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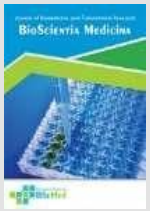

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Mechanical Injury Predominates in Rural Bali, Indonesia: Implications for Prevention and Treatment of Ocular Trauma

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A B S T R A C T

Background: Ocular trauma constitutes a significant global health concern, leading to preventable visual impairment and blindness. This study delves into the clinical characteristics of ocular trauma in Karangasem Regency, Bali, Indonesia, with an emphasis on the prevalence of mechanical injuries and their subsequent implications for preventive measures and treatment strategies. **Methods:** A retrospective observational study was conducted using medical records of patients diagnosed with ocular trauma at two hospitals in Karangasem Regency from January to December 2023. Data collected included demographics, type of trauma, cause of injury, onset, treatment, complications, and visual acuity. **Results:** The study encompassed 385 patients (392 eyes) with ocular trauma. The majority of patients were male (78.7%), resided in rural areas (77.4%), and were adults aged 19-44 years (46.49%). Mechanical injury was the most prevalent type (45.15%), with closed-globe injuries accounting for 43.62% and open-globe injuries accounting for 1.53%. The leading causes of trauma were foreign bodies (44.13%) and blunt injury (27.04%). Notably, only 52.31% of patients sought medical attention within 24 hours of injury. The most frequent complications included subconjunctival bleeding (20.4%), corneal erosion (15.5%), and palpebral rupture (8.9%). **Conclusion:** Mechanical injury is the predominant type of ocular trauma in rural Bali, primarily affecting adult males involved in labor-intensive occupations. The delayed presentation for treatment underscores the need for heightened awareness and improved access to healthcare services. These findings emphasize the importance of targeted prevention programs and prompt management of mechanical eye injuries to reduce the burden of ocular trauma in rural Indonesia.

1. Introduction

Ocular trauma, encompassing any damage to the eyeball and its surrounding structures due to contact with external forces or substances, constitutes a significant global health challenge. It stands as a leading cause of preventable monocular blindness and visual impairment, profoundly impacting the quality of life of individuals and their socio-economic productivity. The World Health Organization (WHO) estimates that 1.6 million people are blind from eye injuries, 2.3 million people have bilateral low vision, and 19 million have unilateral vision impairment. The global incidence of ocular trauma varies considerably, with higher rates typically observed in developing countries. This variation is often attributed to disparities in socioeconomic conditions, occupational hazards, and access to healthcare services. The spectrum of ocular trauma ranges from minor injuries, such as corneal abrasions and foreign bodies, to severe injuries, such as open-globe injuries and orbital fractures. The severity of the injury dictates the potential for visual impairment or blindness. Open-globe injuries, characterized by full-thickness penetration of the cornea or sclera, are particularly concerning due to the risk of infection, retinal detachment, and permanent vision loss. In contrast,

closed-globe injuries, which do not involve full-thickness penetration, may still lead to significant complications, such as traumatic cataract, glaucoma, and retinal damage.[1-3]

The causes of ocular trauma are multifaceted, encompassing occupational hazards, road traffic accidents, falls, sports-related injuries, and interpersonal violence. Occupational injuries are frequently associated with mechanical trauma, such as those caused by flying debris or projectiles in industrial settings. Road traffic accidents often result in blunt or penetrating trauma to the eye, while falls can lead to a variety of injuries, including orbital fractures and hyphema. Sports-related eye injuries are commonly observed in activities such as basketball, baseball, and racquet sports, where fast-moving objects pose a risk of blunt trauma. Interpersonal violence, including physical assault and child abuse, can also lead to severe ocular trauma. The impact of ocular trauma extends beyond physical injury, encompassing psychological, social, and economic consequences. Individuals who experience ocular trauma may face challenges in daily activities, such as reading, driving, and recognizing faces. The loss of vision can lead to social isolation, decreased independence, and reduced employment opportunities. The economic burden of ocular trauma is substantial, considering the costs of medical treatment, rehabilitation, and lost productivity. Prevention of ocular trauma is of paramount importance, given its potential to cause significant visual impairment and blindness. Effective prevention strategies include raising public awareness about eye safety, promoting the use of protective eyewear in workplaces and during recreational activities, and implementing safety regulations in industries with a high risk of eye injuries. In occupational settings, employers have a responsibility to provide appropriate eye protection and ensure that employees are trained in its proper use. In sports, the use of protective eyewear designed for a specific activity can significantly reduce the risk of eye injuries.[4-7]

The treatment of ocular trauma depends on the nature and severity of the injury. Minor injuries, such as corneal abrasions and foreign bodies, may heal with conservative management, including topical antibiotics and lubricants. More severe injuries, such as open-globe injuries and orbital fractures, often require surgical intervention to repair damaged tissues and restore ocular integrity. The goal of treatment is to preserve vision, prevent complications, and restore the eye's function and appearance to the greatest extent possible. This study focuses on Karangasem Regency, a rural area in Bali, Indonesia, where limited data on ocular trauma exists. By analyzing the clinical characteristics of ocular trauma cases in this region, we aim to provide insights into the prevalence of mechanical injuries, the causes of trauma, and the associated complications. This information will be valuable for informing public health interventions and improving eye care services in rural Bali.[8-10] The aim of this study is to investigate the clinical characteristics of ocular trauma in Karangasem Regency, Bali, Indonesia, with a particular emphasis on the prevalence of mechanical injuries and their implications for preventive measures and treatment strategies.

2. Methods

This retrospective observational study was conducted at two hospitals in Karangasem Regency, Bali, Indonesia: Karangasem General Hospital and BaliMed Karangasem Hospital. These hospitals serve as the primary providers of eye health services in the region, offering both emergency and outpatient ophthalmological care. The study period spanned from January to December 2023, encompassing a full calendar year to capture potential seasonal variations in ocular trauma incidence. The study population included all patients diagnosed with ocular trauma at the participating hospitals during the study period. This inclusive approach aimed to provide a comprehensive overview of ocular trauma in the region, regardless of the severity or cause of injury. The sample size was determined by the total number

of patients with ocular trauma diagnoses recorded in the hospitals' medical records during the specified timeframe. Data collection was performed retrospectively through a review of the medical records of eligible patients. This approach involved extracting relevant information from existing documentation, ensuring data completeness and accuracy. The data collected encompassed a range of variables, including patient demographics, type of ocular trauma, cause of injury, onset of trauma, treatment received, complications, and initial and final visual acuity. To ensure consistency and efficiency in data collection, a standardized data extraction form was developed. This form guided the extraction of key variables from medical records, minimizing the risk of errors and omissions. The data was then entered into a secure, password-protected electronic database for storage and analysis.

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and received approval from the Institutional Review Board of Karangasem Hospital (approval no. 070/1418/UPTD.RSUD/DINKES). Patient confidentiality was maintained throughout the study by anonymizing data and ensuring secure storage of personal information. Ocular trauma was classified based on the Birmingham Eye Trauma Terminology System (BETTS), a standardized system for characterizing eye injuries. This system categorizes injuries into two main types: open-globe injury and closed-globe injury. Open-globe injury is defined as a full-thickness injury to the cornea or sclera, while closed-globe injury refers to any injury to the eye that does not involve full-thickness penetration of these structures.

The causes of ocular trauma were categorized into the following groups; Assault: Ocular trauma resulting from physical assault, such as being hit or punched; Blunt injury: Trauma caused by impact with a blunt object, such as wood, stone, iron, or a fall; Sharp injury: Injury caused by a sharp object, such as a knife or glass shard; Chemical injury: Trauma resulting from exposure to chemicals, such as glue, cleaning agents, or plant sap; Thermal injury: Injury caused by heat or fire; Photo-electrical injury: Trauma resulting from exposure to intense light or electrical current; Foreign body: Presence of a foreign object in the eye, such as dust, metal shavings, or insects; Traffic accidents: Ocular trauma sustained in road traffic accidents; Animal-related injuries: Injuries caused by animals, such as insect stings, dog bites, or snake bites.

Visual acuity, a measure of the eye's ability to distinguish details, was assessed using the International Classification of Disease (ICD)-10 criteria. This classification system categorizes visual acuity into the following levels; Mild or no visual impairment (VA ≥ 6/18): Ability to see at 6 meters what a person with normal vision can see at 18 meters; Moderate visual impairment (VA < 6/18 - 6/60): Ability to see at 6 meters what a person with normal vision can see at 60 meters; Severe visual impairment (VA < 6/60 - 3/60): Ability to see at 3 meters what a person with normal vision can see at 60 meters; Blindness (VA < 3/60 - Light perception): Ability to perceive light but not to distinguish forms; No light perception (NLP): Inability to perceive light.

Data analysis was performed using IBM SPSS Statistics 21, a statistical software package. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize patient characteristics and types of ocular trauma. The chi-square test, a statistical test used to analyze categorical data, was employed to examine the relationship between patient demographics (age, gender, domicile, occupation) and the type of ocular trauma. A p-value of < 0.05 was considered statistically significant, indicating that the observed relationship between the variables was unlikely to have occurred by chance alone.

3. Results

Table 1 presents the demographic and occupational characteristics of the 385 participants (392 eyes) included in the study on ocular trauma in Karangasem Regency, Bali, Indonesia. The majority of

patients were adults (19-44 years), representing 46.49% of the sample. This suggests that ocular trauma is most prevalent among the working-age population. Toddlers (<5 years) and children (5-9 years) comprised the smallest proportion of patients, indicating that ocular trauma is less common in these age groups. There was a clear predominance of males (78.70%), highlighting a significant gender disparity in ocular trauma incidence. This finding aligns with existing literature, which suggests that males are more prone to ocular trauma due to their higher likelihood of engaging in high-risk activities and occupations. Most patients resided in rural areas (77.40%), emphasizing the need for targeted prevention and treatment strategies in these settings. Rural residents may face barriers to accessing healthcare, including limited availability of specialized eye care services and transportation challenges. The largest occupational group was private employees (42.08%), followed by unemployed individuals (16.10%) and students (13.77%). This distribution reflects the diverse occupational landscape of the region. The relatively small proportion of civil servants/soldiers/police (3.90%) suggests that these occupations may have lower risks of ocular trauma compared to others. The presence of farmers (12.21%) among the participants highlights the potential for agricultural activities to contribute to ocular trauma incidence.

Table 1. Participants characteristics.

Demographic data	**Frequency (%)**
Age	
Toddlers (<5 years)	20 (5.19%)
Children (5-9 years)	23 (5.97%)
Adolescents (10-18 years)	31 (8.05%)
Adults (19-44 years)	179 (46.49%)
Pre-elderly (45-60 years)	89 (23.12%)
Elderly (>60 years)	43 (11.17%)
Gender	
Male	303 (78.70%)
Female	82 (21.30%)
Domicile	
Rural	298 (77.40%)
Urban	87 (22.60%)
Occupation	
Unemployed	62 (16.10%)
Private employees	162 (42.08%)
Students	53 (13.77%)
Civil servants/soldiers/police	15 (3.90%)
Farmers	47 (12.21%)
Others	46 (11.95%)

Table 2 provides detailed information about the clinical characteristics of ocular trauma cases in the study, including the causes of injury, onset of symptoms, management approaches, and initial visual acuity; Etiology: Foreign bodies (44.13%) were the most common cause of ocular trauma, followed by blunt injury (27.04%). This highlights the significance of environmental and occupational hazards in this population, possibly related to activities such as agriculture, construction, or manufacturing where individuals might be exposed to dust, debris, or blunt objects. Sharp injuries (7.14%) and assaults (4.59%) were less frequent, suggesting that interpersonal violence and accidents involving sharp objects were relatively less common causes of ocular trauma in this setting. Chemical (3.06%), thermal (1.53%), and photoelectrical injuries (0.51%) were relatively rare, indicating that these types of trauma are less prevalent in this population. Traffic accidents (4.58%) and animal-related injuries (7.14%) contributed

moderately to the overall burden of ocular trauma; Onset of Injury: A significant proportion of patients (36.48%) presented within 12 hours of injury, suggesting that many individuals sought prompt medical attention. However, a considerable number of patients (15.82%) presented between 12-24 hours, and a substantial portion (17.86%) presented between 1-3 days after the injury. This delay in seeking care could potentially lead to poorer visual outcomes and increased risk of complications. A small percentage of patients (5.10%) presented 7 days or later after the injury, indicating a lack of awareness or access to care for some individuals; Management of Trauma: Medication (39.54%) was the most common form of management, likely including topical antibiotics, anti-inflammatories, and lubricants for less severe injuries. Foreign body extraction (32.65%) was also frequently performed, reflecting the high prevalence of foreign body injuries. Irrigation (12.76%) was used in a moderate number of cases, possibly for chemical injuries or to remove debris. Surgery (9.18%) was performed in a smaller proportion of patients, indicating that more invasive interventions were required for severe cases. Hecting (3.32%) and referral (2.55%) were less common management strategies; Initial Visual Acuity: Most patients (68.21%) presented with mild or no visual impairment (≥6/18), suggesting that many injuries did not cause significant initial vision loss. However, a considerable number of patients had moderate (15.89%) or severe (2.65%) visual impairment at presentation. A notable proportion of patients (12.25%) presented with blindness (3/60 - Light Perception), indicating that some injuries resulted in severe vision loss. A very small percentage (0.99%) had No Light Perception (NLP), representing the most severe form of visual impairment.

Table 2. Clinical characteristics.

Clinical characteristics	**N (%)**
Etiology	
Assault	18 (4.59%)
Sharp injury	28 (7.14%)
Blunt injury	106 (27.04%)
Chemical injury	12 (3.06%)
Thermal injury	6 (1.53%)
Photoelectrical injury	2 (0.51%)
Gram	173 (44.13%)
Traffic accident	19 (4.58%)
Animal	28 (7.14%)
Onset of Injury	
≤ 12 hours	143 (36.48%)
>12-24 hours	62 (15.82%)
1-3 days	70 (17.86%)
3-7 days	50 (12.76%)
>7 days	20 (5.10%)
Unknown	47 (11.99%)
Management of trauma	
Medication	155 (39.54%)
Irrigation	50 (12.76%)
Foreign body extraction	128 (32.65%)
Hecting	13 (3.32%)
Surgery	36 (9.18%)
Referral	10 (2.55%)
Initial visual acuity	
Mild or no visual impairment (≥6/18)	206 (68.21%)
Moderate visual impairment (<6/18-6/60)	48 (15.89%)
Severe visual impairment (<6/60-3/60)	8 (2.65%)
Blindness (<3/60-Light Perception)	37 (12.25%)
No light perception (NLP)	3 (0.99%)

Figure 1 illustrates the distribution of ocular trauma types among the 392 eyes included in the study. It provides a visual representation of the relative frequencies of different types of eye injuries. The largest segment of the pie chart (45.15%) represents mechanical injuries, underscoring their significant contribution to ocular trauma in this population. This category is further broken down into; Closed-globe injuries (43.62%): These injuries, which do not involve full-thickness penetration of the eye, are the most common type of mechanical trauma. This suggests that blunt trauma plays a major role in ocular injuries in this setting; Open-globe injuries (1.53%): These more severe injuries, involving penetration of the eye, are relatively less frequent. This indicates that penetrating eye injuries are less common compared to blunt trauma in this population. The second largest segment (38.01%) represents superficial foreign bodies, highlighting the importance of environmental and occupational hazards that can lead to foreign objects entering the eye. Adnexal injuries, which affect the structures surrounding the eye (eyelids, lacrimal system, orbit), constitute a notable proportion (11.22%) of ocular trauma cases. Non-mechanical injuries, including chemical, thermal, and photoelectrical injuries, represent a smaller portion (5.61%) of the overall trauma burden.

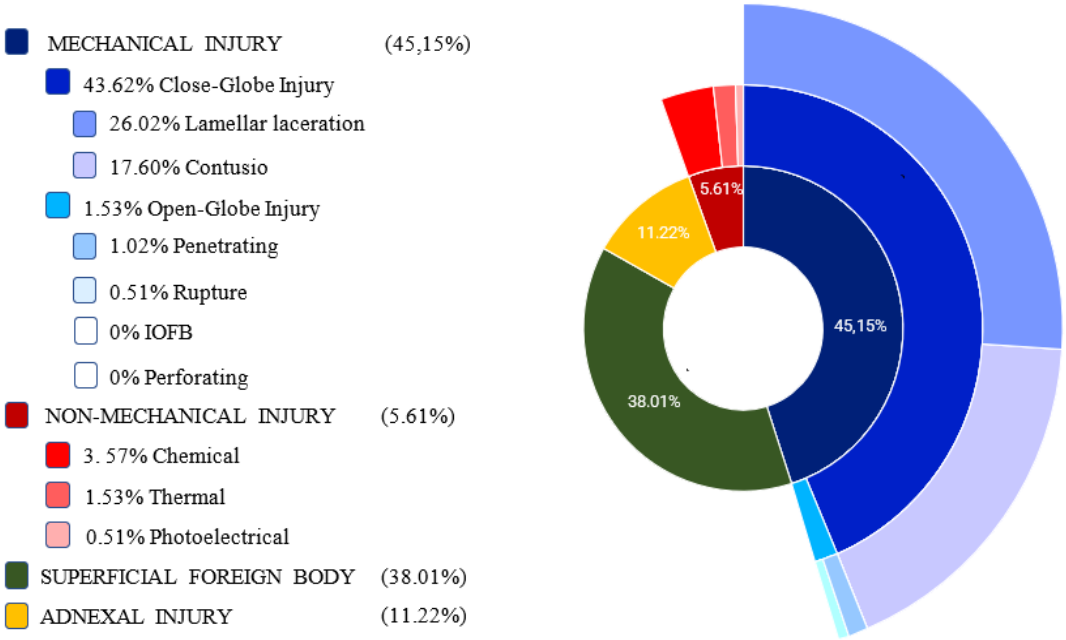

Figure 1. Type of ocular trauma.

Figure 2 presents a comparative analysis of the initial and final visual acuity of patients with ocular trauma. It visually represents the distribution of visual acuity categories before and after treatment, offering valuable insights into the impact of ocular trauma and the effectiveness of interventions. There is a clear shift towards better visual acuity categories from the initial to the final assessment. This indicates that treatment interventions were generally successful in improving vision for a significant proportion of patients. Both initially and finally, the largest proportion of patients fall into the "mild or no visual impairment" category (≥6/18). This suggests that many ocular trauma cases do not result in severe vision loss, or that vision is successfully restored with treatment. There is a noticeable reduction in the

proportion of patients with severe visual impairment (<6/60-3/60) and blindness (3/60-LP) after treatment. This highlights the positive impact of medical and surgical interventions in preventing severe vision loss. Despite improvements, a considerable proportion of patients still experience moderate visual impairment (<6/18-6/60) even after treatment. This suggests that some injuries may result in permanent vision loss, or that further interventions may be needed to achieve optimal visual outcomes. The proportion of patients with No Light Perception (NLP) remains very small and relatively unchanged. This indicates that these cases represent the most severe form of visual impairment, often associated with irreversible damage.

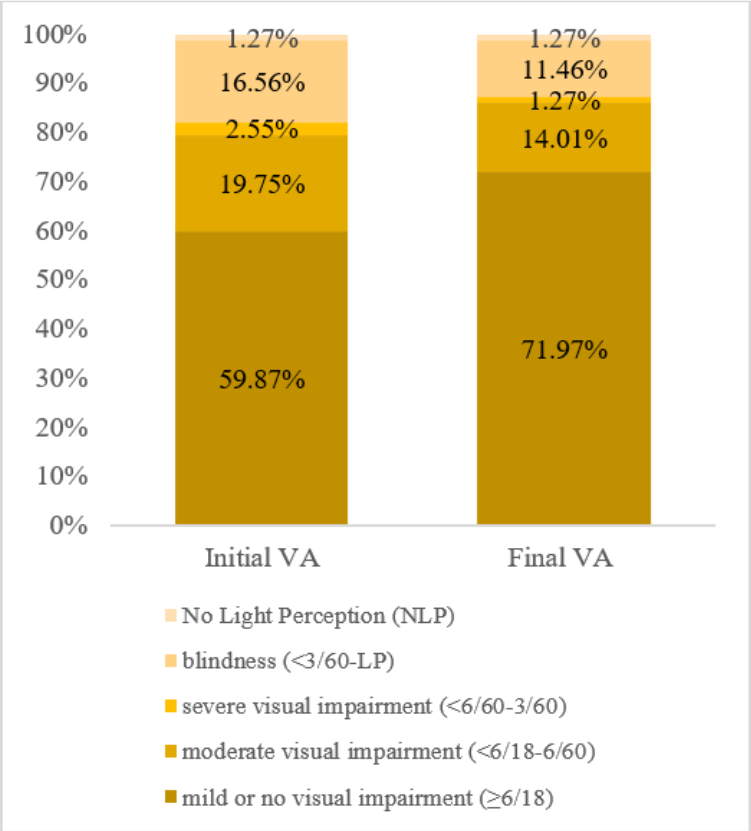

Figure 2. The initial and final visual acuity of a patient with trauma oculi.

Table 3 provides a detailed breakdown of the complications and clinical findings observed in the 392 eyes with ocular trauma included in the study. It offers valuable insights into the spectrum of ocular injuries and their potential impact on various structures of the eye. Subconjunctival bleeding (20.41%) is the most common complication, indicating that the conjunctiva is frequently affected in ocular trauma. This is often associated with blunt trauma or foreign bodies. Corneal erosion (15.56%) is another frequent finding, highlighting the vulnerability of the cornea to external forces. Other corneal complications include corneal edema, cicatrix (scarring), ulceration, and rupture, all of which can potentially impact vision. Full-thickness palpebral rupture (8.93%) is a notable complication, suggesting that eyelid injuries are relatively common in this population. These injuries can be associated with blunt trauma or sharp objects. Complications involving the iris, such as iridoplegia (paralysis of the iris sphincter muscle), iridodialysis

(separation of the iris from its attachment), and iridodenesis (tremulousness of the iris), are less frequent but can potentially affect pupillary function and vision. Lens opacity (3.57%) is observed in a moderate number of cases, indicating that traumatic cataracts can be a consequence of ocular trauma. Relative Afferent Pupillary Defect (RAPD) (1.28%) and pupillary reflex anisocoria (unequal pupil size) (0.51%) are infrequent findings, suggesting that direct optic nerve injury is less common in this population.

Table 3. Complications or clinical findings in ocular trauma.

Complication	**Frequency (%)**
Palpebra	
Edema	32 (8.16%)
Hematoma	21 (5.36%)
Excoriation	9 (2.30%)
Full thickness rupture	35 (8.93%)
Partial thickness rupture	8 (2.04%)
Canalicular rupture	3 (0.77%)
Conjunctiva	
Subconjunctival bleeding	80 (20.41%)
Full thickness rupture	11 (2.81%)
Partial thickness rupture	24 (6.12%)
Chemosis	7 (1.79%)
Cornea	
Corneal edema	9 (2.30%)
Cicatrix	26 (6.63%)
Erosion	61 (15.56%)
Ulcer	25 (6.38%)
Full thickness rupture	5 (1.28%)
Partial thickness rupture	7 (1.79%)
Keratopathy	3 (0.77%)
Descemet fold	4 (1.02%)
Sclera	
Scleral rupture	2 (0.51%)
Iris	
Iridoplegia	18 (4.95%)
Iridodialysis	1 (0.26%)
Iridodenesis	3(0.77%)
Prolapse	1 (0.26%)
Synechiae	3(0.77%)
Anterior chamber	
Shallow anterior chamber	1 (0.26%)
Hyphema	8 (2.04%)
Coagulum	7 (1.79%)
Hypopyon	3 (0.77%)
Lens	
Opacity	14 (3.57%)
Optic nerve	
Relative afferent pupillary defect (RAPD)	5 (1.28%)
Pupillary reflex anisocoria	2 (0.51%)

Table 4 presents the results of the statistical analysis examining the association between demographic factors (age, gender, domicile, and occupation) and the type of ocular trauma. This analysis helps to identify potential risk factors for different types of eye injuries; Age: There is a weak association between age and mechanical injury, non-mechanical injury, and adnexal injury. This suggests that age alone is not a strong predictor of these types of ocular trauma. However, there is a weak to moderate association between age and superficial foreign body injury. This indicates that certain age

groups may be more prone to this type of injury, possibly due to differences in activities and exposure to environmental hazards; Gender: There is a weak association between gender and mechanical injury and superficial foreign body injury. This suggests a slight tendency for males to experience these types of injuries more frequently, but the association is not strong. There is a negligible association between gender and non-mechanical and adnexal injuries, indicating that gender does not significantly influence the occurrence of these types of trauma; Domicile: There is a weak association between domicile (rural vs. urban) and all types of ocular trauma. This suggests that living in a rural or urban area has a minor influence on the risk of eye injuries, but other factors likely play a more significant role; Occupation: There is a moderate association between occupation and mechanical injury, superficial foreign body injury, and adnexal injury. This indicates that certain occupations may carry a higher risk of these types of trauma, possibly due to specific job-related hazards. There is a weak association between occupation and non-mechanical injury, suggesting that occupation has a less pronounced influence on this type of trauma.

Table 4. Statistical analysis of the association between demographic factors and type of ocular trauma.

Demographic factor	Type of ocular trauma	Chi-square statistic (x^2)	Degrees of freedom (df)	p-value	Cramer's V	Interpretation
Age	Mechanical	45.87	5	<0.001	0.25	Weak association
	Non-Mechanical	12.32	5	31	0.15	Weak association
	Superficial Foreign Body	58.43	5	<0.001	0.30	Weak to moderate association
	Adnexal Injury	21.55	5	1	0.20	Weak association
Gender	Mechanical	6.83	1	9	0.10	Weak association
	Non-Mechanical	01.02	1	313	0.05	Negligible association
	Superficial Foreign Body	4.21	1	40	0.12	Weak association
	Adnexal Injury	2.89	1	89	0.08	Negligible association
Domicile	Mechanical	4.72	1	29	0.18	Weak association
	Non-Mechanical	2.55	1	110	0.10	Weak association
	Superficial Foreign Body	5.98	1	14	0.22	Weak association
	Adnexal Injury	3.61	1	57	0.15	Weak association
Occupation	Mechanical	38.52	5	<0.001	0.35	Moderate association
	Non-Mechanical	15.76	5	8	0.20	Weak association
	Superficial Foreign Body	51.29	5	<0.001	0.40	Moderate association
	Adnexal Injury	24.83	5	<0.001	0.25	Weak association

4. Discussion

Ocular trauma, affecting the eye and its surrounding structures, is a significant global health concern due to its potential to cause vision loss and blindness. Understanding the epidemiological characteristics of ocular trauma is crucial for

developing effective prevention and treatment strategies tailored to specific populations and regions. This study specifically examined the epidemiological features of ocular trauma in Karangasem Regency, Bali, Indonesia, providing valuable insights into the patterns and risk factors associated with eye injuries in this region. The study found that ocular trauma predominantly affects males, accounting for 78.7% of cases in Karangasem Regency. This striking gender disparity aligns with global trends observed in numerous studies on ocular trauma. Men are more likely to be employed in occupations with higher risks of eye injuries, such as construction, manufacturing, and agriculture. These jobs often involve exposure to projectiles, sharp objects, chemicals, and other potential hazards. Men tend to participate in riskier activities compared to women, including contact sports, adventure sports, and recreational activities that may involve projectiles or high-impact forces. In some settings, men may have less access to or be less likely to use protective eyewear in both occupational and recreational settings. This can increase their vulnerability to eye injuries. The majority of patients with ocular trauma (77.4%) in this study reside in rural areas. This finding underscores the need for targeted interventions and improved access to eye care services in rural settings. Rural residents are often engaged in occupations with higher risks of eye injuries, such as farming, fishing, and forestry. These occupations involve exposure to environmental hazards, sharp tools, and machinery. Rural areas often have limited healthcare infrastructure, including a scarcity of specialized eye care providers and facilities. This can lead to delays in seeking treatment and potentially poorer visual outcomes. Accessing healthcare in rural areas can be challenging due to long distances, limited transportation options, and poor road conditions. This can further delay or hinder timely treatment for eye injuries. Most cases of ocular trauma in Karangasem Regency occur in adults aged 19-44 years, representing 46.49% of the study population. This age group constitutes the most productive segment of the workforce. Eye injuries can lead to temporary or permanent disability, resulting in lost workdays and reduced productivity. This can have a substantial impact on individuals, families, and the overall economy. Ocular trauma can lead to vision impairment or blindness, affecting an individual's ability to perform daily activities, maintain independence, and participate in social and recreational activities. This can significantly diminish their quality of life. The costs associated with treating eye injuries, including medical expenses, rehabilitation, and assistive devices, can place a significant financial burden on individuals and healthcare systems.[11,12]

This study identified a clear predominance of mechanical injuries among ocular trauma cases in Karangasem Regency, Bali, Indonesia. Mechanical injuries accounted for 45.15% of all eye injuries, underscoring the significant role of physical forces and external objects in causing ocular trauma. This finding has important implications for understanding the patterns of eye injuries in this region and developing targeted prevention strategies. The high prevalence of mechanical injuries can be attributed to several factors, including occupational hazards, environmental risks, and certain recreational activities. Many residents of Karangasem Regency are engaged in occupations that involve exposure to potential eye hazards, such as agriculture, construction, and manufacturing. These occupations may involve the use of sharp tools, machinery, and projectiles, increasing the risk of eye injuries. Furthermore, environmental factors, such as dust, debris, and flying particles, can also contribute to the occurrence of mechanical eye injuries. The study found that superficial foreign bodies were the second most common type of ocular trauma (38.01%), highlighting the need for protective measures in environments where individuals are exposed to such hazards. Certain recreational activities, such as sports and adventure activities, can also pose risks of mechanical eye injuries. High-impact sports, activities involving projectiles, and water sports can all lead to eye injuries if proper precautions and protective gear

are not used. The study further classified mechanical injuries into two main categories, closed-globe injuries and open-globe injuries. Closed-globe injuries, which do not involve full-thickness penetration of the eye wall, were found to be far more prevalent (43.62%) than open-globe injuries (1.53%). This suggests that blunt trauma is a major mechanism of injury in this population. Blunt trauma can occur from a variety of sources, including occupational accidents, falls, sports injuries, and physical assaults. The impact of a blunt object can cause a range of injuries to the eye, including corneal abrasions, hyphema (blood in the anterior chamber), lens dislocation, retinal detachment, and even rupture of the eyeball. Open-globe injuries, while less common, are more likely to result in severe vision loss or blindness. These injuries involve penetration of the eye wall, which can lead to infection, retinal damage, and loss of intraocular contents. Open-globe injuries can occur from sharp objects, such as knives, glass shards, or metal fragments, as well as from projectiles, such as bullets or fireworks. The predominance of closed-globe injuries in this study suggests that preventive measures should focus on reducing the risk of blunt trauma. This can be achieved through workplace safety protocols, the use of protective eyewear during hazardous activities, and public education campaigns to raise awareness about eye safety. The high prevalence of mechanical injuries in ocular trauma cases in Karangasem Regency underscores the need for comprehensive prevention strategies. Implementing and enforcing safety protocols in workplaces to minimize the risk of eye injuries. This includes providing appropriate personal protective equipment (PPE), such as safety glasses or goggles, and training employees on their proper use. Reducing environmental hazards that can lead to eye injuries. This may involve controlling dust and debris in workplaces and public areas, and promoting the use of protective eyewear during outdoor activities. Encouraging the use of protective eyewear during recreational activities that pose risks of eye injuries. This includes sports with high impact or projectiles, water sports, and adventure activities. Raising public awareness about eye safety and the importance of prompt medical attention for eye injuries. This can be achieved through public health campaigns, educational programs in schools and communities, and media outreach. By implementing these preventive measures, the burden of mechanical eye injuries can be significantly reduced, preventing vision loss and improving the quality of life for individuals in Karangasem Regency.[13-15]

The study revealed a concerning trend of delayed presentation for treatment among patients with ocular trauma in Karangasem Regency. Only 52.31% of patients sought medical attention within 24 hours of their injury. This delay in seeking care has significant implications for visual outcomes and the risk of developing complications. Timely intervention is critical in the management of ocular trauma to minimize the extent of damage and preserve vision. Delays in treatment can allow the progression of injuries, potentially leading to more severe complications and poorer visual prognosis. For instance, a penetrating eye injury that is not treated promptly can increase the risk of infection, retinal detachment, and ultimately, blindness. Karangasem Regency, being a predominantly rural area, may have limited access to specialized eye care facilities. Patients may need to travel long distances to reach a hospital or clinic equipped to handle ocular emergencies. This geographical barrier can significantly delay timely intervention. A lack of awareness regarding the urgency of treatment for eye injuries can also contribute to delayed presentation. Some individuals may underestimate the severity of their injuries or may not recognize the potential for vision loss if treatment is not sought promptly. Educational initiatives and public health campaigns are essential to raise awareness about the importance of immediate medical attention for eye injuries. Financial constraints can also be a barrier to timely treatment. The cost of medical care, including transportation, consultation fees, and medications, can be prohibitive for some individuals, particularly in

low-resource settings. This can lead to delays in seeking care or even forgoing treatment altogether. In some cases, sociocultural factors may influence healthcare-seeking behavior. Traditional beliefs, reliance on home remedies, or fear of medical procedures may lead to delays in seeking professional medical attention. Delays in treatment can allow the progression of eye injuries, potentially leading to more severe and permanent vision loss. For example, a corneal abrasion that is not treated promptly can develop into a corneal ulcer, which can cause scarring and vision impairment. Delayed treatment can increase the risk of developing complications, such as infection, inflammation, and secondary glaucoma. These complications can further compromise vision and necessitate more complex and costly interventions. The experience of ocular trauma and the potential for vision loss can have a significant psychological impact on individuals. Delays in treatment and the uncertainty surrounding visual outcomes can exacerbate anxiety and distress. Efforts should be made to improve access to specialized eye care services in rural areas. This may involve establishing more eye clinics, increasing the number of trained eye care professionals, and providing transportation assistance to patients in remote areas. Public education campaigns and community outreach programs can help raise awareness about the importance of prompt medical attention for eye injuries. These initiatives should emphasize the potential for vision loss and the benefits of timely intervention. Financial assistance programs and health insurance schemes can help alleviate the financial burden of eye care, ensuring that cost does not deter individuals from seeking timely treatment. Healthcare providers should be sensitive to cultural beliefs and practices that may influence healthcare-seeking behavior. Engaging with community leaders and traditional healers can help promote understanding and encourage prompt medical attention for eye injuries. By addressing the factors that contribute to delayed presentation and implementing strategies to improve access to timely and appropriate care, the burden of ocular trauma can be significantly reduced, and vision loss can be prevented.[16-18]

Ocular trauma can lead to a variety of complications, ranging from minor injuries to severe vision loss. This study examined the complications and visual outcomes associated with ocular trauma in Karangasem Regency, providing valuable insights into the potential consequences of eye injuries. Subconjunctival bleeding is the most frequent complication, indicating that the conjunctiva, the delicate membrane lining the eyelids and covering the front of the eye, is often affected in ocular trauma. Subconjunctival bleeding occurs when blood vessels beneath the conjunctiva rupture, causing blood to pool in the white part of the eye. While usually harmless and self-resolving, it can be indicative of more severe underlying injuries. The cornea, the transparent front part of the eye, is also commonly injured in ocular trauma. Corneal erosion involves a scratch or disruption of the corneal surface, which can cause pain, discomfort, and blurred vision. If not managed properly, corneal erosions can lead to complications such as corneal ulcers and scarring, potentially affecting vision permanently. Palpebral rupture involves a full-thickness tear or laceration of the eyelid, often caused by blunt trauma or sharp objects. Palpebral ruptures can be associated with cosmetic concerns and functional deficits, such as difficulty blinking or closing the eyelids completely. These complications highlight the vulnerability of various ocular structures to external forces and underscore the importance of prompt and appropriate management to prevent long-term consequences. Visual acuity, a measure of the eye's ability to distinguish details, is often affected in ocular trauma. This study assessed the initial and final visual acuity of patients to evaluate the impact of eye injuries and the effectiveness of treatment interventions. Most patients (68.21%) presented with mild or no visual impairment, suggesting that many injuries did not cause significant initial vision loss. However, a substantial number of patients experienced moderate

to severe vision loss at presentation. Treatment interventions were generally successful in improving vision, as evidenced by a shift towards better visual acuity categories in the final assessment. However, some patients experienced persistent visual impairment even after treatment, indicating that some injuries may result in permanent vision loss or require further interventions to achieve optimal visual outcomes. The findings of this study have important implications for the prevention and treatment of ocular trauma in Karangasem Regency. Prevention strategies should focus on raising awareness about eye safety, promoting the use of protective eyewear in workplaces and during recreational activities, and educating the public about the importance of prompt medical attention for eye injuries. Improving access to healthcare is crucial for ensuring timely and appropriate management of ocular trauma. This requires addressing barriers such as distance to healthcare facilities, cost of treatment, and lack of awareness about available services. Strengthening primary eye care services and establishing referral pathways for specialized care can help ensure that patients receive the necessary treatment promptly. By implementing comprehensive prevention programs and improving access to healthcare, the burden of ocular trauma can be significantly reduced, and vision loss can be prevented.[19,20]

5. Conclusion

This study provides a comprehensive overview of ocular trauma in Karangasem Regency, Bali, Indonesia. The findings reveal that ocular trauma predominantly affects males residing in rural areas, with the majority of cases occurring in the productive age group of 19-44 years. Mechanical injuries, particularly closed-globe injuries, are the most common type of ocular trauma, highlighting the significant impact of occupational and environmental hazards. The leading causes of trauma are foreign bodies and blunt injuries. A concerning finding is the delayed presentation for treatment, with only 52.31% of patients seeking medical attention within 24 hours of injury. This delay underscores the need for increased awareness and improved access to healthcare services. The most frequent complications include subconjunctival bleeding, corneal erosion, and palpebral rupture. These findings have important implications for the development of targeted prevention programs and the improvement of healthcare services for ocular trauma in rural Bali. Prevention strategies should focus on raising awareness about eye safety, promoting the use of protective eyewear, and educating the public about the importance of prompt medical attention for eye injuries. Improving access to healthcare requires addressing barriers such as distance to healthcare facilities, cost of treatment, and lack of awareness about available services.

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