limiting electronic device use before bedtime and using dim red lighting in bedrooms may further support circadian integrity. Given the strong association between circadian regulation and cancer, particularly hormone-dependent cancers, improving sleep quality and minimizing circadian disruption are important considerations in cancer prevention, treatment, and survivorship. [18]

Abbreviations

- Circadian Locomotor Output Cycles Kaput (CLOCK)
- Brain and Muscle ARNT-Like 1 (BMAL1)
- Period genes: PER1, PER2, PER3 (PER)
- Cryptochrome genes: CRY1, CRY2 (CRY)
- ROR: Retinoic acid-related orphan nuclear receptor
- OR- Odds Ratio
- CI- Confidence Interval
- HR- Hazards Ratio
- ALAN- Artificial light at night
- HDI- Human Development Index
- IARC- International Agency for Research on Cancer
- SCN- Suprachiasmatic Nucleus
- TLR's- Toll like receptors
- NK cells- Natural killer cells
- IL-2- Interleukin-2
- MeSH- Medical Subject Headings
- SAM- Sympathetic Adrenal Medullary
- HPA- Hypothalamic-pitutary-adrenal axis
- Th1 cells- T helper 1 cells
- Th2 cells- T helper 2 cells
- BBB- Blood Brain Barrier
- TNF-α- Tumor necrosis factor-α
- ROS- Reactive Oxygen Species
- LEN- Light exposure at night
- GST- Glutathione-S-Transferase
- Erα- Estrogen receptor-α
- HDL- High density lipoprotein
- TG- Triglycerides
- LDL- Low density lipoprotein
- LH- Leutinizing Hormone
- EMT- Epithelial mesenchymal transition
- HEV- High energy visible
- BCAC- Biobank and breast cancer association consortium
- MR- Mendelian randomisation

5. Conclusion

Circadian disruption and sleep disturbances are increasingly recognized as potentially modifiable risk factors for breast cancer, particularly among individuals engaged in night-shift or irregular work schedules. Emerging evidence suggests that misalignment of the biological clock, along with exposure to artificial light at night (ALAN), may influence hormonal regulation and carcinogenic pathways, thereby contributing to breast cancer risk. Interventions aimed at improving circadian hygiene such as optimizing sleep–wake cycles, designing healthier shift schedules, and minimizing nighttime light exposure hold promise as practical and preventive strategies in occupational and public health settings. However, there remains a need for longitudinal and mechanistic studies to establish causality, clarify underlying biological mechanisms, and inform the development of targeted chronopreventive and chronotherapeutic interventions. This study highlights an important avenue for breast cancer prevention that can enhance population health outcomes and paves the way for future research integrating circadian biology into clinical and public health practice.

Future study

Future research should focus on circadian influences on tumor biology and immune function, identification of biomarkers, and individualized treatment timing to improve therapeutic efficacy and prognosis in breast cancer. [20] Large, well-designed prospective studies need to be carried out using objective, circadian-relevant light exposure measurements, include diverse populations, and explore biomarkers and chronobiological parameters to better clarify causal pathways between circadian disruption and breast cancer risk.

Compliance with ethical standards

Disclosure of conflict of interest

The authors have no conflicts of interest to declare.

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