

# Can fireworks-related injuries to children during festivities be prevented?

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**Objective.** To determine the epidemiological features and outcome of fireworks-related injuries among children 0 - 13 years old.

**Design.** A retrospective study from the trauma registry of a children's hospital from 2001 - 2009.

**Results.** Fifty-five children were treated for injuries from fireworks. The mean age was 8.8 years, 78% were boys, and the largest age group was 5 - 9 years old. Firecrackers accounted for 95% of the injuries; the most commonly injured body sites were hands (44%), eyes (42%) and face (31%); 47% of the patients had more than one injury. The most common injury type was burns (67%); 25 children were admitted, mostly to the burns and ophthalmology units. The mean length of hospital stay was 3.5 days. Surgical intervention

was required in 38% of the patients. Most of the fireworks accidents occurred in or around the patients' homes. There were more fireworks-related injuries around Guy Fawkes Day (85%) than New Year's Eve (9%).

**Conclusion.** Consumer fireworks cause serious but preventable injuries to children, either as users or bystanders. Children and their families should be encouraged to enjoy pyrotechnical displays conducted by professionals at designated areas. All fireworks for individual private use should either be supervised by an adult or banned. Current legislation should be more strictly enforced, especially the sale to under-age children.

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In South Africa, fireworks are widely used on New Year's Eve, the 5th of November (Guy Fawkes Day) and for Diwali celebrations (Festival of Lights) during October/November. Fireworks injury studies have found a high incidence among children. In Australia,<sup>1</sup> 88% of emergency department attendees with fireworks injuries were under 18 years of age. In the USA, 85 800 children (average age 10.8 years) were treated over a 14-year period.<sup>2</sup> In Israel,<sup>3</sup> during the Jewish Purim Festival and Arab and Druze Id el-Adha holidays, 53% of those injured by fireworks were children under the age of 16 years. In New Zealand, 68% of the injured were children under the age of 15 years.<sup>4</sup>

The consequences of fireworks injuries, especially among children, are not generally known.<sup>5,6</sup> Levitz<sup>5</sup> described 10 patients in South Africa under the age of 15 with ocular injuries due to fireworks in Johannesburg over the 1996/1997 New Year period.

Despite clear directives from local law enforcement agencies and the identification of specific areas for pyrotechnic displays, legal and illegal discharging of fireworks in public continues to occur. Our objective was to describe the epidemiology, injury

pattern and outcome of fireworks-related injuries in children by using a local representative sample referred to a paediatric trauma centre, and to review fireworks-related legislation.

## Material and methods

Children who sustained fireworks-related injuries were identified from the registered trauma admissions to the Red Cross War Memorial Children's Hospital, Cape Town. Fireworks/firecrackers injuries were selected for the New Year period (3 December - 14 January) and the Guy Fawkes and Diwali period (8 October - 19 November). Diwali usually falls in October/November and includes Guy Fawkes Day. A retrospective analysis for the years 2001 - 2009 was conducted, which included age, gender, nature of accident and referral. Injury types were categorised as burns, lacerations/abrasions, fractures and dislocations, without differentiating between primary and secondary injury. The parts of the body that were injured were grouped in categories: eye, face/head, hand and others. Patients were asked for details of the type of fireworks, which was recorded as firecracker or undefined fireworks, and how it was obtained. Identification of the specific type of fireworks implicated could not accurately be identified. The location of each accident was described either as own home or public place. SPSS for Windows was used to analyse data.

## Results

### Injury demographics

Fifty-five children (<13 years old) with fireworks-related injuries were referred to the Red Cross War Memorial Children's Hospital trauma unit. During this period, 83 626 trauma patients were seen; fireworks cases represented 0.066%. There were 43 boys and 12 girls. Six were <4 years, 25 were 5 - 9, and 24 were >10 years old. Their mean age was 8.8 years (SD 2.7 years; range 3 - 12 years). Acquisition

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of the fireworks varied: across-the-counter purchases in local shops, stockpiles at home, from friends, or (allegedly) picked up in the street. Most children were unsupervised at the time of ignition. The mechanisms of fireworks injuries included the more expected, namely fireworks exploding in the hand (22) or thrown at and exploding near the injured child (32), as well as the more unusual (Table I). Most of the children were uninvolved but curious bystanders. Firecrackers were identified as the causative device in 52 cases, fireworks in 2, and 1 child was forced to swallow gunpowder. No homemade fireworks were identified. Injuries were sustained either at home or unintentionally at public celebrations, e.g. New Year's Eve at Clifton beach, but none at an official pyrotechnics display. Forty of the injuries occurred at home, 4 at public places, and 11 at unknown sites.

Most injuries occurred around Guy Fawkes Day (47), 3 during the period of Diwali celebrations, and 5 at New Year's Eve. Table I depicts typical scenarios preceding the injury.

### Anatomical considerations

One anatomical site only was involved in 53% of the injuries. The most frequent types of injury were burns, lacerations and abrasions (Table II). The most common injuries were to the hands, with partial thickness burns; lacerations; dislocations; amputation of fingers; and fractures. Three children sustained body surface burns of 2 - 28% needing extensive skin grafting. The eyes were the next most common site, with corneal abrasions/lacerations, hyphaema, foreign bodies and one eye requiring enucleation for globe disruption. Eye injuries are potentially very serious, and included sphincter tears, traumatic uveitis, choroidal rupture adjacent to the fovea, and 3 pre-retinal haemorrhages in the temporal macula. Faces sustained flash burns and lacerations, with burns and lacerations to other body parts. One child hid a burning firework in his pants, resulting in a pelvic fracture, genital ablation, necrotic anterior abdominal wall, perforated bowel and degloving of the femoral triangle. A small cracker was inserted into the auditory canal of one child and lit, resulting in perforation and deafness. Influenced by her friends, one 3-year-old ingested gunpowder. Firecracker remnants were found in 2 hands and 2 eyes and were surgically removed. Gunpowder staining in 7 wounds was dissolved and removed following the topical application of liquid paraffin.

The mean age of the 25 children admitted was 9.4 years (SD 2.9 years, range 3 - 12 years). Reasons for admission were injuries to the hands, face and eye. Placement included admission to the trauma ward, burns unit and ophthalmology

**Table II. Injury site and type of injuries sustained**

	Discharged	Admitted	Total
<b>Burns</b>			
Face	9	8	17
Hand	5	6	11
Chest	5	1	6
Other sites	3	0	3
<b>Total</b>	<b>22</b>	<b>15</b>	<b>37 (67%)</b>
<b>Eyes</b>			
Hyphaema	2	1	3
Laceration/abrasion	16	1	17
Enucleation	0	1	1
Embedded foreign body	0	2	2
<b>Total</b>	<b>18</b>	<b>5</b>	<b>23 (42%)</b>
<b>Hands</b>			
Lacerations/abrasions	5	5	10
Haematoma	3	2	5
Fracture/dislocation	0	4	4
Amputation of fingers	0	3	3
Embedded foreign body	0	2	2
<b>Total</b>	<b>8</b>	<b>16</b>	<b>24 (44%)</b>
Massive soft-tissue injury	0	1	1

Multiple site involvement was present in 47% of children. The table only depicts major injury sites.

ward, and one child was admitted to the ICU. Surgical intervention for the injuries was required in 21 cases. Information about duration of hospital stay was available in 80% of cases. The mean length of hospitalisation was 3.5±3.2 days. None of the patients seen died from their injuries.

### Discussion

Despite the annual outcry over the indiscriminate use of fireworks during festive periods and the concomitant cruelty to animals, very little is known or has been published about injuries sustained by humans in South Africa.<sup>5,6</sup> Children, because of their inquisitive nature and the excitement surrounding fireworks, are particularly vulnerable. They also cannot readily appreciate the dangers involved or act decisively in an emergency, hence their susceptibility to firework injuries. The fireworks responsible were freely available and often sold to under-age children and then indiscriminately used. Injuries were more frequent and more severe among children who were active participants rather than bystanders. Most self-inflicted injuries occurred among boys, whereas girls suffered injuries mostly as bystanders.

**Table I. Typical scenarios preceding the injury and risk factors identified among the injured children**

Scenario	Risk factor
Held burning firecracker	Firework type
Firecracker thrown at person or crowd	Availability
Picked up burning firecracker; taking firecracker apart	Curiosity
Lit firework in bed	Experimentation
Hid burning firecracker from mother in his pants	Close proximity
Firecracker inserted in ear by friend and lit	Immaturity
Unpacked firecracker in car – exploded	Lack of supervision
Coaxed to swallow gunpowder from opened firecracker	Peer pressure

In this study, the accidents occurred mainly in or around the home and not at public places, which emphasises the ignorance or lack of consideration about the dangers, or the need for supervision. On festive days, fireworks were most often not used in allocated discharging sites. Although we know that firecrackers (sparklers, novelty designs, penny bangs, rockets, etc.) are dangerous, no information or instructions are available to the public regarding the explosive capacity, time delay from ignition to explosion, the wick, and effects of its combustion. Misuse of the devices can also lead to unintentional collateral damage to property, which was not reported in this survey.

The main 'culprits' are firecrackers and sparklers, which contain up to 130 g of powder charge and may generate temperatures exceeding 500°C.<sup>7</sup> The danger of firecrackers is the power and unpredictable timing of the gunpowder explosion; they should be classified as explosives.<sup>7</sup> Firecracker/rocket injuries primarily involve the hands and eyes, while sparklers cause burns either directly or through setting clothing alight.<sup>3,7-9</sup> Malfunctioning devices account for only a small percentage of injuries.<sup>9</sup>

Although only 45 patients were admitted to the trauma centre, the consequences for some children were significant. Fortunately, most injuries were not severe and, after treatment, children could be released from the emergency department. However, many of those admitted required surgery. The most commonly injured body parts were hands (non-dominant), eyes and face, as mentioned in other reports.<sup>5,7-11</sup> As may be expected from the combustion and heat generated, burns accounted for most of the injuries, leading to loss of fingers, visual impairment, deafness, lacerations, abrasions, contusions and permanent facial and body scars.<sup>6,8,9</sup> Nearly half (47%) of the patients had more than one injury. Burn wounds were all of a contact type and of partial depth; all but 3 healed with topical therapy.

There was a preponderance of coloured and white children with fireworks-related injuries; only 4 of the injured children were black, which could be a reflection of different cultural customs.

Studies emphasise the high incidence of fireworks-related injuries during holiday and religious periods, and are a global concern. In the USA, 95% of such injuries occur around Independence Day; in Greece, there is a peak during the Greek Orthodox Easter; in Iran during their end-of-year celebrations; and in India during the Diwali Festival.<sup>8,9,12</sup> No injuries occurred during the Halloween period.

Fireworks in South Africa are regulated by the Explosives Act (Act 26 of 1956) which states that the police grant licences to sell fireworks, and a retailer may not sell fireworks to children under the age of 16 years.<sup>13</sup> Sale of fireworks by informal traders/street hawkers is illegal. Fireworks may only be sold in sealed packages, as received from the supplier. Importers of fireworks require a permit to do so.<sup>13</sup> A child under the age of 16 years may not handle or use fireworks except when supervised by an adult.

Regionally, specific municipal by-laws regulate the use of fireworks. In Cape Town, discharging fireworks in public is illegal, without obtaining prior permission from the Chief

Inspector of Explosives and the City of Cape Town.<sup>13</sup> The fine for committing this offence is R600 or 12 months in prison. However, the City permits the discharging of fireworks in public on Guy Fawkes Day and New Year's Eve, but only in specially allocated sites (by-law 58:12). In 2009, the City of Cape Town identified 19 public areas that could be used for Diwali and for Guy Fawkes.<sup>13</sup> Some municipalities do not require their residents to apply for permission for using fireworks for religious and cultural celebrations, and allow them to be used at home.

Despite legislation, legal practices are often evaded. According to the amendment inserted in Chapter 11, section 58, by-laws were violated in many cases in our study,<sup>13</sup> including: 58:2 – restriction of sale of fireworks by licensed shops, 58:10 – restriction of firework sales exclusively to permit holders, 58:4 – the requirement for an operational permit, and by-law 58:12 – designation of approved firework discharging sites. Furthermore, illegal use of fireworks can be reported to the metropolitan police and the culprits be fined if they cause a disturbance, nuisance or damages or danger to anyone.

To prevent fireworks-related injuries among children, a comprehensive approach is necessary.<sup>2,4,7-10</sup> Recommendations include parental education and supervision at home during festive seasons, and only attending formally organised fireworks displays.<sup>8,13</sup> Legislation has a significant effect on injury rates. In the USA, the 'injury rate was seven times greater in states with fewer restrictions'.<sup>8</sup> In Hungary, incidences were reduced following a 'legislative ban on private fireworks displays'.<sup>9</sup>

Many studies conclusively recommend the introduction of stricter regulations and banning the indiscriminate sale of fireworks. There should also be greater control of retailers, the public be encouraged to use pre-approved firework sites, and school education initiatives be supported.<sup>15</sup> Proposed amendments to by-laws include that fireworks can only be used by the permit holder, for a certain time duration, and in the 'premises for which it was issued'. As children cannot obtain permits, they would be prevented from handling fireworks. However, these terms would not apply to Guy Fawkes and New Year's Day, for which occasions designated areas are determined for public use and are 'subject to conditions as may be determined by the controlling authority'.<sup>15</sup> As the greatest fireworks use and highest record of child injury is on festive days, by-laws should also apply to these days.

Limitations of our study were the retrospective nature and that it might not be representative of all children injured during the study period. A review of all emergency room (ER) cases of all hospitals in Cape Town would be required before drawing conclusions regarding the prevalence, especially around Guy Fawkes Day. The mid-year population estimate for the Western Cape in 2009 was 5 356 900 people. Since 2005, no fatality has been reported from the Department of Forensic Pathology at the University of Cape Town.

In conclusion, fireworks are associated with serious but preventable injuries among the paediatric age group. Parents should take their children to safer public fireworks displays

rather than allow consumer fireworks to be used by or near their children.<sup>16</sup> More enforcement of regulations, education and parental supervision are needed to reduce fireworks-related injuries, and mail-order pyrotechnics should be banned.

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