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Light at night and breast cancer risk: results from a population-based case–control study in Connecticut, USA

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Abstract

Objective—To investigate the potential association between domestic exposure to light at night (LAN) and the risk of human breast cancer.

Methods—A case–control study of female breast cancer was conducted in Connecticut. A total of 363 incident breast cancer cases and 356 age frequency-matched controls were interviewed using a standardized, structured questionnaire to obtain information on sleeping patterns and bedroom light environment. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated by unconditional multivariate logistic regression.

Results—A non-significantly increased risk of breast cancer was observed among postmenopausal women for those keeping lights on while sleeping (OR = 1.4, 95% CI 0.7, 2.7), those who reported mainly sleeping in the daytime (OR = 1.4, 95% CI 0.5, 4.3), and those not drawing the curtains/window shades while sleeping at night (OR = 1.2, 95% CI 0.8, 1.9).

Conclusion—The results from this study suggest a potential increased risk of breast cancer associated with domestic exposure to LAN. Further studies with larger sample size are needed to confirm the results.

Keywords

Light at night; Breast cancer; Case–control study

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Introduction

The International Agency for Research on Cancer (IARC) recently concluded that 'shift work that involves circadian disruption is probably carcinogenic to humans (group 2A)' [1]. This conclusion is based largely on studies investigating shift work and breast cancer risk in the workplace [2–11].

To date, while several studies have investigated the association between occupational exposure to light at night (LAN) and breast cancer risk, only two studies have evaluated domestic exposure to LAN and breast cancer risk. A case–control study by Davis et al. [10] reported a non-significant 40% greater risk of breast cancer (OR = 1.4, 95% CI 0.8, 2.6) for women who reported the highest ambient light level in the bedroom than those who reported total darkness in the bedroom while sleeping. Another study by O'Leary et al. [11] reported a significant 65% increased risk (OR = 1.65, 95% CI 1.02, 2.69) of breast cancer among women who frequently turned on lights at night during sleeping hours. An increased risk of breast cancer associated with LAN is supported by experimental studies suggesting that electric LAN could suppress the normal nocturnal rise in melatonin, which could in turn increase circulating estrogen levels or inhibit tumor anti-proliferative mechanisms and thus possibly increase breast cancer risk [10–15].

This case–control study was conducted in Connecticut, USA, to investigate the potential association between domestic exposure to LAN (characterized by sleeping patterns and bedroom lighting environment) and the risk of human breast cancer.

Materials and methods

Study population

The study population and methods have been described elsewhere [16]. In summary, cases chosen for the case–control study were histologically confirmed, incident breast cancer patients (International Classification of Diseases for Oncology, 174.0–174.9) between the ages of 30 and 80, with no previous diagnosis of cancer with the exception of non-melanoma skin cancer, who were alive at the time of interview.

Cases were recruited from two counties in Connecticut: New Haven County and Tolland County. In New Haven County, the cases were identified from Yale-New Haven Hospital (YNHH), where records of all newly performed breast-related surgeries were kept. We consecutively selected all breast cancer patients who met the study eligibility requirements as described above. For Tolland County, the cases were ascertained by the Rapid Case Ascertainment Shared Resource of the Yale Comprehensive Cancer Center, where the staffs were assigned geographically to survey all of the state's non-pediatric hospitals in order to identify newly diagnosed cased. Cases identified in the field were sent regularly to the Rapid Case Ascertainment Shared Resource data entry staff where the case's demographic information was entered, verified, and screened against the Connecticut Tumor Registry database. Connecticut also has reciprocal of cancer cases with adjacent states, facilitating complete ascertainment.

The controls from New Haven County were randomly selected from those who underwent breast-related surgery but who were histologically confirmed with either normal tissue or benign breast diseases without atypia. The controls from Tolland County were recruited through either random digit dialing (for those below aged 65) or from Health Care Finance Administration files (for those aged 65 and above). Efforts were made to frequency match the cases and controls by age (within 5-year intervals) using a 1:1 ratio by adjusting the number of controls randomly selected in each age stratum every few months.

Interviews

After approval by the hospitals and by each subject's physician, or following selection through random sampling, potential participants were approached by letter and then contacted by phone. Trained study interviewers interviewed those who agreed, either in the subject's home or at a convenient location. A standardized, structured questionnaire was used to obtain information on known or suspected risk factors for breast cancer. For domestic exposure to LAN, questions targeted detailed information on the participants' sleeping patterns and bedroom light environment in the 10 years prior to diagnosis (or reference date for controls).

Questions on sleeping patterns and bedroom light environment included: (1) whether hours slept occurred during the daytime or at night; (2) whether the lights were kept on while sleeping; (3) the presence of street lights, lighted signs, or any other exterior light which affected the sleeping area; (4) pulling a window shade or curtain while sleeping; (5) having radio, TV, and/or hall lighting on while sleeping, and (6) hours of sleep per day. Other information collected included reproductive history, family history of breast cancer, and other lifestyle factors (e.g., alcohol consumption and cigarette smoking). All procedures were performed in accordance with a protocol approved by the Yale Human Investigation Committee.

Data analysis

Unconditional logistic regression was used to estimate the association between various indices of LAN exposure (sleeping patterns and bedroom light environment) and breast cancer risk and to control for potential confounders. Variables included in the final model were age (<50, 50–59, ≥60 years), race and ethnicity, body mass index (<22.5, 22.5–25, 25–30, ≥30 kg/m^2), age at first menstrual period (≤12, >12), menopausal status, age at first full-term birth (nulliparous, <25, 25–29, 30–35, >35 years), lifetime months of lactation (0, ≤12, >12 months), family history of breast cancer in a first degree relative, and the presence of a positive history of cigarette smoking and alcohol consumption. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to estimate the strength of the association and the precision of the estimates using SAS (9.2 for Windows, SAS Institute Inc., Cary, NC, USA) statistical software.

Results

The demographic characteristics for the 363 breast cancer cases and 356 controls selected for the study are presented in Table 1. The average age of the cases was slightly higher than that of the controls, despite an attempt at frequency matching; therefore, age was controlled for in all subsequent analyses. A slightly higher proportion of cases reported an earlier age at first menstrual period. Cases also reported fewer months of lactation over their lifetime, while more cases reported positive family histories of breast cancer and cigarette smoking.

The results linking exposure to LAN (sleeping patterns and bedroom light environment) to breast cancer risk are shown in Table 2. The relatively small sample size and further stratification of the data by menopausal status make the point estimates less stable. However, the results suggest that while there was no statistically significant association between LAN exposure and breast cancer risk among postmenopausal women, there was a suggestion of an increased risk of breast cancer associated with the exposure to LAN, particularly for exposure indices which directly reflect the light exposure while sleeping. For example, a 40% (OR = 1.4, 95% CI 0.7, 2.7) greater risk of breast cancer was observed for postmenopausal women who reported having kept the lights on while sleeping as opposed to those who did not. Postmenopausal women who reported having spent more time sleeping

during the daytime (an indicator of having a night shift job) had a 40% (OR = 1.4, 95% CI 0.5, 4.3) greater risk of breast cancer. Compared to subjects who reported regularly pulling the window shade or curtain down while sleeping at night, those who did not had a 20% greater risk (OR = 1.2, 95% CI 0.8, 1.9) of breast cancer among postmenopausal women.

Other indices, which attempted to capture additional information about potential light exposure at night (either external lights including street lighting and lighted signs or internal lights including hall lights and having either the television or clock radio on while sleeping), did not show a clear association with breast cancer risk. The significant association was not observed between the duration of sleeping and breast cancer risk possibly due to the small number of subjects reporting very short or very long sleeping hours per day (for example, only four cases and four controls with the habit of sleeping 9 or more hours per day).

Further stratification by ER/PR status, however, appears to suggest that the risk associated with exposure to LAN was mainly seen among ER/PR-positive patients (data not shown). For example, an OR of 1.7 (95% CI 0.5–6.0) was observed for those who reported sleeping during daytime for ER/PR-positive patients. On the other hand, no increased risk was observed among ER/PR-negative patients. However, caution must be taken when interpreting the results by ER/PR status because of the relatively small sample size.

Discussion

The results from this case–control study suggest a potential association between domestic LAN exposure and breast cancer risk among postmenopausal women. Our results and the observed magnitude of the association are generally consistent with two earlier studies, which also evaluated domestic LAN exposure and the risk of breast cancer.

In 2001, a case–control study by Davis et al. [10] evaluated ambient light level in the bedroom at night and breast cancer risk. The study asked women to assess the ambient light level in the bedroom after switching the lights off in preparation for sleep through a subjective scale (total darkness or able to either see hand in front of face, see to the end of the bed, see across the room, barely read or read comfortably). Women who reported the highest level of light in the bedroom had a non-significant 40% greater risk of breast cancer (OR = 1.4, 95% CI 0.8, 2.6) than those who reported total darkness in the bedroom after switching the lights off. In another population-based case–control study, conducted in 1996 in New York, O'Leary et al. [11] reported a significant 65% (OR = 1.65, 95% CI 1.02, 2.69) greater risk of breast cancer for women who reported having turned the lights on two or more times per night, compared with those who reportedly turned the lights on at night very rarely.

Several mechanisms have been suggested to explain the link between LAN exposure and human breast cancer risk. It was originally suggested that electronic LAN could lower melatonin production by the pineal gland and that this suppression may lead to increased estrogen production and subsequently an increased breast cancer risk [17, 18]. Other more recently suggested mechanisms include alteration of clock gene function and desynchronization of the master clock in the suprachiasmatic nuclei from the peripheral clocks in tissue [18–20].

In experimental studies, melatonin suppression has been demonstrated to lead to changes in the gonadotrophin axis [21]. In human studies, sleep deprivation and the ensuing melatonin suppression lead to immunodeficiency [22, 23]. Perhaps, all these factors combined may contribute to an increased risk of breast cancer in women; that is, LAN exposure disturbs the circadian system with alteration of sleep-activity patterns, suppression of melatonin production, and deregulation of circadian genes involved in cancer-related pathways [18].

Circadian genes have been linked to breast cancer risk in our own breast cancer case–control study [20]. A study [24, 25] involving 147 breast cancer cases and 291 matched controls in the Nurses' Health Study II cohort reported a significant inverse association between melatonin levels and invasive breast cancer among postmenopausal women.

Our case–control study was the first to link domestic LAN exposure for the 10-year period preceding disease diagnosis and breast cancer risk. Through in-person interviews, the study collected detailed information on major domestic LAN exposure through exposure indices in this population-based case–control study. The results are generally consistent with two earlier case–control studies [10, 11], which also investigated the association between non-occupational exposure to LAN and breast cancer risk.

Recall bias was a potential limitation in case–control study since the disease was diagnosed when the interviews were taken place. However, differential misclassification on exposure was unlikely since we did not discuss with the interviewers about the specific study hypothesis, and at the time when the study was conducted, the hypothesis that exposure to LAN increases breast cancer risk was not as widely known as today. Non-differential misclassification bias on exposure, on the other hand, was likely since the subjects were asked to recall their exposure to LAN 10 year preceding their disease diagnoses. Non-differential misclassification on exposure might be part of the reason for lack of statistical significant association between LAN exposure and breast cancer risk observed in this study. Moreover, the relatively small sample size of our study has made the point estimates less stable, as reflected by the confidence intervals of the point estimates.

In summary, our study found a non-significantly increased risk of breast cancer associated with domestic exposure to LAN, which are consistent with the results from two earlier epidemiological studies. Further studies with larger sample size are needed to confirm the results observed in this study.

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Table 1
Selected characteristics of breast cancer cases and controls in Connecticut

Factors	Case (*n* = 363)		Controls (*n* = 356)	
	n	**%**	***n***	**%**
Age (years)				
50<	102	28.1	140	39.3
50–59	122	33.6	96	27.0
≥60	139	38.3	120	33.71
Race				
White	320	88.2	316	88.8
Black	32	8.8	28	7.9
Others	11	3.0	12	3.4
Body mass index (kg/m^2)				
<22.5	97	26.7	103	28.9
22.5 to <25	92	25.3	86	24.2
25–30	103	28.4	96	27.0
≥30	71	19.6	71	19.9
Age at first menstrual period (years)				
≤12	174	47.9	156	43.8
>12	189	52.1	200	56.2
Menopausal status				
Pre	74	20.4	127	35.7
Post	289	79.6	229	64.3
Age at first full-term birth (years)				
Nulliparous	44	12.1	60	16.9
<25	175	48.2	159	44.7
25–29	93	25.6	80	22.5
30–35	38	10.5	37	10.4
>35	13	3.6	20	5.6
Lifetime months of lactation				
No	234	64.5	225	63.2
≤12	79	21.8	81	22.8
>12	50	13.8	50	14.0
Family history of breast cancer in a first degree relative				
Yes	88	24.2	75	21.1
No	275	75.8	281	78.9
Cigarette smoking				
No	153	42.2	161	45.2
Yes[a]	210	57.9	195	54.8
Alcohol drinking				
No	56	15.4	57	16.0

Factors	Case (*n* = 363)		Controls (*n* = 356)	
	n	%	*n*	%
Yes[b]	307	84.6	299	84.0

[a] At least 100 cigarettes in the lifetime

[b] At least 12 drinks of any type of alcoholic beverage

Table 2

Risk of breast cancer associated with the sleep habits and bedroom characteristics among Connecticut women, stratified by menopausal status

Variable	Premenopausal (*n* = 201)			Postmenopausal (*n* = 518)		
	Cases/controls	OR	95% CI	Cases/controls	OR	95% CI
Keeping light on while sleeping						
No	67/118	1		263/214	1	
Yes	7/9	1.1	0.4, 3.6	26/15	1.4	0.7, 2.7
Sleeping during						
Night	71/121	1		280/223	1	
Daytime	3/6	0.9	0.2, 3.9	9/6	1.4	0.5, 4.3
Pulling a window shade or curtain while sleeping						
Yes	62//97	1		215/180	1	
No	12/30	0.7	0.3, 1.5	74/49	1.2	0.8, 1.9
Street lights, lighted signs, or any other exterior light outside sleeping area						
No	42/70	1		180/152	1	
Yes	32/57	1.0	0.5, 1.8	109/77	1.1	0.8, 1.7
A clock radio, TV, hall light, etc. on while sleeping						
No	13/24	1		45/37	1	
Yes	61/103	1.1	0.5, 2.5	244/192	1.1	0.6, 1.7

Adjusted for age group, race, body mass index, age at first menstrual period, family history of breast cancer, age at first full-term birth, months of lifetime breast feeding, cigarette smoking, and alcohol drinking

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