THE MAGNITUDE AND PATTERN OF THERMAL OCULAR INJURIES FOLLOWING TWO MAJOR FIRE INCIDENTS IN KENYA IN 2009

A DISSERTATION SUBMITTED AS PARTIAL FULFILLMENT FOR THE DEGREE OF MASTERS OF MEDICINE IN OPHTHALMOLOGY, UNIVERSITY OF NAIROBI

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DECLARATION:

THIS DISSERTATION IS MY ORIGINAL WORK AND HAS NOT BEEN SUBMITTED FOR A DEGREE IN ANY OTHER UNIVERSITY.

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To God who sees me through all things.

To my family for all their love and support.

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LIST OF ABBREVIATIONS:

CC	-	With correction
DSE	-	Disease
EOMM	-	Extra-ocular muscle motility
ICU	-	Intensive care unit
IOP	-	Intra-ocular pressure
KNH	-	Kenyatta National Hospital
LE	-	Left eye
MX	-	Management
ONH	-	Optic Nerve Head
PGH	-	Provincial General Hospital
PH	-	Pin-hole
RE	-	Right eye
R, B, G	-	Color coding: Red, Blue, Green
SC	-	Without correction
TBSA	-	Total Body Surface Area
TEO	-	Tetracycline Eye Ointment
UON	-	University of Nairobi
UV	-	Ultra-violet radiation
VA	-	Visual Acuity
WHO	-	World Health Organization

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ACKNOWLEDGEMENTS

I would like to thank the following for making this dissertation a reality:

My supervisors Dr. D.R. Ilako and Dr. M. Kollmann for their support, supervision, patience, encouragement and constructive criticism throughout the project.

Dr. Gichangi and other staff at the Ministry of Health for their assistance in facilitating this project.

The staff of Kenyatta National Hospital, Nakuru PGH, Kericho District hospital and Mater Misericordae Hospital for their willing cooperation and assistance.

My lecturers and colleagues at the University of Nairobi for their valuable contributions.

My husband Eric Ng'anda for his continued support through the program and the rest of my family for their patience and encouragement.

The support staff at the UON Department of Ophthalmology particularly Anne Kagelisa, for their assistance in the library and use of other facilities.

Drs. Onsomu and Ekuwam for their co-operation.

My statistician Alex for his advice and assistance.

My friends all over for their prayers and encouragement.

Finally, my sponsors Christoffel- Blinden Mission (CBM), without who I would not be here.

1.0 ABSTRACT

OBJECTIVE: To describe the magnitude and pattern of thermal ocular injuries following two major fire incidents in Kenya in the year 2009.

STUDY DESIGN: Cross- sectional analytic study

METHODS: Eighty- eight patients admitted to 4 hospitals with flame burns following two oil tanker explosions were examined between 3-21 days after the incidents. All admitted patients within the study period (February- July 2009) were interviewed and examined. Information on biodata, Total Body Surface Area (TBSA) of burns, facial and ocular burns was collected and recorded on a questionnaire. Detailed ocular examination of the anterior and posterior segment was carried out and recorded on the same questionnaire, after which data was analyzed and presented appropriately.

RESULTS: Males were more involved than females with a ratio of 13:1.Majority were young with a mean age of 23.9 years. The eyelids were the most affected structures (68.2%) followed by eyebrows and eyelashes (60.8%). 1^{st} degree lid burns (40.9%) were more frequent than 2^{nd} (23.3%) and 3^{rd} degree burns (4.0%). The conjunctiva (20.5%) and cornea (10.2%) were affected to a lesser extent. Most patients (98.9%) had normal vision. Facial burns were present in 70.5% of patients and these had a positive association with ocular injuries. Spectrum of ocular injuries also had a positive association with TBSA, which was statistically significant. 3.9% of patients received emergency ocular treatment after the first fire incident compared to 43.2% after the second fire.

CONCLUSION: Ocular adnexae are the most involved eye structures following flame burns, with the eyelids being more commonly affected. Intraocular injury was not common and thus vision was largely preserved. Patients with facial burns and higher percentage TBSA of burn were more likely to incur ocular burns. Despite a learning curve, emergency ocular management of patients was inadequate.

2.0 LITERATURE REVIEW

2.1 INTRODUCTION:

Ocular thermal burns form 7.7- 18% of all ocular trauma cases. Majority of the burns occur in the young, in accidents at work or in the home.[1]

Thermal burns have been reported in industrial fire explosions, blast injuries (industrial, wartime, terrorist attacks), intentional attacks and domestic accidents, including explosion of immersion heaters[2] and fireworks.[3] Many are a combination of chemical-thermal or mechanical-thermal burns.

Although chemical burns are more common and often more severe in nature, thermal burns damage ocular structures leading to serious clinical sequele, especially if not well managed.

A WHO-based study in Gambia showed that among patients admitted for trauma, burns accounted for the greatest number of inpatient days. They were also among the leading causes of surgical deaths.[7] However, in developing countries, lack of infrastructure, resources and traditional practices contribute to unsatisfactory results in management of these patients.[8] Educational, social and infrastructure standards need to be improved for successful management of burns.

With the rising incidence of industrial and domestic fire accidents, ocular thermal burns are on the increase. Despite ocular protective mechanisms and the small surface area of the eye in relation to the total body surface area[4] ocular thermal injuries are relatively common among civilians.

2.2 CLASSIFICATION OF THERMAL BURNS

Ocular burns are among ophthalmic emergencies. In general, thermal burns are unusual and a less common entity when compared to chemical burns. Careful examination of the patient is paramount in initializing treatment. Prognosis of ocular burns is related to the area of involvement, depth of burn and in chemical injuries, relative toxicity of the substance[4]. A detailed examination with documentation of all ocular tissues involved is important in long-term follow up of these patients.

In grading thermal burns, the classifications used for chemical burns i.e. the modified Ropper-Hall classification[13] and others have several shortfalls. Due to protective mechanisms of the eye, the eyelids are the most commonly affected structures and primary corneal insult is rare (and usually mild, if it occurs) [6]. Corneal injuries often occur secondarily as a sequele of lid injuries e.g. exposure keratopathy and ulceration. Limbal ischemia is also an infrequent finding owing to the nature of thermal burns. However, in determination of prognosis, these are important factors in thermal burns and must be noted where present.

In general, thermal burns are an unusual type of ophthalmic injury. They constitute 16% of all ocular burns[11].They can occur from a variety of agents. In questioning, the temperature of the agent involved, duration of contact and character of the agent should be revealed[4]. These factors can help to estimate the amount of thermal energy transferred to ocular tissues. Agents include hot fluids e.g. water and combustible fluids, flammable solids and gases (including steam), explosion of various substances, frost burns, etc. A subgroup also includes electrical burns for which entry and exit points should be located[4].

Ocular thermal burns are broadly divided into two categories according to aetiology [6] :

I. Those caused by heat
II. Those caused by freezing

Majority of thermal burns are caused by heat. Heat is a major inducer of inflammation and stromal protease expression. It can lead to collagen melt if severe[6].

Ocular thermal burns rarely occur in isolation. Associated facial injuries and specifically airway involvement due to inhalational burns should be ruled out. These are life- threatening injuries and require emergency management in a well- equipped specialized unit.

Severe burn injuries frequently involve the face and thus ocular structures. The eyelids are the most frequently involved, accounting for 20-30% of ocular burn injuries[6, 10]. Corneal abrasions and corneal oedema have been reported following thermal burns. Primary corneal coagulation, though rare, may also occur[6].

2.2.1 Eyelid burns:

Oculopalpebral burns are mostly caused by flame, flash and chemical burns. Of these, flame is the most common (53.8%), then chemical agents (25.9%) and then explosions (16.3%).[6]

A. Classification according to Zones of Injury[12]:

When tissue is exposed to a burn injury, the area often resembles a bull's-eye target, with severity of injury decreasing from the center to the periphery. In a 3rd degree burn, the central area is the zone of coagulation, where tissue is destroyed and no longer viable, thus a characteristic white, leathery appearance. The area just peripheral to the center is the zone of stasis, which temporarily has decreased vascularity but can recover barring further injury. It has a deep and superficial zone. The superficial zone demonstrates early stasis because it becomes ischemic within 2hours. The deeper zone shows delayed stasis with ischemia 4-24 hours after injury. If cared for properly, hair follicle epithelial cells remain viable and will re-populate and migrate[12].

The third most peripheral zone is the zone of hyperemia. Vascular structures remain intact and the area blanches on pressure. There's no cell death, only oedema and erythema. 2nd degree burns do not have a zone of coagulation but have varying degrees of zones of stasis and hyperemia. 1st degree burns demonstrate zones of hyperemia only[12].

B. Classification according to Depth of the burn[6, 11, 12]:

The depth of the burn depends on three main factors: Intensity of heat exposure, duration of the exposure and the thickness of the dermis and epidermis[14]. Periocular skin is thin with no subcutaneous fat resulting in deeper burns than a similar exposure to skin elsewhere[14].

Classification according to depth is as follows:

I. First degree burns: these are superficial burns, commonly caused by sunburn, UV ray exposure and short-duration flash burns. Histologically, they involve only the epidermis and heal within 3-7 days, accompanied by superficial peeling. Also known as partial thickness burns, they are dry burns with erythema, oedema, skin warmth and pain. There is no blistering and eyelid function is rarely compromised. Usually contact with the causative agent is brief.

II. Second degree burns: Superficial 2nd degree burns are commonly caused by immersion scalds of short exposure. Histologically they involve the dermis and papillary epidermis. Healing occurs within within 7-21 days. Also partial thickness, they are more severe in nature. They present with intense erythema, bullae formation, edema and significant pain. The wounds blister, weep and form moist blebs.

Deeper burns may be caused by immersion scalds of longer duration and flame injuries. Blisters are large and thick- walled, while the skin appears mottled white and pink to cherry red. Histologically they involve the epidermis, papillary and reticular dermis. Healing occurs in 21-35 days if uncomplicated. Cicatricial lid deformities, hypertrophic scars and progression to full-thickness injury happens if infection or re-injury occurs.

III. Third degree burns: also known as full-thickness burns, they are caused by chemical, electrical, flame and scald injuries. They heal with scarring or disfigurement due to granulation tissue formation in 2-3 weeks. Burned lids have a waxy white/ translucent appearance or a dry, leathery, non-pliable appearance. Eschars form and separate in 2-3 weeks. They are however not painful as terminal nerve endings have been destroyed. Histologically, the wound includes subcutaneous tissue and may include fascia, muscle, tendons and bone. Healing takes many months and often grafting is required.

2.2.2 Corneal injuries:

These may occur primarily or as a complication of eyelid burns.

In the immediate insult, protective mechanisms of the eye help to reduce thermal damage to the globe. These include reflex eyelid closure in response to a direct stimulus e.g. touch or menace; Bell's phenomenon which is rotation of the eyeball upwards and outwards on lid closure to protect the cornea; blepharospasm i.e. sustained and forceful lid closure. There is also reflex movement away from the source of intense heat or shielding, protecting facial and ocular structures[6].

Despite this, corneal abrasions, corneal oedema and primary corneal coagulation may occur. Following lid burns, exposure keratopathy and corneal ulceration (leading to perforation or corneal scar formation) occur.[6]

2.2.3 Other ocular injuries:

Conjunctiva redness, chemosis and oedema have been reported following thermal burns. Oedema may be excercabated by fluid resuscitation and positive pressure ventailation[14]. Foreign bodies lodged in the fornices e.g. burnt eyelashes/ eyebrows may cause hyperemia, infection and foreign body sensation[16]. Symblepharon is a rare complication with thermal burns but has been reported in cases of contact e.g. with hot metal, due to direct apposition of the two surfaces[15].

2.3 MANAGEMENT OF THERMAL BURNS

Objectives of immediate therapy in thermal burns include:

1. Relief of discomfort.
2. Prevent secondary corneal inflammation, ulceration and perforation from infection or from exposure secondary to eyelid damage.
3. Minimize eyelid scarring and resultant malfunction.

Immediate treatment is crucial in minimizing tissue damage and tissue loss. It determines outcomes of ocular injuries incurred.

2.3.1 Management of Eyelid burns:

Immediate management of eyelid injuries involves proper examination, grading of burns where possible and examination of potential graft donor sites. The presence of eyelids and eyebrows should be documented as these are associated with deep partial or full- thickness burns. Though largely neglected, it is recommended that burnt lashes be removed to avoid the possibility of char falling into the eye and prolonging ocular discomfort[14, 16]. Moist sterile dressings applied on the lids allow sloughing of eschars and necrotic debris[6]. Prophylactic ocular lubrication is mandatory in burns involving the eyelids[14, 18].

In the intermediate period, skin grafting of eyelids can be done to minimize lid retraction and ectropion by closing the existing defect. This should be done as early as possible, after eschar removal or sloughing off has occurred i.e. within 2-3 weeks[6]. Post- auricular or supra-clavicular grafts are recommended as they provide superior cosmesis and contract less than other grafts. Contracture release can be performed at the same sitting.

Inadequate management of eyelid burns leads to severe contracture and eyelid deformity. Exposure keratopathy, corneal ulceration and even perforation occur due to inadequate lid closure, ectropion, and poor blink reflex or punctal obstruction.

Late management is aimed correcting complications e.g. contractures, scarring and tissue loss, in order to restore anatomical integrity and improve function of affected structures. It is also done to improve cosmesis. This can only be done after complete resolution of inflammation and scar maturation [17]. Medial canthal displacement, palpebral fissure stenosis, punctal and canalicular obstruction and eyebrow deformities are all corrected at a later stage. Correction of these is done after lid deformities have been fully corrected.

2.3.2 Management of the Cornea and Other ocular structures:

In the immediate period, assessment of corneal integrity is paramount. Mainstay of treatment includes frequent installation of lubricating artificial tears and ointment, which is started within 24 hours of injury and given at least thrice a day. Prompt lubrication reduces the need for immediate ocular or eyelid surgery by preventing exposure keratitis[14].

Bandage soft contact lenses have also been used to increase corneal surface hydration and promote healing. They are however difficult to maintain in place and may dry in ectropion and lagophthalmos. They may also act as a source of infection and thus their use is unsuccessful in some patients [6, 17]. A moisture chamber can be constructed with Saran Wrap or OpSite to protect the cornea. Horizontal lid taping slows down tear film evaporation especially in unconscious patients. Tarsorraphy can also be done for progressing exposure keratopathy or lid eversion, but should not be done in severe lid burns. Lid closure procedures may be postponed in the presence of severe lid burns and lubricant ointment used until surgery is planned.

Topical antibiotics and ophthalmic ointment that have good coverage against *Pseudomonas* and *Staphylococcus* can be used in the early period. These have been the most common organisms cultured in septic burns[8, 14.] Topical cyclopegics 2-3 times a day prevent formation of synechiae and relieve pain from ciliary spasm. Steroids are useful in the initial inhibition of inflammation, however prolonged use leads to delayed healing. They can therefore be used in the immediate 7- 10 days following injury.

3.0 RATIONALE OF STUDY

Kenya suffered two major fire tragedies in 2009 following fuel tanker explosions. The first occurred in January 2009 following the explosion of an overturned oil tanker in Sachang'wan on the Molo- Nakuru highway (see Appendix IV). The victims suffered burns when the tanker caught fire and exploded as victims attempted to siphon fuel. The death toll was 137 people, with over 100 others admitted with serious burns in various hospitals over the country (Appendix I). Four months later, in June another fuel tanker exploded in Kapok'yek near Kericho (Appendix IV), with 45 people injured. Two died and several others were admitted with burn injuries. Both fires left a trail of death and destruction in their wake.

Overwhelmed by the large numbers of seriously injured victims, medical personnel often ignore ocular injuries in the initial management, especially in the face of other life-threatening injuries. However they may lead to important clinical and functional sequele, including severe visual impairment and blindness[5].

A study was therefore necessary to identify, describe and document ocular injuries in those involved; guiding timely intervention where necessary and specialized follow up of patients as appropriate, so as to allow management and documentation of complications.

There was a need to examine current practices in emergency ocular care and establish if a protocol was required for the management of thermal ocular injuries.

4.0 OBJECTIVES

4.1 MAIN OBJECTIVE

To describe the magnitude and pattern of thermal ocular injuries following two major fire incidents in Kenya in January 2009 (Molo and Kericho oil tanker explosion).

4.2 SPECIFIC OBJECTIVES

1. To determine how many of the burn survivors had ocular injuries.
2. To describe the type and extent of ocular injuries present.
3. To determine the relationship between ocular injuries and percentage Total Body Surface Area (TBSA) of burns.
4. To determine the relationship between ocular injuries and distribution of burns in TBSA.
5. To determine the pattern of management instituted and their relation to ocular injuries
6. To describe the immediate outcome of ocular injuries incurred

5.0 METHODOLOGY

5.1 STUDY DESIGN:

A cross-sectional analytic study of patients involved in the Molo and Kericho oil tanker fire explosions.

5.2 STUDY POPULATION:

All burn survivors admitted in selected hospitals as a result of the two incidents.

5.3 PERIOD OF STUDY:

February – July 2009

5.4 STUDY SITE:

The study was carried out at various medical institutions which admitted patients following the two explosions. Using data obtained from the National Disaster Committee (Appendix I), these included:

a) Kenyatta National Hospital, Nairobi
b) Rift Valley Provincial Hospital, Nakuru
c) Mater Misericordae Hospital, Nairobi
d) Kericho District Hospital, Kericho

5.5 DATA COLLECTION:

The various major medical institutions involved in the management of the patients were contacted and approval obtained from the Ministry of Health and hospital management to carry out the study.

All eyes of the patients currently admitted in the institutions from the tragedies underwent a detailed ocular examination by the principal investigator after obtaining informed written consent. Examination was carried out in respective hospital wards as all participants were admitted at the time of the study. Many were bed-ridden.

Visual acuity (uncorrected) was measured using a distance equivalent chart, depending on age and literacy and recorded. Patients with suspected refractive errors were referred and this was taken into consideration in data analysis.

An ocular examination was carried out with a torch to detect gross lesions and pupillary reactions. Anterior segment examination was carried out using a portable Zeiss slit lamp. Lid injuries were classified according to depth of the burn. The cornea was examined and then stained with flourescein strip after installation of 0.5% tetracaine. Cobalt blue light was used to detect any epithelial defects or erosions. Other anterior segment structures (eyebrows, eyelashes, conjunctiva, anterior chamber, iris and lens) were examined with the portable Zeiss slit lamp and findings recorded in the questionnaire.

Intraocular pressure measurement was done after installing one drop of 0.5% tetracaine in each eye with a Schiotz tonometer. Patients were examined while lying supine.

Fundus examination was carried out using a Heine direct ophthalmoscope or Heine 150 indirect ophthalmoscope plus + 2.2 panretinal lens after dilatation with tropicamide 1%. Details on optic nerve, macula, retinal blood vessels and peripheral retina were noted and recorded.

All patients were examined to determine the percentage total body surface area (TBSA) of burns incurred where possible. Findings were confirmed with hospital records, especially where dressing had been done, to obtain the true TBSA. A human sketch on the questionnaire was used to mark the location of burn injuries (anterior and posterior) and record the percentage TBSA of burns.

A structured questionnaire was utilized to record the data obtained (Appendix II). Biodata and clinical information was obtained from the patients and where necessary, from hospital records. Details of any ocular treatment given was noted and recorded.

Photodocumentation was taken where necessary after obtaining informed written consent.

Confidentiality of information obtained was observed.

5.6 INCLUSION CRITERIA:

Casualties admitted in the study hospitals following the two fire explosions who consented to participate in the study.

5.7 EXCLUSION CRITERIA:

Burn survivors with injuries due to causes other than the two incidents.

Those who declined to give consent.

5.8 DATA ANALYSIS:

Analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 11.5. Data was presented using frequency diagrams, tables and pie- charts and bar graphs. P- values were used to demonstrate significant differences at the 95% confidence interval where applicable.

5.9 STUDY LIMITATIONS:

At the time of the study, many patients were left out as they had succumbed to more serious injuries following severe burns. After the first explosion, patients were examined two weeks later due to technicalities. It is possible that those who succumbed were more likely to have more severe ocular injuries than those who survived.

Private institutions with low number of patients were left out of the study due to difficulty in obtaining consent. The bulk of survivors however were admitted to government hospitals initially.

Only admitted patients were examined. Those seen as outpatients and discharged may have also had ocular burns.

5.10 ETHICAL CONSIDERATIONS:

Written informed consent was obtained from all participating. Where not possible, a close relative or guardian was requested to give consent (Appendix V). For unconscious unidentified patients, hospital approval was obtained for examination and photo documentation.

Separate, written informed consent was taken for any photo documentation of individual patients (Appendix V).

Approval was obtained from the Ministry of Health and all participating hospitals before data collection.

Approval by the KNH and UON Ethics Research and Standards Committee was obtained before data collection.

Available treatment was given to all patients recruited with ocular injuries i.e. topical steroids, antibiotics and lubricants. Where not possible, referrals were made.

All information collected was kept confidential.

6.0 RESULTS

A total number of 88 patients (burn survivors) were examined in this study (176 eyes). All the patients admitted in the listed medical institutions at the time of the study were included.

Table 1: Distribution of patients in medical institutions (n=88 people)

Medical Institution	Number of Patients	%
Nakuru P.G.H	39	44.3
Kenyatta National Hospital	22	25.0
Kericho District Hospital	21	23.9
Mater Hospital	6	6.8
TOTAL	**88**	**100**

Most of the patients were seen at Nakuru PGH, the hospital closest to the scene of the fire incidents. This was followed by Kenyatta National Hospital, a national referral hospital.

Table 2: Distribution by Age and Sex of survivors (n=88 people)

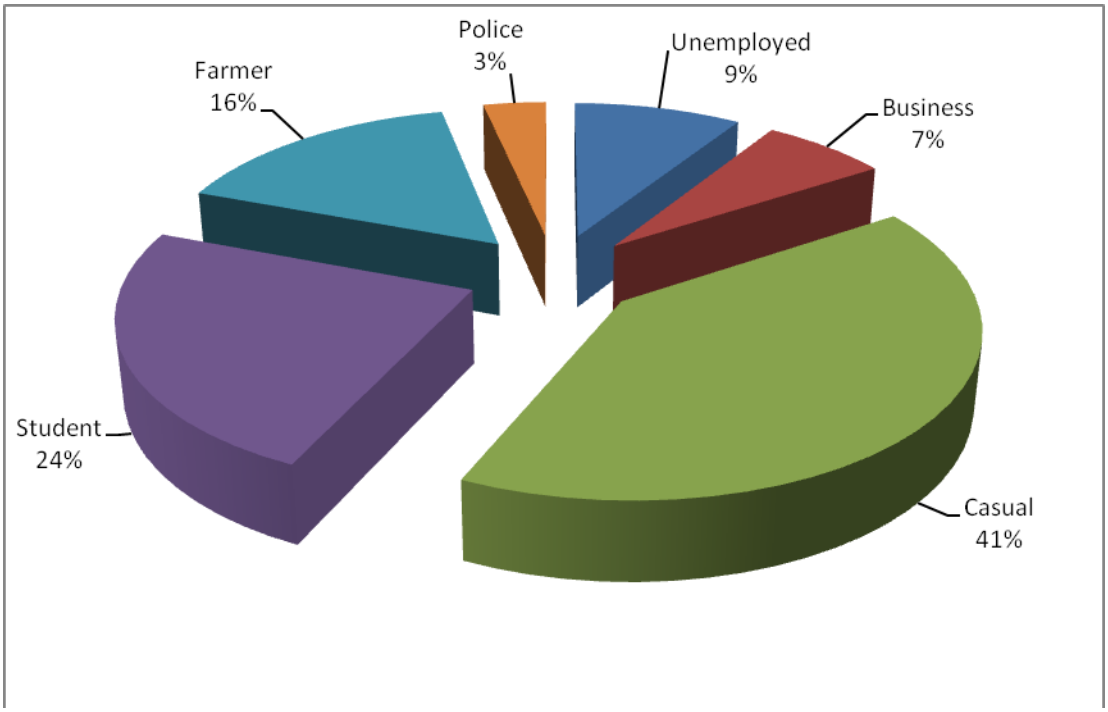
Age (in Years)	Male n=82 (93%)	Female n=6 (7%)	Total n=88 (%)
< 20	27 (30.6)	2 (2.3)	29 (33.0)
20-29	37 (42.0)	3 (3.4)	40 (45.5)
30-39	14 (15.9)	1 (1.1)	15 (17.0)
40-49	2 (2.3)	0 (0)	2 (2.3)
≥ 50	2 (2.3)	0 (0)	2 (2.3)

The Mean age was 23.9 years, median age was 22.5 years. The youngest patient was 10 years and the oldest 59 years.

Among these, children (aged 15 years and below) were 14 (16%).

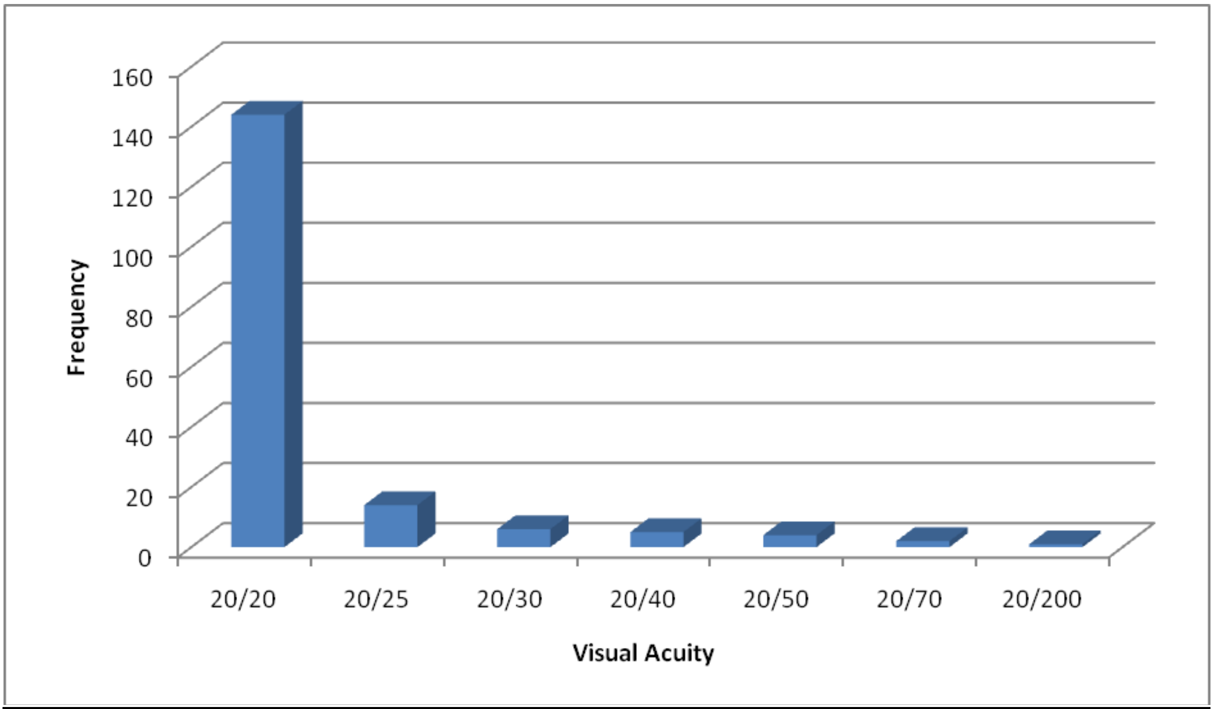
Males were more involved than females in all age groups, with a ratio of 13.7:1

Fig 1: Distribution of Employment status among those involved (n=88 people)



A large proportion of survivors were casual laborers (41%). This was followed by primary school students (24%), a group of curious onlookers.

Figure 2: Distribution of uncorrected visual acuity (n=176 eyes)



Most of the patients examined had normal visual acuity.

Table 3: Association between visual acuity and previous ocular disease (n=176 eyes)

Visual Acuity	Previous Ocular DSE		p-value
	Yes, n=29 (%)	No, n=147 (%)	
20/20	17 (58.6)	128 (87.1)	
20/25	6 (20.7)	8 (5.4)	
20/30	2 (6.9)	4 (2.7)	
20/40	1 (3.4)	4 (2.7)	***0.008***
20/50	2 (6.9)	2 (1.4)	
20/70	1 (3.4)	1 (0.7)	

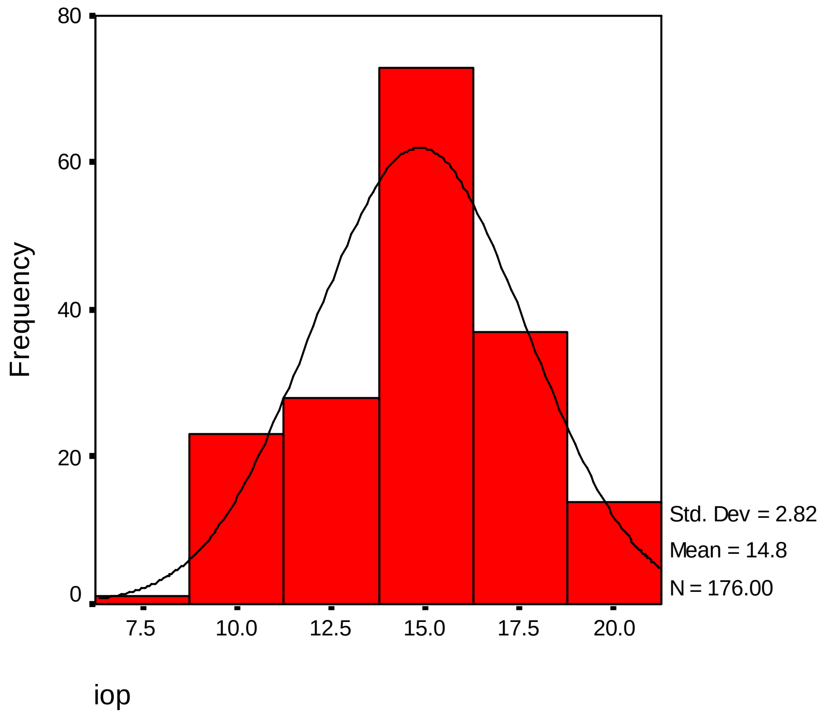
A p-value of <0.05 was considered statistically significant. There was a positive association between those with previous ocular disease and visual acuity, indicating that ocular burns were not responsible for poor vision.

Table 4: Ocular findings present prior to ocular burns (n=29 eyes)

OCULAR CONDITION	FREQUENCY (n=29)	PERCENTAGE (100%)
Allergic conjunctivitis	14	48.3
Refractive errors	6	20.7
Presbyopia	4	13.8
Cataract	2	6.9
Corneal scar	2	6.9
Aphakia	1	3.4
TOTALS	**29**	**100**

Allergic conjunctivitis was the commonest finding on enquiry of previous ocular conditions, followed by refractive errors.

Figure 3: Distribution of Intra-ocular Pressure (n=176 eyes)

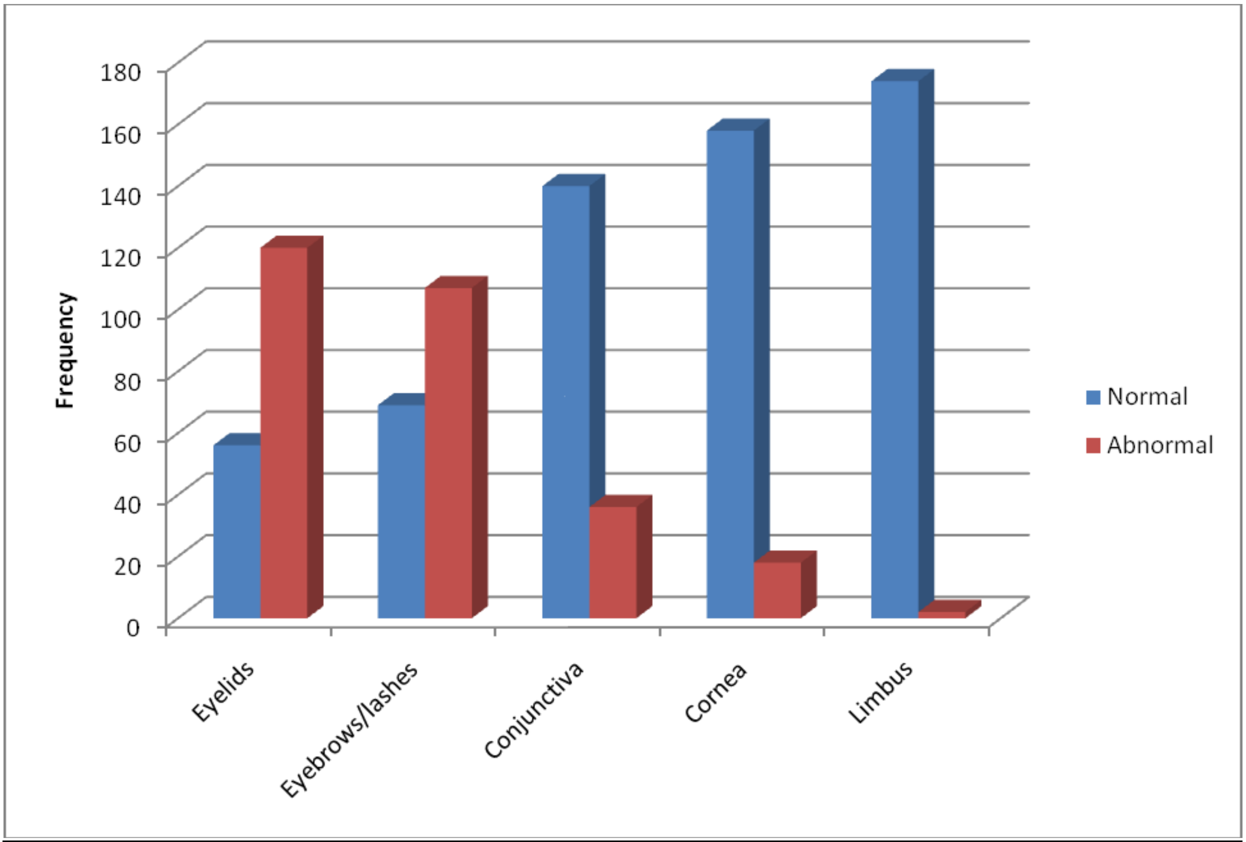


The mean IOP was 14.8 mmHg.

Median IOP was 14.6 mmHg and it ranged between 7.1 – 20.6 mmHg.

Distribution followed a normal curve.

Figure 4: Distribution of Ocular injuries (n=176 eyes):



Ocular adnexae were more affected than intra-ocular structures.

The eyelids were the most affected (68.2%) followed by eyebrows and eyelashes (60.8%). The conjunctiva (20.5%) and cornea (10.2%) were affected to a lesser extent.

Only 2 eyes (1.1%) had limbal involvement.

Table 5: Abnormal Conjunctival findings (n=34 eyes)

Conjunctiva findings	Frequency (n=34)	Percentage (100%)
Chemosis	16	47.1
Infective conjunctivitis	18	52.9

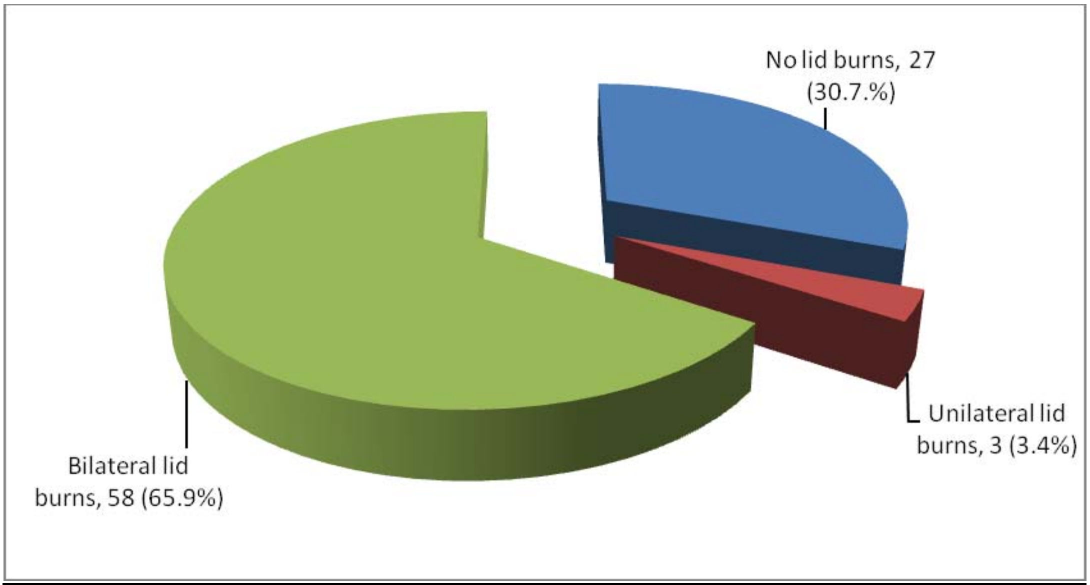
Infective conjunctivitis was the commonest conjunctiva finding. Chemosis was seen acutely post- burns.

Table 6: Abnormal Corneal findings (n=17 eyes)

Cornea findings	Frequency	%
Superficial punctate keratitis	17	9.7

Superifical punctuate keratitis was the only burn-related abnormality seen in the cornea.

Figure 5: Distribution of Eyelid burns (n= 88 people):

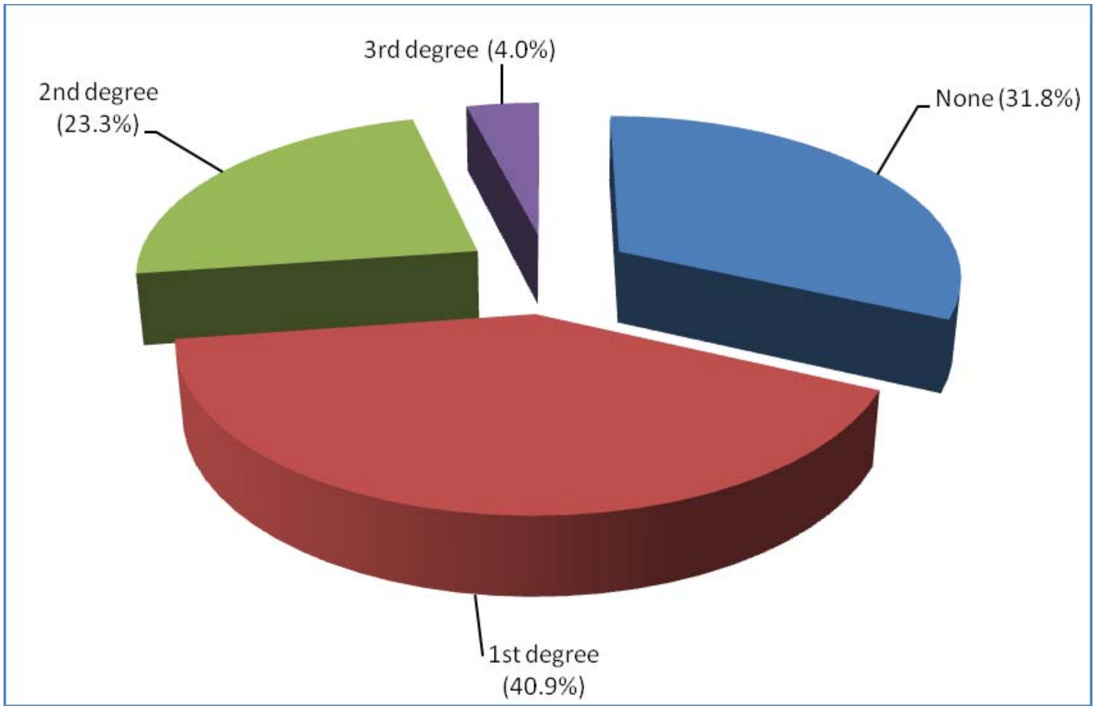


69.3 % (61) of the patients had eyelid burns.

Of these, majority had bilateral involvement (65.9%) while a small number (3.4%) were unilateral.

About a third of patients had no eyelid burns.

Figure 6: Classification of eyelid burns (n=176 eyes)



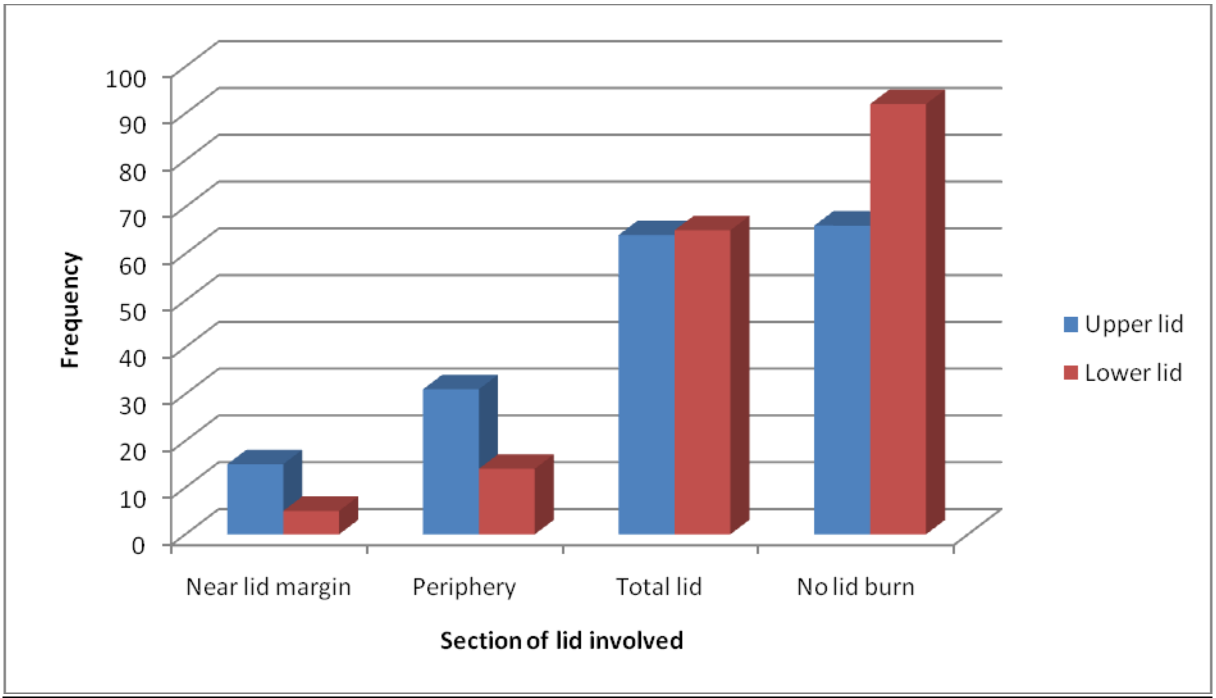
First degree burns were the most common incurred (40.9%) followed by second degree burns. Other eyelid injuries noted were lid oedema (6.7%) and lagophthalmos (1.1%).

Table 7: Lid involvement: (n=176 eyes)

Lid Involvement	Frequency (n=176)	Per cent (100%)
Both lids (upper& lower)	81	46.0
None	63	35.8
Upper lid only	30	17.0
Lower lid only	2	1.1

In most cases both lids were involved (46.0%). Upper lid burns were more common than those of the lower lid.

Figure 7: Details of Sections of lid involved (n=352lids i.e. upper & lower X 176eyes)



In most cases it was an "all or none" scenario, whereby the total lid was involved or none of it.

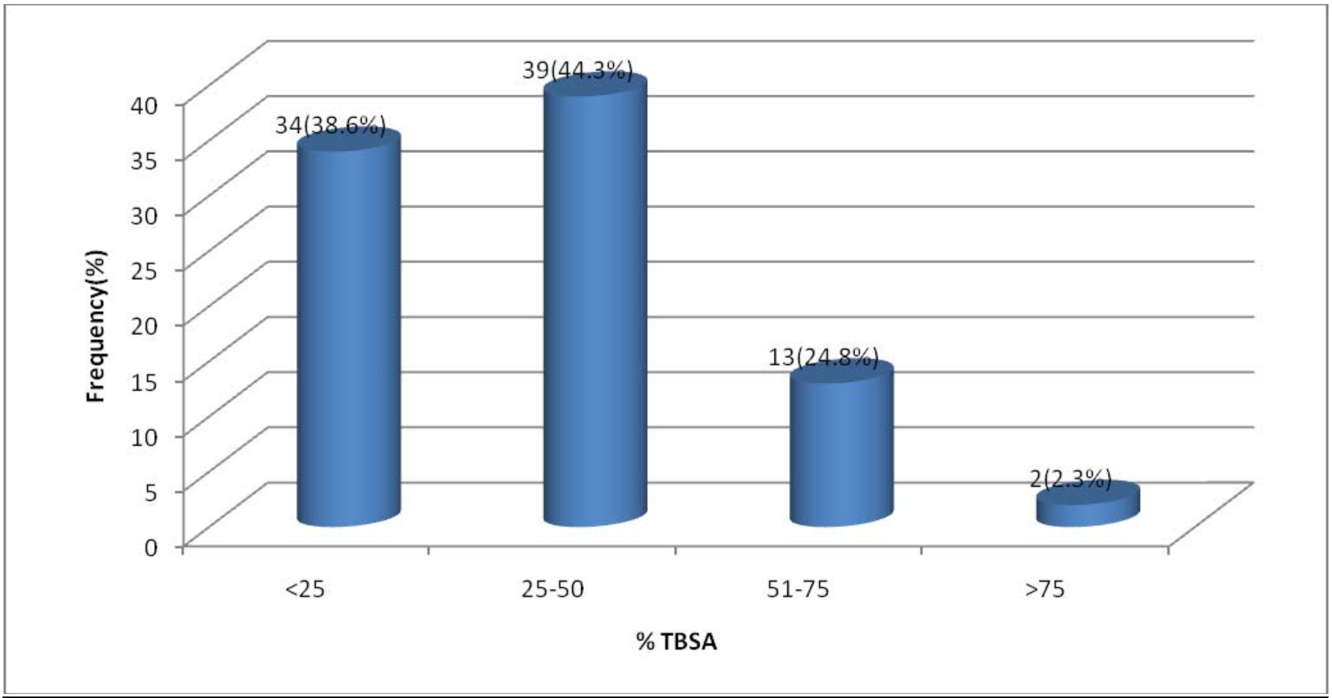
Lid burns near the lid margin alone were less frequent than those in the periphery.

Table 8: Involvement of lid margin (n= 352 lids)

Lid Margin	Frequency (n=352)	Percentage (100%)
Yes	40	11.4
No	312	88.6

In those with burns bordering the lid margins, 50% had involvement of the lid margin.

Figure 8: Distribution of Total Body Surface Area (TBSA) of Burn: (n=88)



Majority of the patients had 25- 50% percentage TBSA of burns, followed closely by those with less than 25 % body burns.

Table 9: Association between percentage TBSA and Ocular findings:

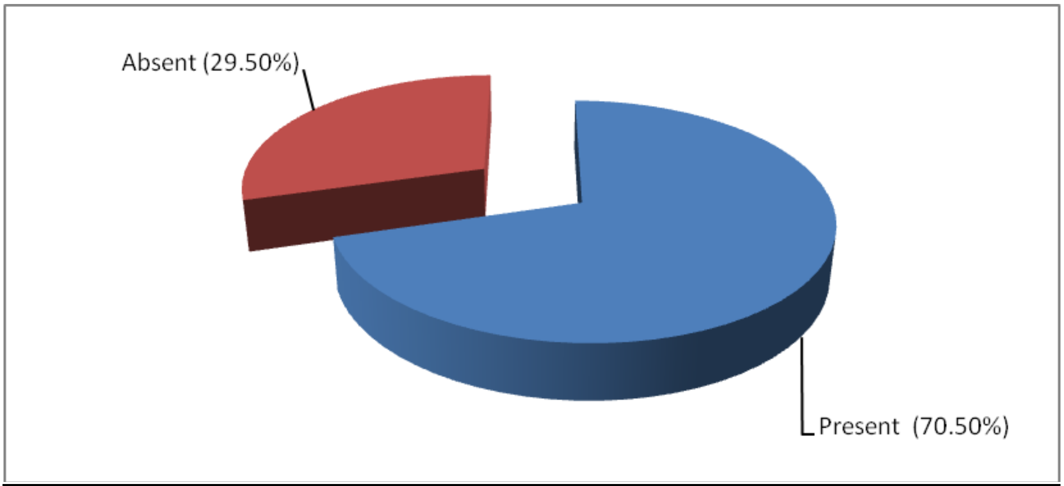
	Percentage TBSA			p-value
	< 25, n (%)	25-50, n (%)	> 50, n (%)	
Eyelid burns				
Absent	26 (38.2)	23 (29.5)	7 (23.3)	
Present	42 (61.8)	55 (70.5)	23 (76.7)	***0.013***
Eyebrows/lashes				
Normal	24 (35.3)	36 (46.2)	9 (30.0)	***0.218***
Burnt	44 (64.7)	42 (53.8)	21 (70.0)	
Lid margin involvement				
Yes	6 (8.8)	9 (11.5)	5 (16.7)	***0.528***
No	62 (91.2)	69 (88.5)	25 (83.3)	
Conjunctiva findings				
Normal	57 (25.5)	67 (85.9)	16 (53.3)	***<0.001***
Abnormal	11 (16.2)	11 (4.1)	14 (46.7)	
Corneal findings				
Normal	67 (98.5)	73 (93.6)	18 (60.0)	***<0.001***
Abnormal	1 (1.5)	5 (6.4)	12 (40.0)	
Limbal involvement				
Normal	68 (100)	78 (100)	28 (93.3)	***0.007***
Abnormal	0 (0)	0 (0)	2 (6.7)	

A p-value of <0.05 was considered statistically significant.

There was statistically significant association between percentage TBSA and eyelid burns, conjunctiva, cornea and limbus findings.

There was no significant association with lid margin involvement.

Figure 9: Presence of Facial burns (n=88):



Majority of the patients had facial burns (70.5%).

Of those with facial burns, 7 patients (11.3%) had no associated ocular injuries while the rest (55, 88.7%) had ocular as well as facial burns.

Table 10: Association between eyelid and upper limb burns in those with facial burns (n=62 people):

Upper Limbs (arm) burns	Eyelid Injury		OR (95% CI)	p-value
	Yes, n (%)	No, n (%)		
Yes	41 (73.2)	5 (83.3)	0.6 (0.0 to 5.6)	0.962
No	15 (26.8)	2 (16.7)		

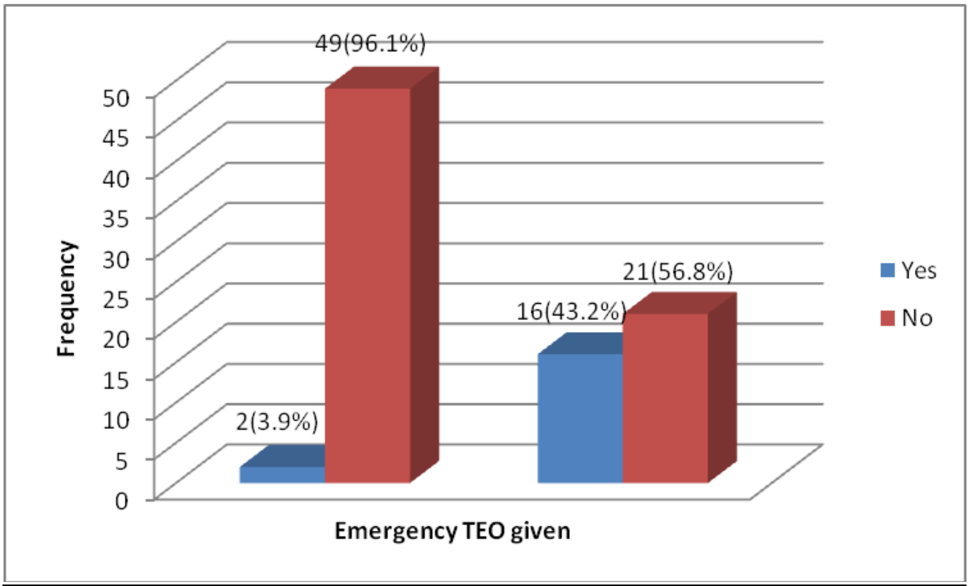
In those with facial burns, burns to the upper limbs were found to have a protective effect on lid burns due to mechanical shielding. The effect was however not statistically significant.

Table 11: Association between Facial Burns and Ocular findings:

	Any Facial Burns		P-value
	Yes, n (%)	**No, n (%)**	
Eyelid Burns			
Absent	10 (8.1)	46 (88.5)	
Present	114 (91.9)	6 (11.5)	***<0.001***
Eyebrows/lashes			
Normal	22 (17.7)	47 (90.4)	***<0.001***
Burnt	102 (82.3)	5 (9.6)	
Lid margin involvement			
Yes	20 (16.1)	0	
No	104 (83.9)	52 (100.0)	***0.002***
Conjunctival findings			
Normal	90 (72.6)	50 (96.2)	***<0.001***
Abnormal	34 (27.4)	2 (3.8)	
Corneal findings			
Normal	107 (86.3)	51 (98.1)	***0.019***
Abnormal	17 (13.7)	1 (1.9)	
Limbus involvement			
Normal	122 (98.4)	52 (100.0)	***0.357***
Abnormal	2 (1.6)	0	

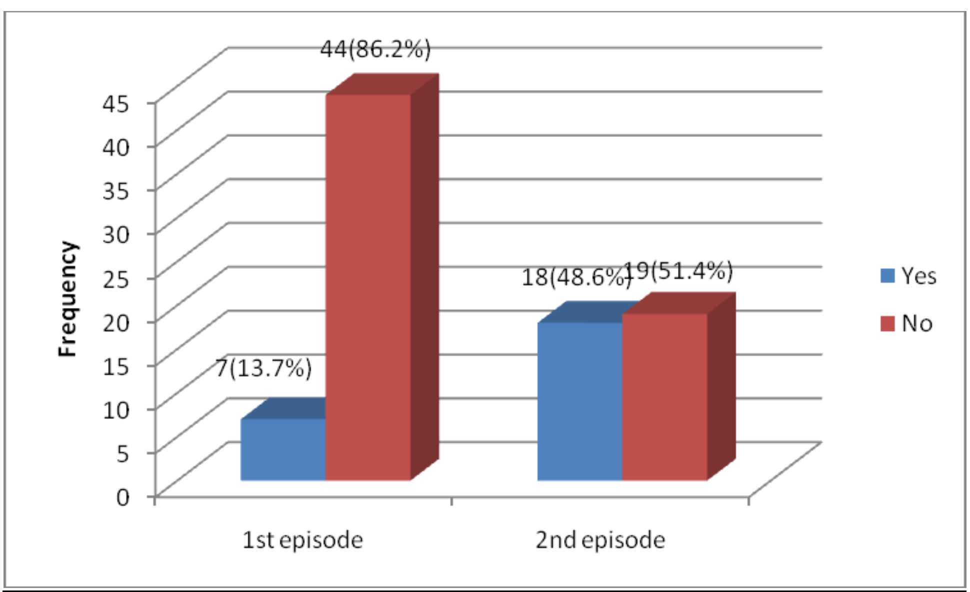
57% of those with facial burns also had ocular injuries. There was a positive association between facial burns and eyelid, cornea and conjunctival injuries.

Figure 10: Emergency ocular treatment (TEO) given: (n=88)



There was a learning curve between the two episodes (1st and 2nd explosion) as more patients received ocular treatment within 24 hours after the second fire episode.

Figure 11: Ocular Treatment given after 24hours:



The same learning curve is seen with ocular treatment given after first 24 hours. More patients received TEO after the second fire, showing an improvement in ocular management.

7.0 DISCUSSION:

Ocular thermal injuries are among important causes of visual impairment and their sequele may lead to blindness.

In the year 2009, two oil tankers exploded in Kenya along the Nakuru- Kericho Highway under similar circumstances. The first tanker explosion was in January and the second in June. Both were transporting petrol and overturned along the highway. The areas are largely farming areas whose main source of income is agricultural activities. Large, small-scale as well as livestock farming is carried out by the residents. The areas are also bordered by forests which provide income in terms of forestry and nearby police posts are used for security. Following the overturning of the tankers, residents rushed to the scene and attempted to siphon fuel from the tankers. Many had the intention of selling it later for a small profit. Although the source of the fire was not confirmed, reports indicate that someone intentionally lit the fire in anger after police officers at the scene demanded a fee for collection of petrol[15]. The tankers exploded leaving several people dead and other seriously injured. Those included in the study were those admitted to various hospitals during the study period. Most patients were seen in public hospitals and a few in private institutions.

After the blast injuries, the nearest government hospitals i.e. Nakuru P.G.H Hospital and Kericho district hospital received most of the patients (see Table 1). Eighty- eight patients were seen at the time of the study. This was an under-estimation of the patients received. A large group with severe injuries succumbed to their injuries before the study period (Appendix I) and others with minor injuries were treated and discharged home within a day or two. KNH, being a referral hospital, received most patients with serious burns, children and those who needed ICU care. Few patients were examined in the private hospitals because, apart from receiving a small number of patients, approval for examination of patients was more difficult to obtain.

The age of the victims ranged from 10 years to 59 years, with a mean age of 23.9 years. The peak age bracket was between 20-29 years (45.5%). This can be explained by the fact that a large percentage of the working force fall within this age group. Stern et al found a mean age of 36 years with a male preponderance[10]. Many of the victims could have been looking for an alternative source of income to support themselves and their families. They were followed by those less than 20 years, 48% of them school-going children. The children were mostly curious onlookers from a nearby school. They were playing soccer in the field after school when the tanker overturned and they rushed to the scene to observe the on-goings. Those who were within 10- 50metres were caught in the rapidly-spreading explosion. Few were lured by the possibility of easy money and were also siphoning the spilt fuel. Thermal burns in children have been reported to be largely accidental and associated with flammable substances in the home[8]. Curiosity has also been associated with younger children i.e. toddlers aged 2-3 years[8]. The mechanism of injury in this setting was different and being an unusual occurrence in the community, children were likely to be drawn by curiosity to the scene. The preponderance of young people could also be explained by the fact that they were more likely to participate in the activity of siphoning fuel, an 'adventure' to some.

There was a high preponderance of males compared to females in all age groups (Table 2) with a ratio of 13.7 : 1. Other studies have shown that males are more likely to be affected than females, particularly in occupational settings [8,11]. The disparity is however much less. Albertyn et al found a ratio of 2:1[8]. Males, in our setup, constitute the larger working force. The areas of the incidents are large-scale farming areas i.e. nearing sugar-cane and tea plantations and men constitute the larger casual labor force. They are also more likely to be looking for alternative sources of income from the siphoned fuel. Most females involved were subsistence farmers who were accidentally injured when burn victims ran into nearby farms after they caught fire, carrying containers with fuel. The spilt fuel spread fire quickly and injured those nearby. Those who were at a distance of up to 150 meters were involved.

The socio-demographic data revealed that of those affected (Fig.1), the largest group were casual laborers (41%). This could be explained by the nearby large-scale farming plantations where most were working. They were likely to be searching for alternative sources of income from the siphoned fuel. These were followed by students (24%), a group of curious onlookers. Unemployed individuals were relatively few (9%) and this could be attributed to the location of the incidents. Policemen from the nearby police post were also involved (3%). While it is thought that they were there to maintain law and order, there were claims that they also acted as "marshals", allowing fuel-siphoning at a small fee[15].

Most of the examined patients had normal visual acuity. Thermal burns have generally been shown to have good visual outcomes [6,10,11]. Poor vision was attributable to previous ocular disease (Table 3). Intra- ocular pressures were found to have a normal distribution among the subjects.

Under ocular injuries, ocular adnexae were more involved than intraocular structures, with eyelid burns being the most common injury. Eyelids play a great protective role to other structures in thermal burns[6]. They have also been found to be the most commonly affected structures[10], with complications arising from deep second and third degree burns e.g. contractures and deformity[6]. First degree burns rarely cause complications[6]. Early surgical intervention is aimed at protecting intra-ocular structures by maintaining proper function of the eyelids. Out of 88 patients, 61 (69.3 %) of the patients had eyelid burns. This was higher than that seen in other studies which showed a range of 9.3- 15%[10,18,19]. Majority had bilateral lid involvement (58, 65.9%) while a small number (3, 3.4%) were unilateral. Spencer et al found percentages of 54 and 30 respectively[19]. About a third of patients (27, 30.7%) had no eyelid burns.

Most of the patients studied suffered first degree burns (40.8%) with fewer suffering second (23.3%) and third degree (4.0%) burns. Of these, 2 already had lagophthalmos, one of whom had tissue loss from the upper lid as well. Other lid injuries noted were lid oedema (6.7%).This was associated with facial oedema secondary to facial burns and in one patient, renal failure with generalized body swelling.

Forty- six percent of patients had burns in both lids as compared to upper (17.0%) or lower lid (1.1%) only. This demonstrates the severity of the thermal burns incurred. The upper lid was more likely to be affected than the lower lid due to its larger surface area[5]. All those with lid margin involvement had second or third degree burns. The lid margin was involved in 11.4% of cases and this has a future implication on deformity. Those with both lid margin and medial third of the lid burns are likely to have drainage of tears affected as punctual occlusion secondary to cicatricial scarring could occur. Those with burns involving the lower half of the lid are more likely to get scarring deformities with healing e.g. ectropion and entropion. A classification of eyelid burns according to sections involved has not yet been formulated. In this study, the lid was subdivided into areas bordering the lid margin and those in the periphery. Most burns did not fall into either category as they involved the whole lid or none at all (Figure 7).

The common findings in the conjunctiva were chemosis and secondary infective discharge. Chemosis was seen in patients reviewed within 48 hours of injury and was thus an acute finding. Those with infective discharge had a hospital stay varying from 3- 14 days and this could be attributed to hospital stay. Stern et al reported conjunctiva burns and conjunctivitis in patients with thermal burns [10].In the immediate period, eye care was not a priority as some patients had other life-threatening injuries. Poor ocular hygiene while in hospital could also have been a factor.

The cornea was affected in 10.8% of cases. Because of protection by the lids, the cornea is often not seriously damaged in thermal burns[6]. Superficial punctate keratitis was the only burn-related finding here. One patient had a pre-existing corneal scar due to previous trauma. Due to the low incidence of injury to the cornea, most patients had good vision despite lid injuries.

Only 2(1.1%) patients were found to have limbal ischemia. This has a future implication on healing i.e. when the limbus is affected significantly, the cornea may develop recurrent epithelial defects, and conjunctival invasion onto the cornea may occur due to the loss of stem cells responsible for renewing corneal epithelium[11].

Other intra-ocular structures i.e. the anterior chamber, iris, pupil, lens and posterior segment were found to be normal in these patients. 2 patients above 50 years of age with previous progressive poor vision were found to have cataract (Table 4).

Facial burns were also assessed. Previous studies have shown that 15-20% of those with facial burns incurred ocular injuries as well [10, 18, 19]. In this study, the percentage was higher, with 57% of patients having both facial and ocular burns. This could be attributed to the mechanism of injury: the victims were siphoning fuel from the ground and nearby ditches into which it had flowed. When the explosion occurred, most were bent over the fuel and were thus more likely to get facial burns. There was a significant correlation between ocular injuries in different structures with facial burns. Cases of facial burns without ocular injury could be attributed to shielding of the eyes with the arms to try and protect the eyes. The effect was however not statistically significant (Table 10).

The relation between TBSA and ocular injuries was also assessed so as to estimate the severity. Majority of patients seen had less than 50% TBSA of burns. Spencer et al found that 54.5% of patients seen had TBSA of less than 21% [19]. Severe burns are often associated with death (as in this study) or late referral [18, 19] and are likely to be missed. There was statistically significant association between percentage TBSA and eyelid burns, conjunctiva, cornea and limbus findings. Those with TBSA of >50% were more likely to have ocular injuries than those with less percentages. Burns from fire exposure may require a heightened index of suspicion because ocular burns might be overlooked in the setting of larger body burns[11].

The ocular management of these patients in the first 24 hours and thereafter brought out a gap in eye care. Tetracycline eye ointment, being the common and sometimes only available and affordable eye medication was the only drug found in use at the time of the study. It was used as an intra-ocular antibiotic and lubricant, as well as superficially for severe lid burns. In the first episode, only 3.9% of patients examined received TEO within 24hours of admission. After that, the number rose to 13.7% who were using it at the time of the study. Most of the health care practitioners in the institutions were unaware of what further medication to use and were overwhelmed with the care of other life-threatening injuries. Eye care workers had not yet been involved actively in the management of the patients. This was not a unique scenario. Hodge et al found that even though general practitioners are the first contact with the patient, knowledge on emergency ocular care and referral systems are limited[20] . In the second episode, there seemed to be a learning curve with 43.2% of patients receiving TEO within the first 24 hours and a further 48.6% using it at the time of the study. The local ophthalmologist was involved early, within 24 hours of the incident. Gutt steroids, antibiotics, lubricants and cycloplegics provided by the University of Nairobi were given to patients who required them. Referrals were given to patients who already had scarring and were likely to require follow up and reconstruction at a later date.

8.0 CONCLUSION:

1. The largest group of people involved comprised of young males working as casual laborers, followed by children who were curious onlookers.
2. The ocular injuries incurred involved ocular adnexae and intra-ocular structures were largely spared.
3. The most common complication seen was eyelid burns followed by conjunctival and corneal injuries.
4. Most of the patients had normal vision.
5. Ocular injuries had a positive correlation to Total body Surface Area (TBSA) of burns and facial burns.
6. Ocular management of patients, despite a learning curve, was insufficient. Lack of knowledge among primary health care practitioners limited adequate management.

9.0 RECOMMENDATIONS:

There is need to follow up these patients in order to assess late complications and adequately manage them where present.

There is a need to train other health care workers on emergency management of common ocular injuries and immediate referral as appropriate.

A protocol on management of ocular injuries in burn victims should be developed for better emergency management.

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11.0 CLINICAL PICTURES

FIRST DEGREE LID BURNS:

Picture 1: Patient with 1st degree lid burns, healed, sparing the lid margin

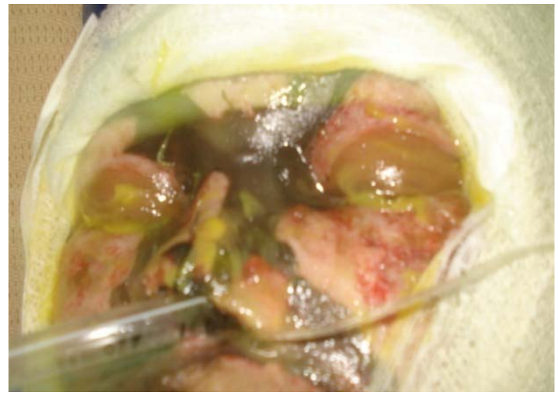
Picture 2: Patient with healed 1st degree lid burns with lid margins involved

SECOND DEGREE BURNS:

Picture 3&4: Patients with facial burns and second degree lid burns, healing with crusting. The lid margins are involved.

THIRD DEGREE LID BURNS:

Picture 5: Patient with 3rd degree lid burns with lagophthalmos, more in left eye.



Picture 6: Child with severe facial + inhalational burns, plus 3rd degree lid burns forming eschars.

Picture 7: Patient with deep 2nd and 3rd degree lid burns forming eschars. The lid margin in the left eye is mostly spared.

Picture 8: Child with marked facial and inhalational burns, the lids are oedematous with 1st degree lid burns. Lid margins are involved.

FACIAL BURNS SPARING THE EYELIDS

Patient with facial burns with the eyelids largely spared. Further examination revealed what could be finger imprints on the lower cheeks. Shielding of the eyes with his hands could have spared them from injury.

12.0 CASE PRESENTATIONS:

CASE PRESENTATION 1:

The above patient was a 22 year old female who was examined on day 13 after the fire. Her case demonstrates another major mechanism of injury, given that she was at least 200meters from the primary explosion site. She was working in her farm when the fire occurred. Another victim already on fire and carrying a container full of oil fell close by. As the fuel spilt the fire spread fast to her and she incurred burns on the face, upper and lower limbs.

On examination, she was sick-looking but conscious with TBSA burns of 50%, predominantly 1st and 2nd degree, including inhalational burns. Vision was 20/25 in the right eye and 20/50 in the left. RE: The upper lid had deep 2nd and 3rd degree burns, with lagophthalmos. Bell's phenomenon was good. Eyebrows and lashes were singed. The cornea was clear and rest of the globe normal. LE: the upper lid had mixed deep 2nd and 3rd degree burns, with lagophthalmos. Eschars were forming on the upper lid despite previous debridement. Bell's phenomenon was inadequate and 2mm of the cornea was exposed inferiorly, with punctuate staining. The rest of the globe was normal.

This patient was not on any lubricants at the time of examination. It was reported that at admission, she was able to close both eyes. Deep second degree burns can progress to 3rd degree if infection or re-injury occurs, leading to scarring and exposure of the cornea. Lubricants, contact lenses, moisture chambers and lid closure (taping, tarsorraphy) all help to preserve the cornea before reconstruction is done. The above patient was put on ocular lubricants. Unfortunately she succumbed to her injuries before further management could be planned.

CASE PRESENTATION 2:

The above patient is a 17 year old male who was examined 3days after the fire explosion. He was injured while siphoning fuel from the ground, thus most of his burns occurred on the face and upper limbs. In his past ocular history, he had suffered from previous burns to the left side of his face when he was 3years old. This had left him with a scarred lids and tissue loss on the left upper lid.

On examination, the TBSA of burns was 20%, predominantly 1st degree. Vision was 20/20 in both eyes and motility was free. The right eye had 1st degree burns with singed eyelashes and eyebrows. The globe was normal. The left eye had both 1st and 2nd degree lid burns. Upper lid had madarosis and tissue loss of 40% laterally, with hypertrophic conjunctiva visible beneath it. The lower lid had ectropion with singed eyelashes. Bell's phenomenon was good and there was no exposure keratopathy or staining of the cornea. The rest of the left globe was normal. The patient was already on lubricant ointment at the time of examination, prescribed by the resident ophthalmologist.

Patients with previous burns are at higher risk of scarring with second exposure. Once granulation tissue has formed in 2-3 weeks, grafts or flaps should be used to replace both anterior and posterior lamellae. Failure to do so leads to exposure of the cornea and may lead to blindness. The above patient was put on long-term lubricants and referred to an occuloplastic surgeon on discharge for lid reconstruction.

13.0 APPENDICES

13.1 APPENDIX I

SUMMARY OF ADMITTED PATIENTS: (Molo fire explosion)[21]

HOSPITAL	01- 02- 2009	04- 02- 2009	13-02-2009 (Day of examination)
Nakuru PGH	117	59	30
Kenyatta N. H.	-	22	15
Mater Hospital	-	13	6
Molo District Hospital	26	9	-
Aga Khan Hospital	-	3	3
Nairobi Hospital	-	3	3
Valley Hospital	1	0	-
DEATHS AT THE SCENE	89		
TOTALS	238	109	57

SUMMARY OF ADMITTED PATIENTS: (Kericho Explosion)

HOSPITAL	17/6/2009	18/6/2009	19/6/2009
Kericho D.H	43	30	20
Kenyatta N.H	-	7	7
Nakuru P.G.H	-	-	8
Tenwek M.H	-	-	1
Kericho Nursing Home	-	-	1
TOTALS	43	37	37

13.2 APPENDIX II : QUESTIONNAIRE

QUESTIONNAIRE NO.###

BIODATA: **DATE:**

PATIENT NAME: AGE: SEX: M ☐ F ☐

OCCUPATION:

CONTACT INFORMATION:

RESIDENCE: VILLAGE: LOCATION: CONSTITUENCY:

ADDRESS:

TEL NO(s):

NAME AND CONTACT OF CLOSE RELATIVE:

CLINICAL INFORMATION:

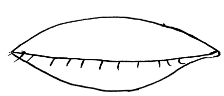
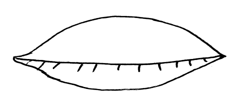
DURATION (DAYS) FROM INCIDENT:

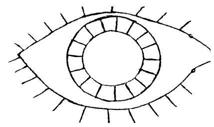
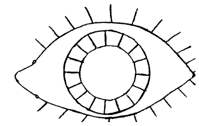
PREVIOUS OCULAR DSE/INJURY/SURGERY:

EMERGENCY MX:

CURRENT MX:

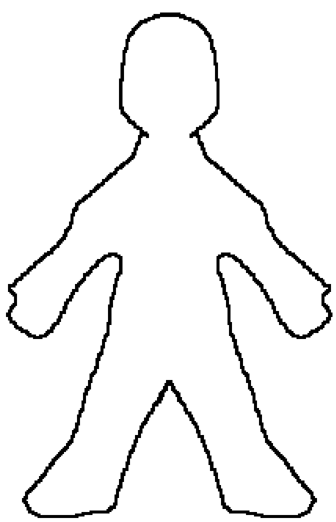
CLINICAL EXAMINATION:

	RIGHT EYE	**LEFT EYE**
VISUAL ACUITY (sc/ PH/ cc)		
EOMM		
INTRAOCULAR PRESSURE (GAT / Icare / Schiotz / other)		
EYELIDS (degree of burn:(R,B,G), lid defects, lid margins)		
EYEBROWS/ EYELASHES		
CONJUNCTIVA a) Bulbar		

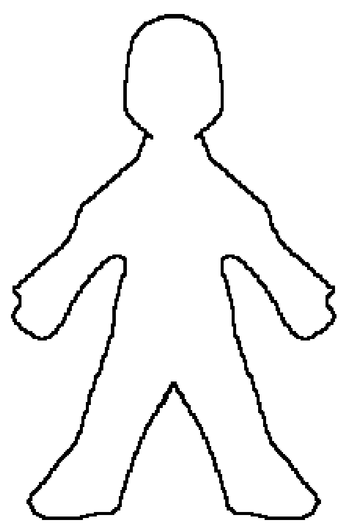
b) Palpebral		
SCLERA		
CORNEA		
ANTERIOR CHAMBER		
IRIS		
LENS		
VITREOUS		
RETINA & ONH		

TBSA (PERCENTAGE AND DISTRIBUTION):

FRONT



BACK



DIAGNOSIS:

13.3 APPENDIX III: WHO CLASSIFICATION OF VISION

20/20 – 20/60	Normal vision	6/6 – 6/18
<20/60 – 20/160	Moderate visual impairment	<6/18 – 6/60
<20/160 – 20/400	Severe visual impairment	<6/60 – 3/60
<20/400- 20/1000	Profound visual impairment (blind)	< 3/60

<u>**APPENDIX IV: MAP OF KENYA**</u>

The arrow points to the Nakuru- Kericho highway, along which both incidences occurred.

APPENDIX V: CONSENT FORM

I, __________________________________ of P.O Box _________________________ and/ or district/ town _______________________ hereby consent to be included in this study.

I further state that the eye examination procedures have been explained to me and I fully understand what is to be done.

I understand that the data obtained will be kept confidential and the results will be used in promoting improved eye management services.

Date ________________________

Signed _______________________

Photo documentation:

I also hereby consent to any photo documentation. I understand that this will only be used for academic/ educational purposes and not for any other purpose.

Date: _________________________

Signed: ________________________

I confirm that I have explained the nature and effect of the procedures which include slit lamp examination, measurement of intraocular pressure and dilated fundoscopy using direct / indirect ophthalmoscope. I have also explained the effects of drugs used in examination i.e. tetracaine and tropicamide.

Date: __________________________

Signed: _________________________