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REVIEW

Fireworks: boon or bane to our eyes?

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Abstract Fireworks are an integral aspect of national, cultural and religious festivals globally, featuring in a vast range of celebrations including Diwali in India and New Year's Eve in the USA. We have seen a trend in eye injuries related to the use of fireworks, with millions of people, of which a large proportion comprising children, are injured annually—and rather than falling, as one would hope, this number is remaining stable. A comprehensive study of the impact of firework-related injuries to the eye is not available, and the efforts to mitigate this are not widely discussed in the literature. This literature review therefore focusses on studying the impact of firework-related eye injuries, the effect of legislation on mitigating these injuries and their associated morbidity.

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Introduction

Lights are a symbol of celebration, hope and prosperity and are believed to drive away evil spirits. However, the circumstances are such that even a small mishap with fireworks can lead to life and vision-threatening complications. The most commonly reported sites of firework-related injury are the head and neck region, with the eyes in particular being the most commonly injured location (45%) [1–4] followed by hands (38%) [5] (Fig. 1). The face suffers the brunt of the attack of fireworks, which tends to occur when the user bends over the firework to light it or watch it closely [6]. Eye injuries are not only common but they are among the most serious injuries due to fireworks worldwide, with nearly one in six eye injuries resulting in permanent visual loss [7, 8].

Materials and method

PubMed search was carried out using the following keywords: eye injury/trauma, firecracker/firework injuries, prevention of ocular trauma. Titles were screened for relevance to topic: case reports, case series, peer review articles, both quantitative and

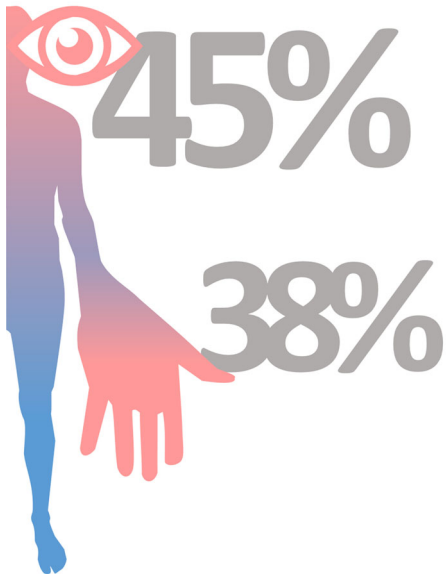

Fig. 1 Most commonly reported sites of firework-related injury is the head and neck region, in particular the eyes (45%), followed by hands (38%)

qualitative studies were included. A total of 21 studies were shortlisted from PubMed, and 8 articles including press releases, news articles and web pages relevant to the topic were included and analysed.

Different strokes for different folks

The incidence of firework-related injuries was found to be highest in the 5–20-year-old age group [9–11] (Fig. 2). Many international studies have reported that firework-related injuries affect children more-so than adults. Most children who sustain firework-related injuries are unsupervised; therefore, having adult supervision is a supposed method to reduce such incidents. However, in a 1996 study by Smith et al. [4], it was noted that in 54% of cases of children sustaining firework-related injury, an adult supervisor was in fact present. An experimental temperament and adventurous nature make children more vulnerable to these injuries [12, 13]. As an effort to mitigate this, sale of fireworks for children should be completely banned and children should always be accompanied by adults during fireworks use/display [14]. In all age groups, males were more likely to be injured by fireworks than females [6, 9, 11, 15–19] (Fig. 3 and Table 1). This may be due to their adventurous, experimental and inquisitive nature, making them more vulnerable to firework-related injuries. These factors should be taken into account, and the importance of avoidance of dangerous behaviour should be emphasised in awareness campaigns. This can include yearly educational programme a month before the festival season like Diwali in India. Pamphlets containing safety tips for using fireworks emphasising the importance of wearing protective eyewear, measures for safe handling of fireworks and first-aid measures can be distributed to the public. These pamphlets could include some data and pictures of firework-related injuries as powerful visual tools to educate people about the danger associated with them.

Disaster for every season

As previously mentioned, fireworks underpin celebrations in many parts of the world. These celebrations include the Fourth of July, New Year's Eve, Diwali festival, Chinese New Year, Mid-Autumn festival, Hari Raya, Halloween. Data from various studies on

Fig. 2 Pictorial representation of highest incidence of fireworks related injuries in the 5–20-year-old-age group

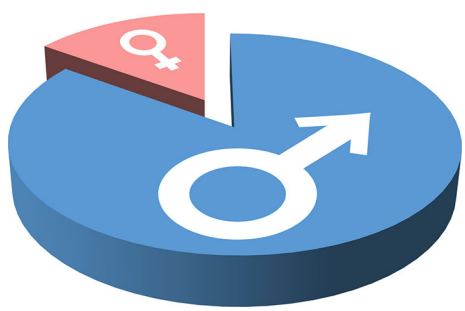

Fig. 3 Firework-related injuries have a higher incidence among males than females

Table 1 Percentage of male involvement in firework-related injuries and ratio of male to female involvement in firework-related injuries reported in various studies

	% of male involvement	Male:female ratio
Puri et al. [1]	87	7:1
Wang et al. [2]	87.9	7.41:1
Bull et al. [3]	92.21	11.83:1
Frimmel et al. [4]	76	3.21:1
Bagri et al. [5]	75	3:1
Lin et al. [6]	89.1	8.17:1
Edwin et al. [7]	82	6.9:1
Mean	84.17	6.77:1

the incidence of firework-related casualties show that there is a clear spike around these periods in the countries where the aforementioned festivals are celebrated [9].

Hitting the eye hard: different forms of firework-related eye injuries

The most common type of injury sustained due to fireworks is burning. From anterior to posterior, fireworks can lead to the following types of eye injury:

- Eyelid: burns, lacerations.
- Conjunctiva: burns, abrasions, foreign body, symblepharon formation.
- Cornea: abrasion, laceration, foreign body.
- Anterior chamber: hyphema, iritis, foreign body.
- Iris: sphincter tears, iridodialysis.
- Lens: Traumatic cataract, subluxation, dislocation.
- Vitreous cavity: haemorrhage, foreign body
- Retina: detachment.
- Optic nerve: avulsion.
- Globe rupture.

Bottle rockets are famous especially in India, where a projectile rocket firework is placed inside a glass bottle and fired. Among the different types of fireworks, these bottle rockets are said to cause the most devastating eye complications, including blindness due to their rapid flight and erratic path [20]. Due to its nature, these fireworks not only cause injury to the igniter, but also to bystanders in their vicinity [5, 11, 20]. Blindness can be caused by corneal abrasion, gunpowder burns, traumatic cataract, retinal detachment and globe rupture. Sparklers and fountain/flare are associated with injuries including corneal abrasions and minor burns. However, their flames have the potential to ignite clothes, which may lead to severe burns. Sparklers burn at 1200 degree Fahrenheit, a temperature sufficient to melt glass and gold which causes third-degree skin burns [21] and devastating ocular trauma.

A 1995 study [22] of the US eye injury registry reported that during their period of observation from 1990 to 1994, fireworks resulted in legal blindness in 44% and enucleation in 10% of all injured persons. A study from Northern China [23] showed that nearly half of their patients (47.5%) with firework-related eye injuries underwent multiple surgeries. Of these patients, final visual outcome was found to be better in those with better initial visual acuity and closed globe injuries compared with those sustaining endophthalmitis, intraocular foreign body, retinal detachment and open globe injuries. This is the only study as of yet which discusses the predictive factors of final visual outcome following firework-related eye injuries.

Overall, the factors leading to eye injuries related to fireworks are as follows [6, 9, 10, 17, 22]:

1) Misuse or improper handling of products.
2) Usage of illegal products.
3) Device malfunctioning or failure.
4) Erratic and unpredictable flight characteristics.
5) Device ricochet off hard surfaces.
6) Lack of adult supervision for children.

Various simple measures that can be taken to prevent fireworks related eye injuries are provided as tip sheet (Fig. 4).

Fig. 4 Tipsheet on simple measures to prevent firework-related injuries

Places where actions spoke loud: effects of legislation

Fortunately, firework-related injuries are preventable, with the potential to be abolished by mitigating fireworks usage. Legislations that restrict the sale of fireworks and interventions to improve the safe use of fireworks worldwide are required. Berger et al. [2] investigated the effect of fireworks sales restrictions at the state level in the USA. States with strict laws enforcing restriction of fireworks sales demonstrated that the frequency of firework-related fire and injuries decreased by 50 times and 7 times, respectively [2]. In the UK, following introduction of the Fireworks (Safety) Regulations of 1996/97 banning banger fireworks, there were no incidents of injuries related to these fireworks in Newcastle. Imposing further stricter laws showed promising results: The Fireworks Act of 2003 and the Fireworks Regulations 2004 restricting the sales of fireworks to 3 weeks around Bonfire night also resulted in restriction of occurrence of related injuries to a focus within the 3-week period [19]. Similarly in Norway, there was a 50% reduction in the number of incidents of fireworks-related eye injuries after bottle rockets were banned in 2008 [15]. Although wearing protective eye gear does not prevent injuries from occurring, they can aid in preventing devastating complications [24]. The Norwegian study [15] also reported a reduction in the number of incidents after protective glasses were offered free of cost upon purchase of fireworks. However, the consumer product safety commission warns that despite the enforcement of safety laws and regulations, "all fireworks, by their nature, are hazardous and can cause injuries" [25]. All types of legally available consumer firework, which are marketed as being safe, have been reported to be associated with serious injury, blindness and in some occasions death [26]. The World Health Organisation has already called for strict laws to restrict and ban fireworks [27]. In developed countries, data proven by studies had led to strict laws and regulations, thus reducing the number of adverse events. However, the status of laws and regulations of fireworks is questionable in developing countries.

So far, there has only been one reported incidence of severe eye injury (two patients had permanent visual loss and three had lifelong glaucoma risk) resulting from public firework display in the UK [28]. This reinforces the rules that fireworks ought to be restricted to public display by professional pyrotechnicians in designated areas and banning them completely from private use. This allows for the

prevention of serious accidents, yet still allows for public display of fireworks during times of celebration. Imposing strict laws which force the manufacturers to adhere to quality control measures is also absolutely essential [9, 11]. Strict laws on fireworks manufacture and handling need to be standardised all over the world to address the global population safety.

Conclusion

Fireworks which are known to symbolise prosperity and happiness also pose unimaginable danger to the eyes of innocent users and bystanders. Fortunately, these are preventable injuries, which can be avoided if proper actions are taken by healthcare and government authorities.

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