

An outbreak of bilateral photokeratitis and eyelid erythema following exposure to an artificial source of ultraviolet radiation, Tamil Nadu, India, 2018

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Background: Metal halide lights (MHLs) emit ultraviolet radiation (UVR) and should be used with enclosed fixtures. We investigated a cluster of blurred vision in a locality in South India reported among light music event attendees to identify risk factors.

Methods: We searched for attendees with any eye-related symptoms by door-to-door. We described cases by time, place, and person and inspected the environment to generate a hypothesis. We followed-up the cohort of the attendees to examine the hypothesis of exposure to MHL as the cause of the outbreak. We computed relative risk (RR) and 95% confidence interval (CI) by comparing attack rates among attendees by seating location and duration of exposure.

Results: Of the total 500 attendees, we could interview 319 (64%) and 89% (284/319) attendees developed bilateral photokeratitis (median age = 24 years [range: 2–80 years]). Attack rate was higher among female (92% [172/189]) than male (85% [110/130]). Attack rate among those seated within 12 meters from dais was higher (95% [241/253]) than the rest (65% [43/66]; RR = 1.5; 95% CI = 1.2, 1.7) and attack rate was higher among those continuously exposed to MHL (97% [268/277]) than others (38% [16/42]; RR = 2.5; 95% CI = 1.7, 3.7). The duration of exposure was associated with increased risk of bilateral photokeratitis (χ^2 test for linear trend = 74; $P < 0.00001$). During the environmental inspection, we identified the use of MHL with a broken outer envelope.

Conclusions: Photokeratitis was associated with exposure to UVR from MHL with a broken outer envelope. We recommended the usage of MHL along with enclosed fixtures.

Keywords: India; Metal halide light; Outbreak; Photokeratitis; Ultraviolet radiation

Introduction

Ultraviolet radiation (UVR) is a part of the electromagnetic spectrum with a wavelength of 100 to 400 nm, shorter than the visible light but longer than x-rays.¹ The ultraviolet spectrum is divided into three bands: UVA (315–400 nm), UVB (280–315 nm), and UVC (100–280 nm).¹ Sunlight is the only natural source of UVR. The artificial sources of UVR are tanning devices, welding arc, phototherapy devices, UVR lamps, and high-intensity lights.² UVR exposure to humans could be natural, occupational, household, recreational, therapeutic, and occupational.

The high radiant energy of the UVR damages the epithelium of the eye and skin, thus, causes some acute effects. Exposure to UVR causes acute diseases such as photokeratitis, photoconjunctivitis, and eyelid erythema in the eye.^{1,2} Photokeratitis is a self-limiting disease of the cornea with the clinical symptoms of redness of the eye, blurring of vision, watering from the eye, photophobia, ocular pain, and foreign-body sensation of the eye.^{3,4} Photokeratitis is also known as UV keratitis, welder's eye, and snow blindness.^{4,5}

On 18 August 2018, local media reported a cluster of blurred vision among attendees of a light music event organized the previous day at Palani, Tamil Nadu, Southern India. The State Public health authority deputed Field Epidemiology Training Programme (FETP) trainee along with an ophthalmologist to investigate the cluster in collaboration with the district surveillance team. We investigated the cluster from 19 August to

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What this study adds

This study describes the occurrence of adverse events following acute exposure to artificial ultraviolet radiation in low-middle-income countries (LMICs). Metal halide lights, which are meant for illuminating stadium and industries, were used during a public event in India. Epidemiological evidence suggests that unsafe exposure to metal halide light for a brief period could cause photokeratitis, skin erythema, and corneal erosion among event attendees. This study adds the usage of metal halide lights should be regulated for public use through awareness campaigns in India. Also, the disease surveillance systems need to be flexible to capture such events of public health importance.

confirm the diagnosis, identify potential risk factors, and recommend public health measures.

Methods

The presenting symptoms of redness of both the eyes, foreign-body sensation, and blurred vision suggested the diagnosis of bilateral photokeratitis by an ophthalmologist. We defined the case as any one of the following symptoms such as redness of the eye, watering of the eye, photophobia, blurred vision, eye pain, foreign-body sensation in the eye, eyelid swelling, and eyelid erythema among the event attendees since 8 PM (Indian Standard Time) 17 August 2018 at Palani, Tamil Nadu, India.

Using this definition, we searched door-to-door to identify the cases. We excluded the attendees with preexisting eye diseases and those with the history of eye surgery. We generated a list of the event attendees with inputs from the event organizers.

We calculated the attack rate of bilateral photokeratitis by age, gender, type of the attendees, and seating location during the event with a total number of attendees as the denominator. We drew an epidemic curve by the time of onset of bilateral photokeratitis and plotted cases by their seating location during the event.

We inspected the venue and arrangements. We interviewed the event organizers and a few event attendees on the sequence of events to generate the hypothesis. Based on the descriptive epidemiology, interview, and environmental investigations, we generated the hypothesis that exposure to metal halide light used during the event could be the reason for bilateral photokeratitis.

We conducted a retrospective cohort study of the event attendees to examine the hypothesis. We conducted a face-to-face interview with the event attendees with a standardized questionnaire. The responses were recorded in a mobile-based android application. We collected information on demographics, usage of spectacle during the event, time of onset of symptoms, time duration of attending the event, whether seated throughout the event (=continuously exposed) or took break(s) in between the event (=intermittently exposed), whether they developed symptoms during the event, seating location during the event. Based on the seating location information and the location of damaged lights, we calculated the distance between the individual and the light sources.

We computed relative risk (RR) and 95% confidence interval (CI). We calculated population attributable risk (PAR) with the formula $[P_e(RR - 1)] / [P_e(RR + 1)]$, where P_e stands for exposure rate in the general population.⁶ We examined dose-response between the duration of exposure and attack rates of bilateral photokeratitis with χ^2 test for linear trend. We followed-up the case-patients until they became symptoms free. We used Epi Info (Ver. 7.2.3.1; Centers for Disease Control and Prevention, Atlanta, GA) for data management and analysis.

Results

Overall, 500 persons reportedly attended the event, and we could interview 64% (n = 319) of them. The response was higher among female (71% [189/267]) than male (58% [130/223]). All the attendees less than 15 years old responded. We could not obtain age and gender details for 181 nonresponders for making a comparison with that of the responders.

Of the interviewed, the median age of the attendees was 24 years (range: 2–80 years) and 284 (89%) of them had bilateral photokeratitis. Alternatively, the attack rates would have been 93% and 57%, had we assumed all the nonresponders as cases or noncases, respectively.

In terms of attack rate by age and gender, it was maximum (94% [63/67]) among children 5–14 years old and was higher among females (92% [172/189]) than males (85% [110/130]). The attack rate of bilateral photokeratitis did not differ by type

Table 1. Attack rate of bilateral photokeratitis by age, gender, and type of attendee, Palani, Tamil Nadu, India, 2018

Characteristics	No. Cases	No. Attendees	Attack rate (%)
Age group (years)			
<5	3	5	60
5–14	63	67	94
15–44	162	185	88
≥45	56	62	90
Gender			
Female	174	189	92
Male	110	130	85
Type of attendee			
Event performers	10	13	77
Spectators	274	306	90
Overall	284	319	89

Bold indicates to differentiate the overall numerator, denominator and attack rate from the sub-groups.

of attendees (spectators: 90% [274/306] and performers: 77% [10/13]) (Table 1).

None of the examined had preexisting eye disease or a history of eye surgery. Twelve percent of case-patients (35/284) developed symptoms and signs of photokeratitis during the event (Figure 1). More than 90% (255/284) of them reported redness of both the eyes, foreign-body sensation in both the eyes, photophobia, watering of both the eyes, blurred vision, and 6% (17/284) developed eyelid erythema. Nine case-patients (3%) who developed corneal erosions were hospitalized in a tertiary care center. All the cases were treated with artificial tears and nonsteroidal anti-inflammatory drugs. The majority of the case-patients (95%) became normal after 96 hours of the event.

The attack rate was higher among those exposed continuously to the metal halide light (97% [268/277]) than those got exposed intermittently (38% [16/42]; RR = 2.5; 95% CI = 1.7, 3.7; PAR = 57%) (Table 2). Further, those seated in the front rows (i.e., 12 m from dais) were at higher risk than those seated behind (RR = 1.5; 95% CI = 1.2, 1.7; PAR = 27%) (Figure 2). The gradient of the duration of exposure was associated with incremental the risk of developing bilateral photokeratitis (RR for 1–2 hours = 1.7; RR for 2–3 hours = 1.9 as compared with <1 hour of exposure; χ^2 test for linear trend = 74; $P < 0.00001$).

The light music event was organized on 17 August 2018 from 8 to 11 PM (Indian Standard Time) in a temporarily established semi-open hall measuring 162 m² (18 × 9 m). The sidewalls of the hall were open, and the roof was made with a marquee at a height of 3.7 m. Two 300-Watt halogen lights along with enclosed glass fixtures were mounted on the dais at 4.5 m apart facing the dais, and one 400-Watt metal halide light hung vertically from the marquee at the height of 2.4 m and 4.5 m from the dais (Figure 2).

During the inspection of the venue and arrangements, we identified that organizers had mounted metal halide light without fixtures and the outer envelope of the metal halide light found broken. After 7 days of postevent, all the case-patients recovered completely from bilateral photokeratitis and eyelid erythema.

Discussion

Following an outbreak of bilateral photokeratitis among light music attendees in a rural locality in South India, we did a cohort study and identified that the outbreak was attributable to the usage of metal halide light with the broken outer envelope.

Outbreaks of photokeratitis attributed to metal halide and mercury vapor lights have been reported across the world in a variety of settings.^{4,7–14} Settings in which these outbreaks had

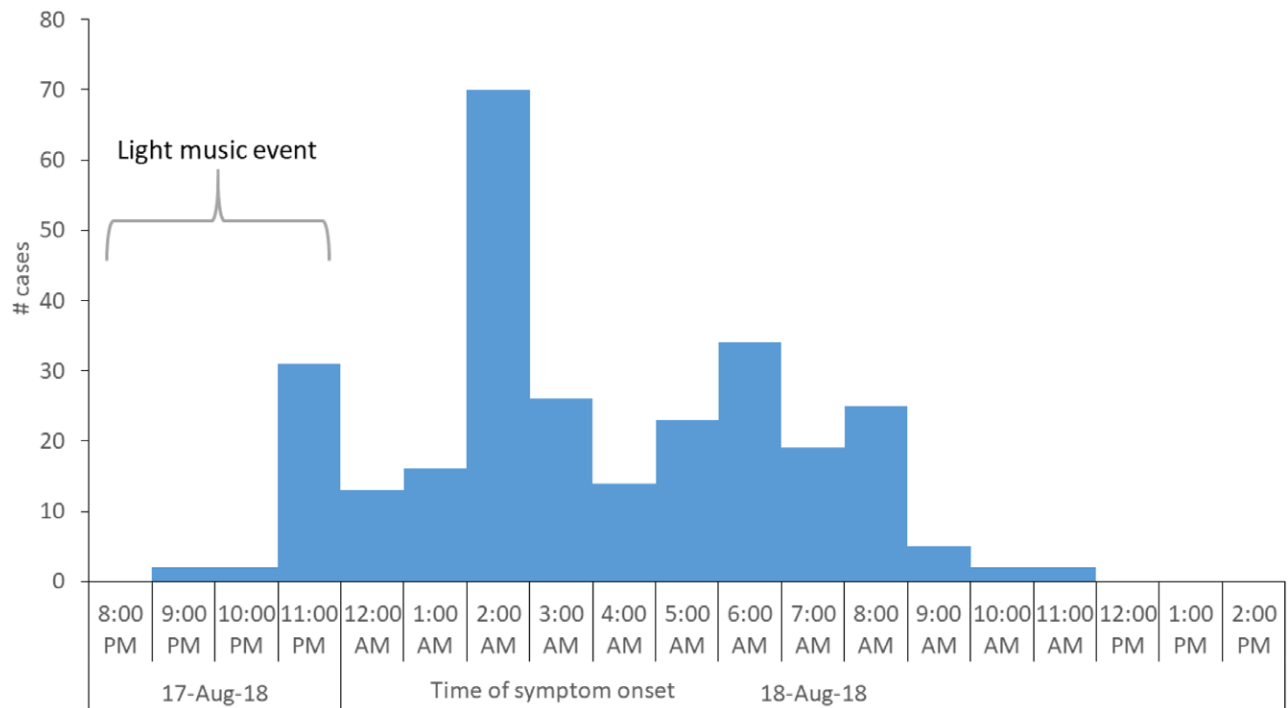


Figure 1. Bilateral photokeratitis cases by time of onset of symptoms, Palani, Tamil Nadu, India, 2018.

Table 2.
Attack rate of bilateral photokeratitis by selected risk factors, Palani, Tamil Nadu, India, 2018

Risk factors	Attack rate of bilateral photokeratitis						Relative risk (95% confidence interval)	Population attributable risk (%)
	Among exposed			Among unexposed				
	No.	Total	%	No.	Total	%		
Continuous exposure to metal halide lights	268	277	97	16	42	38	2.5 (1.7, 3.7)	57
Seated within 12 m from the dais	241	253	95	43	66	65	1.5 (1.2, 1.7)	27

been reported were gymnasium,^{9,10,13,14} cattle market,¹² indoor school event,⁴ political gathering⁷, and poultry abattoir.⁸

Clinical symptoms reported in this outbreak were consistent with the previously reported outbreaks.^{4,7} Our study has many similarities with previously reported outbreaks in India.^{4,7} All the three reported outbreaks occurred in a mass gathering wherein damaged or broken metal halides were used, and participants who seated close to the damaged halide lights were affected more often than those seated far away.^{4,7} However, the setting in one of the two was an indoors.⁴

It is important to understand the structure and mechanism of functioning of metal halide lights. They are made up of an inner quartz tube and outer glass envelope.¹⁵ The inner tube contains mercury vapor and metal halide gases which produces an electrical discharge between two electrodes and through ionized gas, thus, generated intense light.¹⁵ The outer envelope is meant to shield and filter the short-wavelength UVR.¹⁵ Metal halide and mercury vapor light are available as “T” or “R” type. “T” type bulbs have a self-extinguishable feature that shuts off the light within 15 minutes after the outer cover is broken, whereas “R” type bulbs are not self-extinguishable.¹⁴ In fact, the US Food and Drug Administration recommends the use of “R” type bulbs in enclosed light fixtures.¹⁵ These “R” type bulbs, if operated without fixture or with broken outer envelope, could result in intense emission of UVR. This emission could lead to eye-related symptoms and skin erythema.¹⁵

In resource-limited settings like India, only “R” type bulbs are used commonly as it is cheaper and widely available, whereas the “T” type bulbs are expensive and not available in the market. Hence, outbreaks of photokeratitis may continue to occur. However, local media may report them as outbreaks of eye diseases following some events. Disease surveillance systems routinely tuned towards communicable diseases, however, need flexible to capture and notify such events of an unusual occurrence.

In general, the adverse effects of UVR are directly proportional to the duration of exposure and inversely proportional to the distance of UVR source. In the previously reported outbreaks, duration of exposure and distance from the source of UVR were considered as risk factors for photokeratitis.^{4,7} In this outbreak, the duration of exposure to UVR and distance from the source of exposure were significantly associated with the occurrence of bilateral photokeratitis. These findings are consistent with an earlier investigation of photokeratitis in Tamil Nadu, wherein we had documented the association with that of distance and that of duration exposed.⁴

Additionally, we documented the significant association between the various level of distance from the broken metal halide light and occurrence of bilateral photokeratitis. The risk of bilateral photokeratitis was increased to 70% and 90% for those with 1–2 hours and 2–3 hours of exposure, respectively.

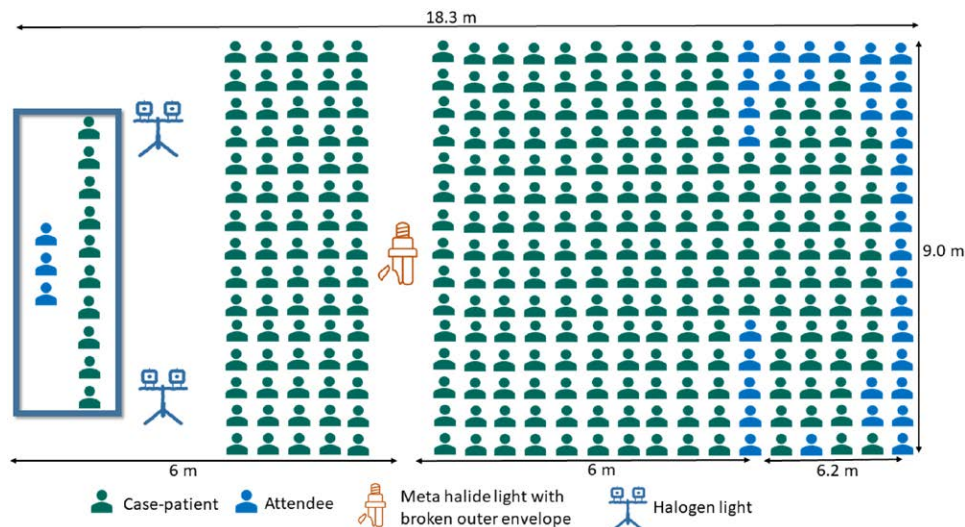


Figure 2. Description of the light music event venue that led to bilateral photokeratitis and distribution of cases of photokeratitis by their seating place among event attendees, Palani, Tamil Nadu, India, 2018.

As the events occurred in rural settings in India and considering the fact that the symptoms of bilateral photokeratitis are mild, self-limiting in nature, and most of the case-patients would have lost their wages for the days they underwent treatment. Moreover, the speciality private consultations would increase the health expenditure. Apart from these outbreaks, acute health events following exposure to noise or chemical were not reported elsewhere.

Hence, we have established strength, temporality, and dose-response of association between exposure to UVR and bilateral photokeratitis. Such documentation from these field epidemiologic studies led to sharing draft guidelines with the local governments (Rubeshkumar PC, unpublished observations, 2018) and a systematic review.¹⁶ We believe that the evidence synthesized from the systematic review could be helpful in shortlisting such lights from the manufacturing and usage.

We communicated the findings to concerned Government authorities, event organizers, and relevant stakeholders. We also created awareness among the event organizers about the consequences of using high-intensity lights.

Limitations

Our study findings could suffer from a few limitations. We could not include all the event attendees in the retrospective cohort study. Hence, selection bias could have played a major role. Such level of nonresponse is typical considering the outdoor and unregulated nature of the event in settings like ours. Hence, constructing the cohort size and then identifying them in the community is a challenge. Given the serious nature of the illness and the attention the event received subsequent to the outbreak, we assume that any occurrence of eye problem in an attendee would have been captured through the enhanced surveillance established during the outbreak investigation. Such selection bias is unlikely to have affected the estimated attack rate and risk ratio. Nevertheless, we have provided the estimates with assumptions above. In terms of risk factors, such nonresponse could have influenced the strength of association. However, the estimated dose-response suggested that the direction of the association would not have been different from that of the reported figures.

We could have had information bias about certain exposures. Our ascertainment of seating location, nature, and duration of attending the event could have suffered from misclassification. However, such error is likely to be nondifferential in nature. Despite such error, the strength of association was beyond null for those exposures.

Conclusions

We concluded that the outbreak of bilateral photokeratitis and eyelid erythema in a locality in South India was attributable to the usage of metal halide light with a broken outer envelope and was mounted without fixture during the light music event. To prevent outbreaks in future, we recommended restricting the usage of metal halide lights in outdoors along with enclosed fixtures and creating awareness among the event organizers about the safe practices.

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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