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CLINICAL RESEARCH ARTICLE
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Outdoor light at night and risk of coronary heart disease among older adults: a prospective cohort study

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Aims We estimated the association between outdoor light at night at the residence and risk of coronary heart disease (CHD) within a prospective cohort of older adults in Hong Kong.

Methods and results Over a median of 11 years of follow-up, we identified 3772 incident CHD hospitalizations and 1695 CHD deaths. Annual levels of outdoor light at night at participants' residential addresses were estimated using time-varying satellite data for a composite of persistent night-time illumination at ~1 km^2 scale. We used Cox proportional hazards models to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) of the association between outdoor light at night at the residence and risk of CHD. The association between light at night and incident CHD hospitalization and mortality exhibited a monotonic exposure-response function. An interquartile range (IQR) (60.0 nW/cm^2/sr) increase in outdoor light at night was associated with an HR of 1.11 (95% CI: 1.03, 1.18) for CHD hospitalizations and 1.10 (95% CI: 1.00, 1.22) for CHD deaths after adjusting for both individual and area-level risk factors. The association did not vary across strata of hypothesized risk factors.

Conclusion Among older adults, outdoor light at night at the residence was associated with a higher risk of CHD hospitalizations and deaths. We caution against causal interpretation of these novel findings. Future studies with more detailed information on exposure, individual adaptive behaviours, and potential mediators are warranted to further examine the relationship between light at night and CHD risk.

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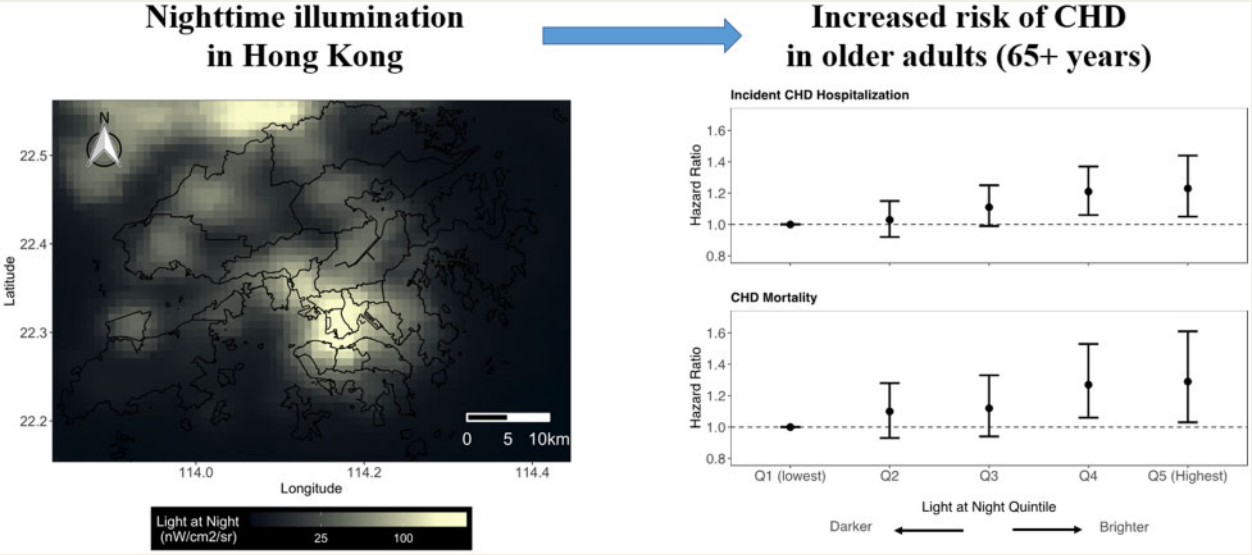
Graphical Abstract



Keywords Light at night • Cohort study • Coronary heart disease • Mortality • Hospitalization

Introduction

Coronary heart disease (CHD) is a leading cause of death globally, responsible for >8.9 million deaths and 165 million disability-adjusted life years in 2017.[1] While traditional risk factors account for a substantial proportion of CHD, the importance of environmental risk factors such as ambient air pollution and night-time noise are increasingly recognized.[2–4]

Outdoor light at night has been linked with a higher risk of cancer,[5,6] obesity,[7] high blood pressure,[8] depression and suicide,[9,10] self-reported insomnia,[11] and CHD.[12,13] The importance of quantifying any potential adverse impacts of light pollution is underscored by the rapid rates of urbanization across the globe; it is estimated that over 80% of the world population is being exposed to light-polluted skies at night.[14]

Circadian rhythms are important regulators of cardiovascular physiology and disease.[15] Light at night has been shown to suppress the secretion of nocturnal pineal melatonin and disrupt circadian rhythms.[15] Studies in both animals and humans suggest that disruption of circadian rhythms may be associated with a higher risk of CHD.[15–19] Given this evidence, it is plausible that light at night may be an unrecognized risk factor for CHD; however, few studies have evaluated this hypothesis.[12,13] Accordingly, we sought to estimate the association between residential outdoor light at night and risk of CHD among older adults in Hong Kong.

Methods

Study population

For this study, we leveraged existing data from the Chinese Elderly Health Service Cohort, a large prospective cohort study of Hong Kong residents aged 65 years and older administered by the Hong Kong Department of Health.[20] From 1998 to 2001, 66 820 older adults, about 9% of Hong Kong elders, were recruited into the 18 Elderly Health Centers of the Department of Health, one in each of the 18 districts, and were followed up through 31 December 2011. Of these, we excluded: (i) 5373 participants for whom we could not obtain a geocoded residential address, (ii) 1845 participants with missing values of any of the covariates included in the fully adjusted model described below, and (iii) 910 participants diagnosed with CHD during or before the year of enrolment. The final analytic sample included 58 692 participants (Supplementary material online, *Figure S1*). Cohort profile and data collection have been detailed elsewhere.[20,21] Ethics approval was obtained from the Ethics Committee of the Faculty of Medicine, The University of Hong Kong and the Department of Health of Hong Kong.

Assessment of outdoor light at night

Outdoor light at night was derived from the United States Defense Meteorological Satellite Program Satellites (DMSP-OLS). The DMSP-OLS light at night is 30 × 30 arc-second gridded nocturnal luminosity equivalent to ~1 km. It suffers from saturation that cannot distinguish light at night in bright areas (such as urban) even though they are much brighter.[22] By merging low, medium, and high fixed-gain levels images, the National Geophysical Data Center (NGDC) corrected the saturation of DMSP-OLS light at night and released global datasets of Radiance Calibrated light at night for 1996, 1999, 2000, 2003, 2004, 2006, and 2010.[23] To ensure comparability across years and satellites, we used interannual calibration coefficients provided by the United States National Oceanic and Atmospheric Administration to derive exposure estimates.[23]

We estimated an objective measure of light at night in units of radiance ($nW/cm^2/sr$) for each geocoded address in each year from 1998 to 2011 based on the most recent Radiance Calibrated light at night measure from the NGDC (*Figure 1*). These images have been suggested to be a good proxy measure of the relative levels of night-time illumination at ground level and have recently been used to estimate the impact of light pollution.[5,22]

Outcome ascertainment

We obtained records of emergency hospital admissions for CHD by linking the cohort with the electronic health record system of the Hong Kong Hospital Authority, which manages all 42 public hospitals in the entire territory of Hong Kong. We obtained records for deaths due to CHD via record linkage to the death registry of the Department of Health. Incident CHD hospitalization was defined as the first occurrence of emergency hospital admissions for CHD between 1998 and 2011, while CHD mortality was defined as any death from CHD. Coronary heart disease hospitalizations and deaths were coded according to the International Classification of Diseases, 9th (ICD-9) before 2001: 410–414 and 10th (ICD-10) from 2001: I20–I25, based on a primary discharge diagnosis or primary cause of death.

Clinical information

Clinical examinations and questionnaire interviews of participants were conducted by registered nurses and doctors (Supplementary material online). Clinical examinations at baseline included height, weight, blood pressure, glycated haemoglobin, and non-fasting total cholesterol. We computed body mass index (BMI) as weight in kilograms divided by height in metres squared and categorized as: <23.0 kg/m^2 (normal range and lower), 23.0–24.9 kg/m^2 (overweight), and ≥25.0 kg/m^2 (obese). Information on demographic characteristics and lifestyle factors was collected using a standardized and structured questionnaire.[20]

Participants were asked about their smoking status, indicated by their usual number of cigarettes per day and years of smoking, and were categorized as current smokers, former smokers, and never smokers.

Based on responses to questions about alcohol history, participants were classified as never drinkers, ex-drinkers, occasional drinkers (social drinkers or seasonal drinkers), and regular drinkers. We further categorized participants as never drinkers vs. ever drinkers (ex-drinkers, occasional drinkers, and regular drinkers).

The volume of physical activity was quantified by calculating hours of metabolic equivalent of task per week (MET-h/week) based on reported type, frequency, and duration of physical activity, and was then categorized as low (<1.0 MET-h/week), moderate (1.0–20.9 MET-h/week), and high (≥21.0 MET-h/week) volume of physical activity.[21]

Disease history at baseline was determined on the basis of self-reported medical history, supplemented by records of hospitalizations at baseline and clinical assessment, which included hypertension, diabetes mellitus, musculoskeletal (including osteoarthritis, rheumatoid arthritis, gout, low back pain, frozen shoulder), chronic obstructive pulmonary disease (COPD)/asthma, hypercholesterolaemia, and cerebrovascular disease.

Depressive symptoms

Psychological disorders are risk factors for CHD.[24] We assessed the presence of depressive symptoms at baseline based on the Chinese version of the 15-item Geriatric Depression Scale, which has been previously validated.[25] A score ≥8 is interpreted as suggestive of depression.

Long-term air pollution assessment

We used a validated satellite-based spatiotemporal model to estimate the annual concentration of $PM_{2.5}$ at the residential address of each participant.[21,26] Additional methodologic details are given in Supplementary material online.

Night-time traffic noise assessment

We estimated 2011 average night-time road traffic noise levels based on proximity to the five nearest roadways using the equation proposed by Tang and Tong (Supplementary material online, *Figure S2*).[27] We estimated the night-time traffic noise at the residential address of each participant (Supplementary material online).

Neighbourhood-level covariates

We included neighbourhood-level covariates with neighbourhoods defined by tertiary planning unit (TPU). For each of 291 TPUs in the study area, we estimated the following variables: per cent of residents with tertiary education, per cent with monthly domestic household income above US$1923, per cent of the population aged 65 years or older, and population density. We also included a district level, a larger administrative area than TPU, covariate of smoking rate among residents over 15 years old as a proxy for potential for the exposure to environmental tobacco smoke.

Statistical analysis

We used time-varying Cox proportional hazards regression to estimate the association between light at night and risk of CHD stratified by age at follow-up and by calendar year.[5] Follow-up time was used as the time-scale, calculated as the date of recruitment to the first of: date of CHD hospitalization, date of death, or 31 December 2011. We visually examined the proportional hazards assumption by plotting the Schoenfeld residuals and Kaplan–Meier survival curves and found no evidence suggesting departures from this assumption.

We first examined the association between light at night and CHD using a minimally adjusted model including age, calendar year, sex, and educational attainment as potential confounders. We next used a fully adjusted model that additionally included adjustment for the following established CHD risk factors: history of hypertension, hypercholesterolaemia, or diabetes, physical activity, BMI, alcohol consumption, TPU-level per cent with tertiary education, per cent with income ≥1923/month, per cent of elders ≥65 years, and population density, district smoking rate, yearly $PM_{2.5}$, and night-time traffic noise at the residential address. Note that light at night and $PM_{2.5}$ are time-varying while all other covariates were only assessed at study enrolment or 2011 (night-time traffic noise).

Results are expressed as hazard ratios (HR) per interquartile range (IQR) increase in continuous light at night or HRs in each of the upper four quintiles relative to the quintile with lowest light at night. We estimated the linear test for trend across quintiles by assigning the median

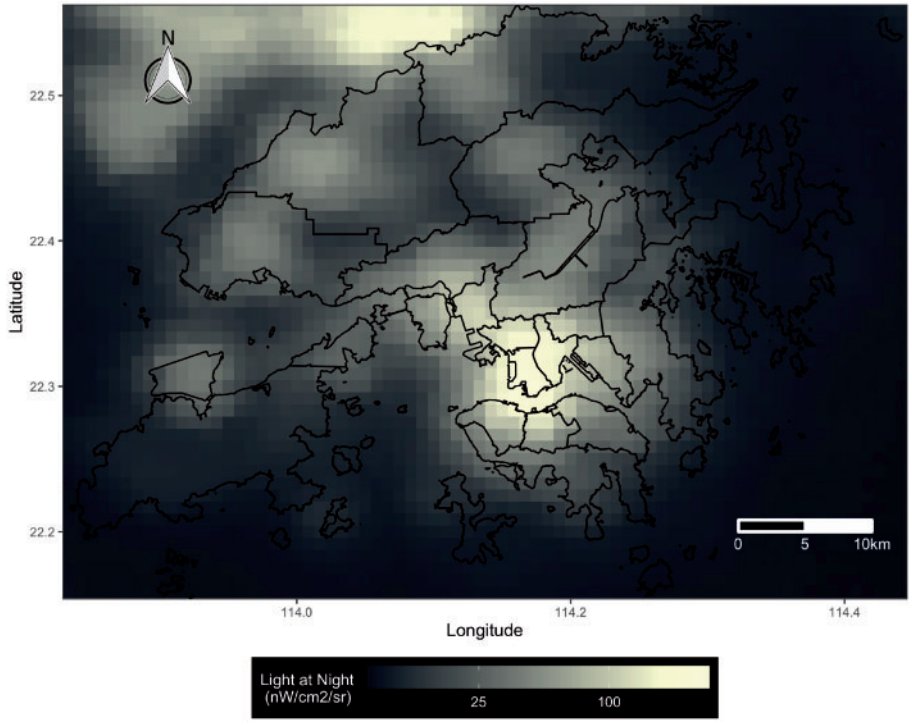


Figure 1 Hong Kong District Map showing the 2006 Defense Meteorological Satellite Program's (DMSP's) Operational Linescan System (OLS) light at night data in nanowatts per centimetre squared per steradian. The whole territory of Hong Kong covers a land area of over 1106 km^2 and a sea of over 1648 km^2. The solid lines delineate 18 districts of Hong Kong.

values of light at night to each quintile and treating the resulting variable as a continuous variable in models. To further examine the exposure-response curve describing the association between light at night and risk of CHD, we alternatively modelled light at night using a restricted cubic spline with three knots located at 10th, 50th, and 90th percentiles.

To examine the potential joint effects of $PM_{2.5}$ and night-time traffic noise, we cross-classified participants into those residing in low (lower 50th percentile of exposure range: ≤37.3 μg/m^3) vs. high (upper 50th percentile of exposure range: >37.3 μg/m^3) $PM_{2.5}$ areas and across light at night quintiles. We then evaluated the potential for interaction on both additive and multiplicative scales (Supplementary material online).

We conducted several sensitivity analyses to confirm the robustness of our results. First, to address the potential for exposure misclassification due to participants moving, we repeated the main analyses excluding participants who moved during the course of follow-up ($n = 6347$, 11%). Second, we repeated the main analyses additionally adjusting for the presence at baseline of the following conditions that might impair sleep quality: musculoskeletal disorders, COPD, or asthma, cerebrovascular disease, medications taken regularly (yes vs. no), and the presence of depressive symptoms. Third, we additionally adjusted for housing type (private, public and aided, and others), which might be correlated with light at night. Finally, the impacts of light at night might be different among night shift workers due to potential for different circadian rhythms and altered activity patterns. As we lack information on night shift work, in sensitivity analyses we excluded any participants still working at baseline ($n = 2956$, 5%).

To assess whether the association between light at night and CHD differed across subpopulations, we examined potential effect modification by age at baseline, sex, BMI, smoking status, alcohol consumption, educational attainment, history of hypertension, history of hypercholesterolaemia, and history of diabetes. We tested homogeneity across stratum-specific HRs using the interaction between continuous light at night and each potential modifier.

We performed all analyses in R software version 3.6.1 with 'Survival' package (version: 3.1-8) for the survival analysis. A two-tailed *P*-value <0.05 was considered statistically significant.

Results

Between 1998 and 2011, the 58 692 study participants who met our inclusion criteria experienced 3772 incident CHD hospitalizations and 1695 CHD deaths (*Table 1* and Supplementary material online, *Tables S1* and *S2*). Participants were predominantly females (65.8%), never smokers (71.2%), elders who performed a moderate volume of physical activity (78.0%), and had a personal expenditure of 128–384 US$ per month (68.9%). Participants in higher quintiles of outdoor light at night were more likely to live in areas of higher population density, $PM_{2.5}$, and night-time traffic noise. Participants in lower quintiles of light at night tended to report higher levels of physical activity, but have fewer years of education.

Outdoor light at night at the residence was associated with a higher risk of CHD hospitalization and mortality (*Table 2*). In fully adjusted models, the HR in the highest quintile was 1.23 (95% CI: 1.05, 1.44) for CHD hospitalization and 1.29 (95% CI: 1.03, 1.61) for

CHD mortality, compared with the lowest quintile. An IQR (60.0 nW/cm^2/sr) increase in annual levels of light at night was associated with an HR of 1.11 (95% CI: 1.03, 1.18) for CHD hospitalization and an HR of 1.10 (95% CI: 1.00, 1.22) for CHD mortality.

We further examined the shape of the exposure-response curve for the relationship between light at night and risk of CHD (*Figure 2* and *Take home figure*). Although the exposure-response curve increases monotonically, a plateau is evident at the highest levels of light at night exposure.

We examined the potential joint effects of light at night and $PM_{2.5}$ on risk of CHD. We found some indication of interaction for CHD mortality, but no evidence of interaction between light at night and $PM_{2.5}$ for CHD hospitalization (Supplementary material online, *Table S3*).

Sensitivity analyses

Results were robust across a number of sensitivity analyses (Supplementary material online, *Tables S4–S6*). A total of 6347 participants moved during the follow-up, and after excluding those participants, the estimated associations remained unchanged. Additional adjustment for conditions that might impair sleep quality or excluding participants who were still working during the baseline ($n = 2956$) did not materially change the results. Additional adjustment for medication and housing type did not materially alter the observed association between light at night and risk of CHD.

We conducted stratified analyses to identify potentially vulnerable subpopulations (*Figure 3*). Although the association for CHD mortality was stronger among relatively younger elders, elders free of hypercholesterolaemia at baseline, and those that consumed alcohol, none of these differences were statistically significant.

Table 1 Summary statistics of the participants' baseline characteristics

Characteristics	Overall
Light at night, nW/cm^2/sr, range	2.2–233.1
$PM_{2.5}$, μg/m^3, mean	35.0
Night-time traffic noise, dB(A), mean	47.1
Individual factors	
Age, years, mean ± SD	77.5± 6.0
Sex, %	
Male	34.2
Female	65.8
BMI, %	
<23.0 kg/m^2 (normal range and lower)	37.1
23.0–24.9 kg/m^2 (overweight)	22.6
≥25.0 (obese)	40.3
Smoking status, %	
Never smokers	71.2
Former smokers	19.1
Current smokers	9.7
Alcohol drinking, %	
Never drinker	72.2
Ex-drinker	9.6
Occasional drinker	14.1
Regular drinker	4.0
Physical activity volume, MET-h/week, %	
<1.0	15.3
1.0–20.9	78.0
≥21.0	6.7
Education level, %	
≥Secondary	17.3
Primary	37.2
<Primary	45.5
Expense per month, US$, %	
<128	16.3
128–384	68.9
≥385	14.8
Hypertension, %	35.6
Hypercalcaemia, %	15.7
Diabetes, %	12.1
TPU level risk factors, mean per cent ± SD	
≥65 years of age	12.1± 4.2
>Secondary education	13.1± 8.0
Income ≥1923 US$/month	59.6± 11.6
Population density, 1000 persons/km^2	51.9 ± 33.8
District level risk factors	
Smoking rate, mean per cent ± SD	11.6± 0.4

BMI, body mass index; MET-h/week, hours of metabolic equivalent of task per week; $PM_{2.5}$, fine particulate matter; SD, standard deviation; TPU, tertiary planning unit.

Discussion

In this longitudinal study of 58 692 Chinese elders followed for a median of 11 years, outdoor light at night at the residential address was associated with a higher risk of CHD hospitalization and mortality, even after adjustment for a wide range of individual and area-level risk factors for CHD. Results were robust to several additional sensitivity analyses.

Emerging epidemiologic studies have reported that outdoor light at night is associated with a higher risk of high blood pressure,[8] psychiatric disorders,[9,10] and cancer.[5,6] For example, in an analysis of the 2009 Korean Community Health Survey, Min and Min reported a 1.29-fold (95% CI: 1.15, 1.46) higher risk of depressive symptoms and 1.27-fold (95% CI: 1.16, 1.39) higher risk of suicidal behaviours for adults living in areas with the highest vs. lowest levels of light at night.[9] Among 109 672 women participants of the US Nurses' Health Study II, James *et al.*[5] reported that an IQR (31.6 nW/cm^2/cr) increase in light at night was associated with 1.05 (95% CI: 1.00, 1.11) higher risk of incident breast cancer.

To our knowledge, this is the first prospective cohort study to examine the association between light at night and risk of CHD. However, our results are broadly consistent with an emerging literature. In a cross-sectional study among 700 elderly individuals in Japan, Obayashi *et al.*[13] found that higher levels of night-time light intensity measured inside the bedroom were positively associated with measures of carotid atherosclerosis. A separate prospective study found that night-time light in the bedroom was associated with the progression of subclinical carotid atherosclerosis among 989 elderly participants.

Table 2 Association between outdoor light at night and risk of coronary heart disease in the Hong Kong Department of Health Elderly Health Service Cohort (n = 58 692)

	Number of events	Minimally adjusted model[a] HR (95% CI)	Fully adjusted model[b] HR (95% CI)
Incident CHD hospitalizations			
Quintile 1 (median 24.5 nW/cm^2/sr)	734	Reference	Reference
Quintile 2 (median 38.4 nW/cm^2/sr)	730	1.01 (0.91, 1.12)	1.03 (0.92, 1.15)
Quintile 3 (median 56.6 nW/cm^2/sr)	762	1.06 (0.96, 1.18)	1.11 (0.99, 1.25)
Quintile 4 (median 85.6 nW/cm^2/sr)	782	1.12 (1.01, 1.24)	1.21 (1.06, 1.37)
Quintile 5 (median 137.4 nW/cm^2/sr)	764	1.07 (0.96, 1.19)	1.23 (1.05, 1.44)
P for trend[c]		0.09	0.01
Continuous light at night (per IQR increase[d])	3772	1.04 (1.00, 1.09)	1.11 (1.03, 1.18)
CHD mortality			
Quintile 1 (median 24.5 nW/cm^2/sr)	354	Reference	Reference
Quintile 2 (median 38.4 nW/cm^2/sr)	332	1.09 (0.93, 1.26)	1.10 (0.93, 1.28)
Quintile 3 (median 56.6 nW/cm^2/sr)	324	1.10 (0.95, 1.28)	1.12 (0.94, 1.33)
Quintile 4 (median 85.6 nW/cm^2/sr)	341	1.22 (1.05, 1.41)	1.27 (1.06, 1.53)
Quintile 5 (median 137.4 nW/cm^2/sr)	344	1.18 (1.01, 1.37)	1.29 (1.03, 1.61)
P for trend[c]		0.02	0.03
Continuous light at night (per IQR increase[d])	1695	1.08 (1.01, 1.15)	1.10 (1.00, 1.22)

CHD, coronary heart disease; CI, confidence interval; HR, hazard ratio; IQR, interquartile range.
[a]Models included age, calendar year, sex, and educational attainment.
[b]Models were additionally adjusted for body mass index, smoking status, alcohol drinking, physical activity, personal income, history of hypertension, hypercholesterolaemia, diabetes, tertiary planning unit (TPU) level of per cent of population aged ≥65 years, per cent with secondary education, per cent with income ≥1923 US$ per month, and population density, district level of smoking rate, yearly fine particulate matter ($PM_{2.5}$), and night-time traffic noise at the residential address.
[c]Test for trend is based on the median value for each quintile.
[d]An IQR increase in outdoor light at night at the residential address is 60.0 nW/cm^2/sr.

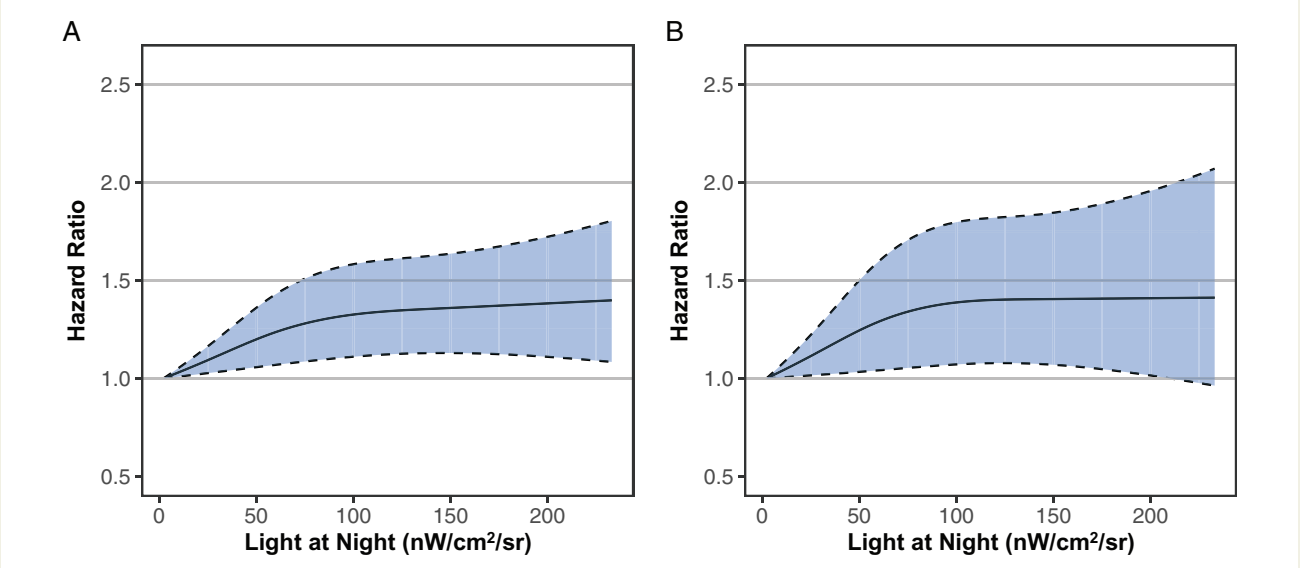
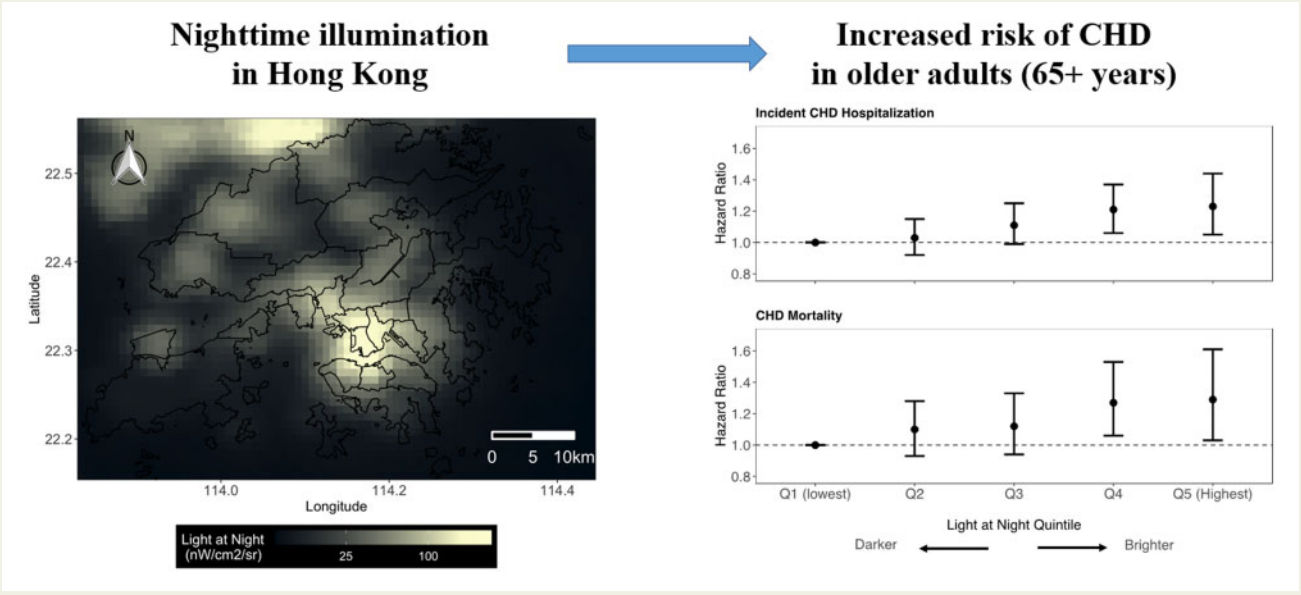


Figure 2 Exposure-response curve for the association between outdoor light at night at the residential address and risk of coronary heart disease in older adults. (*A*) Incident coronary heart disease hospitalization. (*B*) Coronary heart disease mortality. Light at night was fitted as a smooth term using a restricted cubic spline with 3 knots. The blue-shaded areas represent 95% confidence interval.



Take home figure Outdoor light at night at the residential address and risk of coronary heart disease (CHD) among older adults.

Our results are also consistent with insights provided by studies of night shift workers, who tend to be exposed to higher levels of light at night, have disrupted circadian rhythms, and have higher risk of CHD.[17,28] For example, in an analysis of 189 158 women in the Nurses' Health Study, rotating night shift workers had a 2–18% higher risk of CHD compared with women who never worked rotating night shifts.[17] A meta-analysis[28] of 34 prior studies reported that night shift work was associated with risk ratios of 1.23 (95% CI: 1.15, 1.31) for myocardial infarction and 1.24 (95% CI: 1.10, 1.39) for coronary events.

Biological plausibility for the observed association

Exposure to night-time light may increase the risk of CHD by the disruption of circadian rhythms which affect endothelial function and thrombus formation.[15,29] Genetically modifying the molecular circadian rhythms of animals resulted in the circadian rhythm disruption and cardiovascular dysfunction.[18,19] Thus, outdoor light at night that penetrates into the bedroom could lead to a higher risk of CHD by disrupting our intrinsic circadian rhythms, potentially leading to circadian misalignment.[15] By triggering inflammatory responses, light at night has also been proposed to be an environmental stressor that detrimentally affects the immune system.[30]

Strengths and limitations

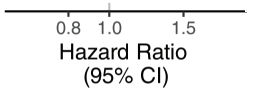
These results need to be considered in light of potential limitations. First, this study is based on outdoor light at night, which is not necessarily equivalent to total light experienced in the bedroom, since there may also be indoor sources of night-time light as well, or the use of black out curtains or other adaptive behaviours that limit the amount of outdoor light that penetrates into the bedroom. Thus, we caution that these results should be interpreted as reflecting the association of CHD with outdoor light at night rather than with total night-time light in the bedroom. Indeed, the apparent saturation effect observed in the exposure-response curve is consistent with personal adaptative behaviours such as the usage of light-blocking shades or curtains in places with brighter light at night. Moreover, our estimates of light at night are derived from satellite data and provide only a measure of light intensity, but not insights into the spectrum of lighting. Second, we do not have data on sleep quality, thus we are unable to assess sleep patterns or quality as a potential mediator of the association. In additional sensitivity analyses, we further adjusted for diseases that might influence sleep quality, and findings were not materially different from the main findings. Third, although we adjusted for a large number of risk factors for CHD at the individual and neighbourhood levels, including air pollution, population density, and night-time noise, we cannot exclude the possibility of residual confounding by unrecognized correlates of both light at night and CHD risk. Fourth, as the current study was conducted in a Chinese older population, the results may not be generalizable to younger individuals or to other locations beyond Hong Kong.

On the other hand, notable strengths of our study include the prospective study design, large sample size, well-characterized population, a wide range of values of light at night, and adjustment for a number of individual and neighbourhood-level covariates. Future studies from other populations or countries are needed to confirm or refute these findings.

Conclusions

Within the context of a large prospective cohort of elderly residents of Hong Kong, we found that individuals living in areas of the region with higher levels of outdoor light at night may be at higher risk of

Characteristics	Subgroup	Incident CHD hospitalization		CHD mortality	
		Hazard Ratio (95% CI)	Effect Modification	Hazard Ratio (95% CI)	Effect Modification
Age	< 71 y	1.09 (0.97, 1.23)	Ref.	1.32 (1.06, 1.63)	Ref.
	≥ 71 y	1.10 (1.01, 1.19)	0.942	1.05 (0.95, 1.17)	0.09
Sex	Male	1.07 (0.97, 1.19)	Ref.	1.13 (0.98, 1.31)	Ref.
	Female	1.10 (1.01, 1.20)	0.736	1.08 (0.95, 1.22)	0.638
BMI	23.0–24.9 kg/m^2	1.09 (0.95, 1.24)	Ref.	1.07 (0.87, 1.32)	Ref.
	< 23.0 kg/m^2	1.16 (1.04, 1.30)	0.438	1.23 (1.07, 1.42)	0.261
	≥ 25.0 kg/m^2	1.04 (0.94, 1.15)	0.599	0.99 (0.84, 1.17)	0.582
Smoking status	Never smoker	1.08 (1.00, 1.17)	Ref.	1.08 (0.96, 1.23)	Ref.
	Ever smoker	1.11 (0.99, 1.24)	0.767	1.12 (0.96, 1.31)	0.748
Alcohol drinking	No	1.07 (0.99, 1.15)	Ref.	1.04 (0.92, 1.16)	Ref.
	Yes	1.17 (1.03, 1.32)	0.251	1.26 (1.06, 1.50)	0.083
Educational attainment	≥ Primary	1.07 (0.98, 1.17)	Ref.	1.16 (1.02, 1.32)	Ref.
	< Primary	1.12 (1.01, 1.24)	0.539	1.03 (0.89, 1.19)	0.201
Hypertension	No	1.13 (1.03, 1.24)	Ref.	1.18 (1.02, 1.36)	Ref.
	Yes	1.06 (0.97, 1.17)	0.366	1.05 (0.92, 1.19)	0.232
Hypercholesterolemia	No	1.11 (1.03, 1.20)	Ref.	1.14 (1.03, 1.27)	Ref.
	Yes	1.04 (0.89, 1.20)	0.392	0.91 (0.72, 1.16)	0.068
Diabetes	No	1.06 (0.99, 1.15)	Ref.	1.09 (0.97, 1.21)	Ref.
	Yes	1.21 (1.05, 1.40)	0.128	1.18 (0.96, 1.45)	0.495



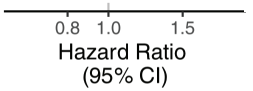


Figure 3 The hazard ratios of incident coronary heart disease hospitalization and mortality per interquartile range (60.0 nW/cm^2/sr) increase in annual light at night by personal characteristics at baseline. BMI, body mass index; CHD, coronary heart disease; CI, confidence interval.

coronary heart disease. These findings substantially extend the existing evidence that light at night is detrimental to healthy aging broadly and points to light at night as a potential novel risk marker for CHD. We caution against causal interpretation of these novel findings and call for further studies with direct measurements of individual exposure to night-time light, adaptive behaviours, and sleep quality.

Data availability

Data sharing with qualified researchers may be considered after submission of a proposal to Elderly Health Service, Department of Health, Hong Kong.

Supplementary material

Supplementary material is available at *European Heart Journal* online.

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Conflict of interest: G.A.W. has served as a paid member of multiple expert panels for the Health Effects Institute (Boston, MA, USA) providing expertise on the health effects of air pollution. G.A.W. currently serves as a paid visiting scientist at Google Research (Mountain View, CA, USA).

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