Research Letter

The Association between Outdoor Artificial Light at Night and Breast Cancer Risk in Black and White Women in the Southern Community Cohort Study

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Introduction

Black women in the United States are more likely to develop breast cancer at a younger age and to be diagnosed with more aggressive subtypes and more advanced stage disease, both contributing to higher rates of breast cancer mortality among Black women.[1] Light at night (LAN) has been proposed as a breast cancer risk factor because it inhibits nighttime production of melatonin, a hormone that may modulate biological pathways involved in breast cancer carcinogenesis.[2,3] Several epidemiologic studies have linked higher outdoor LAN estimated from satellite imagery to elevated incidence of breast cancer, including in cohorts predominantly comprised of White women with relatively high socioeconomic status (SES).[4,5,6] However, it remains unclear whether LAN is associated with breast cancer risk among Black women and women of lower SES.

Methods

We examined the relationship between LAN and incident breast cancer in the Southern Community Cohort Study (SCCS).[7,8] The vast majority of participants (86%) were recruited from community health centers in the southeastern United States that primarily served uninsured and underinsured populations, and $\sim 2/3$ were Black. Our analytic cohort included 30,518 Black and 12,982 White women who were cancer free and reported residential addresses at baseline. LAN exposures were estimated by linking geocoded baseline addresses (2002–2009) with satellite images in 2004 obtained by the U.S. Defense Meteorological Satellite Program's Operational Linescan System, and we used the high-dynamic range data to avoid saturation in high-LAN areas.[9] Incident breast cancer cases were identified via linkage to state cancer registries and vital status was ascertained from the Social Security Administration—both through 31 December 2017. Data on estrogen receptor (ER) status and cancer stage were obtained from cancer registries and supplemented by pathology reports and medical records. Race was self-reported at baseline. Institutional review boards at Vanderbilt University (Nashville, TN) and Meharry Medical College (Nashville, TN) approved the study and

participants provided informed consent at the time of enrollment. We used Cox proportional hazards models to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) comparing higher quintiles of LAN (Q2–Q5) with the lowest quintile, as well as for each 10-unit increase in LAN. Models were adjusted for multiple covariates as listed in table footnotes.

Results

Among all women in the cohort, we found a statistically significant increased risk of breast cancer overall in association with increasing levels of LAN [$HR_{Q5\,vs.\,Q1} = 1.27$ (95% CI: 1.00, 1.60), $p_{trend} = 0.05$] and for ER^+ breast cancer specifically [$HR_{Q5\,vs.\,Q1} = 1.37$ (95% CI: 1.02, 1.84), $p_{trend} = 0.01$] (Table 1). For Black women, the highest quintile was associated with a 28% increase in overall and ER^+ breast cancer risk [$HR_{Q5\,vs.\,Q1} = 1.28$ (95% CI: 0.98, 1.68), $p_{trend} = 0.05$ and 33% (1.33 (95% CI: 0.94, 1.88), $p_{trend} = 0.02$), respectively] with borderline statistical significance. The patterns of association appeared similar in White women, but the effect estimates were relatively less precise owing to smaller sample sizes and the p_{trend} values were not statistically significant. For ER^- breast cancer in Black women, breast cancer incidence appeared higher for women in Q2–Q5 of LAN compared to Q1 but did not show a clear exposure–response relationship. Results from the analysis stratified by tumor stage were mixed (Table 2): in Black women, the relationship between LAN and increased breast cancer risk was observed for localized breast cancer only, whereas in White women, the relationship was observed for regional/distant stages.

Discussion

Our findings corroborate the previously reported positive association between LAN and breast cancer risk and extend prior work by characterizing this relationship among both Blacks and Whites in a large cohort of women recruited from disadvantaged communities. Several previous cohort investigations, including in the California Teachers Study,[4] the Nurses' Health Study II,[5] and the National Institutes of Health–AARP Diet and Health Study,[6] reported a modest increase in breast cancer risk associated with higher outdoor LAN levels (10–14%, comparing the highest to the lowest quintile). In our SCCS analysis, the effect sizes appeared larger compared with those in previous cohorts[4,5,6] although the distribution of LAN was similar and the confidence intervals overlap. We speculate that the large proportion of low SES and Black women in the SCCS may have partially contributed to the larger effect sizes. Compared with those in more advantaged populations, low SES individuals are more likely to have sleep disturbances and shorter sleep duration due to poor housing conditions, high stress, and irregular and unpredictable daily schedules,[10] and therefore they may be more likely to

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Table 1. Associations [HR (95% CI)] between LAN and incidence of overall, ER$^+$ and ER$^-$ breast cancer in the Southern Community Cohort Study (2002–2017).

	LAN in 2004						
	Q1	Q2	Q3	Q4	Q5	p_{trend}	Per 10 nW/cm^2 per steradian increase
LAN, 10 nW/cm^2 per steradian [median (IQR)]	1.2 (0.8, 1.7)	6.2 (3.8, 9.1)	20.3 (16.3, 24.3)	35.9 (32.3, 39.5)	55.6 (48.9, 68.2)	—	—
All women							
Person-years	97,909	98,772	96,743	98,964	98,225	—	—
Overall breast cancer							
Cases (n)	233	230	258	229	274	—	—
Base model	Ref	1.00 (0.83, 1.20)	1.15 (0.96, 1.37)	1.03 (0.86, 1.23)	1.26 (1.05, 1.50)	0.01	1.03 (1.01, 1.05)
Full model	Ref	0.98 (0.82, 1.18)	1.13 (0.93, 1.36)	1.01 (0.82, 1.25)	1.27 (1.00, 1.60)	0.05	1.03 (1.01, 1.06)
ER$^+$ breast cancer							
Cases (n)	145	122	157	140	175	—	—
Base model	Ref	0.85 (0.67, 1.08)	1.13 (0.90, 1.42)	1.02 (0.81, 1.29)	1.31 (1.05, 1.63)	0.002	1.04 (1.01, 1.07)
Full model	Ref	0.82 (0.64, 1.05)	1.10 (0.86, 1.40)	1.02 (0.77, 1.34)	1.37 (1.02, 1.84)	0.01	1.05 (1.01, 1.08)
ER$^-$ breast cancer							
Cases (n)	44	52	58	59	67	—	—
Base model	Ref	1.18 (0.79, 1.76)	1.34 (0.91, 1.99)	1.34 (0.91, 1.99)	1.54 (1.05, 2.26)	0.03	1.06 (1.01, 1.10)
Full model	Ref	1.15 (0.77, 1.72)	1.18 (0.78, 1.79)	1.09 (0.70, 1.69)	1.23 (0.77, 1.98)	0.58	1.04 (0.98, 109)
Black							
Person-years	57,224	61,130	69,009	81,085	82,379	—	—
Overall breast cancer							
Cases (n)	133	130	195	188	233	—	—
Base model	Ref	0.92 (0.72, 1.17)	1.24 (1.00, 1.55)	1.04 (0.84, 1.30)	1.29 (1.04, 1.59)	0.01	1.03 (1.01, 1.06)
Full model	Ref	0.90 (0.71, 1.15)	1.21 (0.95, 1.53)	1.02 (079, 1.31)	1.28 (0.98, 1.68)	0.05	1.04 (1.00, 1.07)
ER$^+$ breast cancer							
Cases (n)	85	69	117	110	146	—	—
Base model	Ref	0.77 (0.56, 1.06)	1.18 (0.89, 1.56)	0.97 (0.73, 1.29)	1.28 (0.98, 1.68)	0.01	1.04 (1.01, 1.07)
Full model	Ref	0.74 (0.54, 1.02)	1.14 (0.85, 1.54)	0.96 (0.70, 1.34)	1.33 (0.94, 1.88)	0.02	1.05 (1.01, 1.09)
ER$^-$ breast cancer							
Cases (n)	26	38	51	54	62	—	—
Base model	Ref	1.36 (0.82, 2.23)	1.64 (1.02, 2.62)	1.49 (0.93, 2.37)	1.68 (1.06, 2.67)	0.06	1.05 (1.01, 1.10)
Full model	Ref	1.36 (0.82, 2.24)	1.53 (0.94, 2.50)	1.35 (0.82, 2.25)	1.52 (0.89, 2.61)	0.33	1.04 (0.99, 1.10)
White							
Person-years	40,685	36,641	27,734	17,878	15,846	—	—
Overall breast cancer							
Cases (n)	100	100	63	41	41	—	—
Base model	Ref	1.11 (0.84, 1.47)	0.94 (0.68, 1.28)	0.96 (0.67, 1.39)	1.12 (0.78, 1.62)	0.84	1.00 (0.95, 1.06)
Full model	Ref	1.09 (1.09, 0.82)	0.94 (0.67, 1.34)	1.02 (0.66, 1.57)	1.31 (0.79, 2.18)	0.51	1.03 (0.96, 1.11)
ER$^+$ breast cancer							
Cases (n)	60	53	40	30	29	—	—
Base model	Ref	0.98 (0.68, 1.42)	0.99 (0.67, 1.48)	1.18 (0.76, 1.83)	1.33 (0.85, 2.08)	0.15	1.04 (0.98, 1.11)
Full model	Ref	0.95 (0.65, 1.39)	0.94 (0.61, 1.47)	1.06 (0.62, 1.80)	1.33 (0.71, 2.49)	0.16	1.07 (0.98, 1.16)
ER$^-$ breast cancer							
Cases (n)	18	14	7	5	5	—	—
Base model	Ref	0.86 (0.43, 1.74)	0.57 (0.24, 1.37)	0.64 (0.24, 1.72)	0.73 (0.27, 1.97)	0.34	0.96 (0.83, 1.11)
Full model	Ref	0.84 (0.41, 1.72)	0.57 (0.22, 1.49)	0.67 (0.21, 2.21)	0.88 (0.21, 3.65)	0.71	1.04 (0.84, 1.27)

Note: Base model: adjusted for age (continuous). Full model: adjusted for age (continuous), education (less than high school, high school or GED, some college or vocational training, college graduate or higher), marital status (single, married, separated, divorced or widowed), income (<\$15,000, \$15,000–<\$25,000, \$25,000–<\$50,000, ≥\$50,000), health insurance coverage (yes, no, missing), family history of breast or ovarian cancer among first-degree female relatives (yes, no), mammogram (never, more than 2 y ago, within 2 y, missing), smoking status (current, former, never), pack-years (0, >0–≤5, >5–≤15, >15–≤30, >30, missing), number of live births (0, 1, ≥2), age at first birth (nulliparous, <20, 20–<30, ≥30, missing), age at menarche (≤12, >12 years of age), postmenopausal status (yes, no), ever use of menopausal hormone therapy (yes, no), average number of alcoholic drinks consumed per day (0, >0–1, >1), and population density and percentage of households living under the 2000 federal poverty line in the census tract (both continuous). For variables with >2% missing values (health insurance coverage, mammogram, pack-years, and age at first birth), participants with missing values were coded as a separate category. Otherwise, participants with missing values were grouped with the largest category (categorical variables) or coded using the median (continuous variables). —, not applicable; CI, confidence interval; ER, estrogen receptor; GED, General Educational Development; HR, hazard ratio; IQR, interquartile range; LAN, light at night; Q, quartile; Ref, reference.

engage in nonsleep activities at night that lead to higher exposures to ambient LAN. The strong correlation between LAN and urbanization may also suggest its correlation with cancer screening behaviors, and, subsequently, stage of disease at diagnosis. However, we did not see consistent evidence of a stronger relationship between LAN and stage of disease. We cannot exclude the possibility of residual confounding in our analyses due to factors such as lifestyle, work schedules, and access to health care. Moreover, outdoor LAN estimated from satellite imagery may not accurately reflect LAN exposures at the individual level. Future studies incorporating personal-level measures of light exposure may provide additional support for the association between LAN and breast cancer risk and help disentangle observed differences between groups.

Acknowledgments

Table 2. Associations (HR (95% CI) between LAN and incidence of breast cancer according to tumor stage in the Southern Community Cohort Study (2002–2017).

| | LAN in 2004 | | | | | | |
	Q1	Q2	Q3	Q4	Q5	p_{trend}	Per $10\,nW/cm^2$ per steradian increase
Black							
Localized							
Cases (n)	62	65	105	99	119	—	—
HR (95% CI)[a]	Ref	0.95 (0.67, 1.34)	1.35 (0.97, 1.89)	1.15 (0.80, 1.65)	1.45 (0.99, 2.14)	0.05	1.04 (1.00, 1.08)
Regional/distant							
Cases (n)	65	58	79	81	103	—	—
HR (95% CI)[a]	Ref	083 (0.58, 1.19)	0.99 (0.69, 1.40)	0.84 (0.58, 1.22)	1.03 (0.69, 1.53)	0.67	1.03 (0.98, 1.07)
White							
Localized							
Cases (n)	61	61	38	27	22	—	—
HR (95% CI)[a]	Ref	1.06 (0.73, 1.52)	0.85 (0.54, 1.33)	0.95 (0.55, 1.63)	0.93 (0.48, 1.81)	0.70	0.99 (0.89, 1.09)
Regional/distant							
Cases (n)	37	37	23	13	17	—	—
HR (95% CI)[a]	Ref	1.14 (0.71, 1.82)	1.13 (0.64, 2.01)	1.20 (0.57, 2.53)	2.42 (1.07, 5.45)	0.08	1.10 (0.99, 1.23)

Note: —, not applicable; CI, confidence intervals; GED, General Educational Development; HR, hazard ratio; LAN, light at night; Q, quartile; Ref, reference.

[a]Adjusted for age (continuous), education (less than high school, high school or GED, some college or vocational training, college graduate or higher), marital status (single, married, separated, divorced or widowed), income (<$15,000, $15,000–<$25,000, $25,000–<$50,000, ≥$50,000), health insurance coverage (yes, no, missing), family history of breast or ovarian cancer among first-degree female relatives (yes, no), mammogram (never, more than 2 y ago, within 2 y, missing), smoking status (current, former, never), pack-years (0, >0–≤5, >5–≤15, >15–≤30, >30, missing), number of live births (0, 1, ≥2), age at first birth (nulliparous, <20, 20–<30, ≥30, missing), age at menarche (≤12, >12 years of age), postmenopausal status (yes, no), ever use of menopausal hormone therapy (yes, no), average number of alcoholic drinks consumed per day (0, >0–1, >1), and population density and percentage of households living under the 2000 federal poverty line in the census tract (both continuous). For variables with >2% missing values (health insurance coverage, mammogram, pack-years, and age at first birth), participants with missing values were coded as a separate category. Otherwise, participants with missing values were grouped with the largest category (categorical variables) or coded using the median (continuous variables). $p_{interaction}$ = 0.28 for Blacks and 0.37 for Whites.

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