

RESEARCH ARTICLE

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Screening and Risk Factor Assessment of Cataract and Glaucoma in Hypertensive and Diabetic Populations along the Surabaya Coast

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Abstract

Background: The coexistence of cataract, glaucoma, diabetes mellitus, and hypertension imposes a substantial ocular health burden in aging populations, especially in coastal communities exposed to ultraviolet radiation.

Methods: This observational-analytical study evaluated the influence of hypertension and diabetes mellitus on the incidence of cataract and glaucoma among residents of Kedung Cowek, Surabaya (April 2025). Direct clinical examinations, demographic and medical histories, and ocular assessments were performed on all eligible patients presenting with blurred vision and documented hypertension or diabetes (total sampling).

Results: Among 12 hypertensive patients along the Surabaya Coast, 8 (66.7%) had ocular abnormalities. Cataract was the most common finding (5 cases, 41.7%), followed by glaucoma (3 cases, 25%). Pterygium occurred in 4 cases (33.3%), likely linked to high UV exposure.

Conclusion: Diabetes, and hypertension appears to accelerate cataract and glaucoma development in this coastal population. Oxidative stress from combined metabolic and environmental factors may overwhelm ocular defenses, increasing vision-related risk.

Keywords: Cataract; glaucoma; diabetes mellitus; hypertension

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Introduction

A cataract is defined as lens opacification that diminishes visual acuity; a healthy lens is transparent and permits the unhindered passage of light to the retina. When the lens loses its clarity, light transmission is compromised, resulting in blurred vision. Cataracts may progress insidiously and often go unnoticed in their early stages (Miller et al., 2021). Cataract represents a substantial global public health challenge; several sources estimate that over 20 million individuals worldwide have a vision impairment due to cataract (GBD 2019 Blindness and Vision Impairment Collaborators, 2021). Indonesia exhibits marked regional disparities in age-related blindness: East Java records the highest prevalence at 4.4 %

(95 % CI = 3.1–5.6 %), followed by West Nusa Tenggara at 4.0 % (95 % CI = 3.0–5.1 %) and South Sumatra at 3.4 % (95 % CI = 2.4–4.4 %). Among adults aged 50 years and above, East Java also bears the most significant absolute burden, with 371,599 individuals, while West Java and Central Java account for 180,666 and 176,977 cases, respectively (Rif'Ati et al., 2021).

On the other hand, glaucoma is a multifactorial ocular disorder characterized primarily by elevated intraocular pressure (IOP), which can lead to progressive and irreversible vision loss. It is classified into primary and secondary forms, with further subdivisions into open-angle and angle-closure types. In adults, the major categories include primary open-angle glaucoma (POAG) and angle-closure glaucoma, alongside secondary variants of both types (Dietze

et al., 2024).

According to data from the World Health Organization (WHO) and the Global Solar UV Index, the UV Index across Indonesia typically ranges from 10 to 12 classified as "extreme" during peak sunlight hours (10:00–15:00), year-round. In major coastal cities such as Surabaya, Jakarta, Denpasar (Bali), and Makassar, average UVI values frequently reach 11–12, among the highest in the world. Unlike temperate regions with seasonal variation, tropical equatorial zones like Indonesia maintain high UV intensity every day of the year.

To date, no literature studies have examined the incidence of cataract and glaucoma among individuals with hypertension and diabetes mellitus in coastal regions, especially in Indonesia.

Method

This observational-descriptive study employed direct clinical examinations of patients to assess the influence of hypertension and diabetes mellitus on the incidence of cataract and glaucoma in the Kedung Cowek V, Surabaya. Demographic data, medical history, and ocular examination results were collected and analyzed using descriptive statistics to identify significant risk factors for the condition.

The target population consisted of all patients who presented to the Kedung Cowek health center in Surabaya. The study sample consisted of all patients residing in the coastal area of Kedung Cowek during April 2025 who met the inclusion criteria. A total-sampling approach was employed, enrolling all eligible patients from the designated area.

Assessments for cataract, pterygium, and intraocular pressure (IOP) were conducted using a standardized vision screening protocol, which included basic physical examination, administered by qualified ophthalmologists.

Inclusion criteria included patients presenting to the Kedung Cowek health center with complaints of blurred vision subjectively; patients with a documented history of hypertension; and patients with a documented history of diabetes mellitus.

Exclusion criteria included patients lacking a history of hypertension and patients lacking a history of diabetes mellitus.

Result and Discussion

The findings showed that females predominated in the overall sample, with 29 participants, while males comprised 18 participants.

Table 1. Demographic data.

Variable		n	%
Gender	Male	18	38
	Female	29	62
Age	21-30	4	9
	31-40	6	13
	41-50	10	22
	51-60	18	40
	61-70	4	9
	71-80	3	7
Occupation	Unemployed	3	6
	Housewives	28	60
	Fisherman	12	26
	Private employees	1	2
	Retirement	1	2
	Cleaning service	1	2
	Self-employed	1	2
Diabetes Mellitus		3	17
Hypertension		8	44

The most prevalent age group was 51–60 years (n = 18), while the least represented age group was 71–80 years (n = 3). The most common occupation was housewife, reported by 28 participants. The second most common occupation was fisherman, reported by 12 participants.

Table 2. Hypertension and ocular problem.

Ocular problem	Percentage
Cataract	38%
Pterygium	50%
IOP +	13%

The results showed that 8 out of 12 patients with hypertension exhibited eye abnormalities, with pterygium being one of the most common disorders in coastal areas, recorded in 4 samples.

Table 3. Diabetes Mellitus and ocular problem

Ocular problem	Percentage
Cataract	38%
Pterygium	50%
IOP +	13%

The findings indicated that eye abnormalities were evenly distributed across groups, with each group having one sample exhibiting such abnormalities.

From the research findings, it was observed that 8 out of 12 hypertension patients exhibited ocular abnormalities, with pterygium being one of the most prevalent conditions, identified in 4 samples from coastal regions. Coastal regions are characterized by elevated UV indices, which significantly contribute to the development of pterygium. This aligns with existing epidemiological data, which highlight UV radiation as a primary environmental risk factor for ocular surface disorders. For instance, studies have demonstrated that populations residing in coastal areas, due to prolonged sun exposure and reflective surfaces (e.g., water and sand), exhibit higher incidences of pterygium compared to inland regions. However, as previously noted, latitude alone does not fully account for this variability, underscoring the multifactorial nature of pterygium pathogenesis (Lu et al., 2007; Pyo et al., 2016).

The findings of this study demonstrate the presence of cataracts in hypertensive patients, corroborating the meta-analysis by Yu et al., which included 25 studies (9 cohort, five case-control, and 11 cross-sectional) from 23 articles. The pooled results revealed a significantly elevated risk of cataracts in hypertensive populations, with cohort studies reporting a relative risk (RR) of 1.08 (95% CI: 1.05–1.12) and case-control or cross-sectional studies indicating an odds ratio (OR) of 1.28 (95% CI: 1.12–1.45) (Yu et al., 2014). The mechanistic underpinnings of this association are Hypertension-induced systemic oxidative stress, wherein an imbalance between free radical production and antioxidant defences results in the degradation of lens proteins and lipids, precipitating opacification and microvascular dysfunction (microangiopathy), which impairs nutrient and oxygen delivery to the lens, disrupting metabolic homeostasis and accelerating cataract formation (Yu X et al., 2014; Li et al., 2024).

In the study, cataracts were found in patients with diabetes mellitus, but they were not more prevalent than other orbital abnormalities. While diabetes mellitus is a recognized risk factor for accelerated cataract formation, the observed cataract prevalence in our diabetic cohort was not markedly elevated. This may reflect the influence of disease duration, glycemic control, and age distribution within the population. Additionally, screening methods limited to basic anterior segment evaluation may have missed early or subtle lens opacities, particularly posterior subcapsular changes common in diabetes. A study conducted at Ibnu Sina Hospital in Makassar revealed that only 10.96% of cataract patients had a documented history of diabetes mellitus (Puspitasari, Ay et al., 2023).

Several proposed mechanisms could explain this problem. Previous research has proposed that the polyol pathway—where the enzyme aldose reductase (AR) facilitates the conversion of glucose into sorbitol—plays a key role in cataract formation. Numerous investigations have explored the involvement of this pathway in the disease process. Excessive intracellular sorbitol accumulation induces a hyperosmotic imbalance, causing swelling and degeneration of lens fibers, which ultimately leads to cataract development. In individuals with diabetes, sorbitol production occurs at a faster rate than its conversion into fructose by sorbitol dehydrogenase, resulting in greater osmotic stress within the lens (Kiziltoprak et al., 2023).

An additional proposed mechanism involves osmotic stress resulting from pronounced swelling of the cortical lens fibres, which accelerates cataract progression, particularly in younger individuals with type 1 diabetes mellitus. The buildup of sorbitol triggers osmotic imbalance that places strain on the endoplasmic reticulum (ER)—the primary site for protein synthesis—leading to the production of free radicals. Such ER stress can

also be initiated by fluctuations in glucose concentration, which activate an unfolded protein response, generating reactive oxygen species and thereby inducing oxidative damage to the lens fibres. Elevated glucose levels in the aqueous humour may further promote the glycation of lens proteins, producing advanced glycation end products. In addition, higher concentrations of hydrogen peroxide (H_2O_2) in the aqueous humour of diabetic patients can drive Fenton reactions, producing hydroxyl radicals (OH^\cdot) once they diffuse into the lens. Another elevated factor in diabetic lenses and aqueous humour is the nitric oxide (NO^\cdot) free radical, which can react to form peroxynitrite, an oxidizing agent that exacerbates cellular injury. The heightened vulnerability of diabetic lenses to oxidative stress is compounded by their diminished antioxidant defence capacity (González et al., 2023).

A large-scale epidemiological investigation conducted in Korea identified hypercholesterolemia, diabetes mellitus, advancing age, lower educational attainment, and reduced monthly household income as independent risk factors for the onset of pure cortical cataracts (Rim et al., 2014). In the current analysis from Syeda et al analyze the relationship between pure nuclear cataracts and distinct determinants, namely diabetes mellitus, components of the metabolic syndrome, age, and low educational level. Moreover, multivariate modeling demonstrated that both age and diabetes mellitus constitute independent predictors of posterior subcapsular cataract development. Collectively, these findings indicate that mixed-type cataracts are associated with specific socioeconomic and clinical risk factors, including diabetes mellitus, advanced age, diminished monthly family income, and lower educational achievement (Syeda et al., 2024).

The synergistic interplay of ultraviolet (UV) radiation, hyperglycemia, and hypertension exacerbates oxidative damage to the ocular lens, ultimately leading to cataract formation. Prolonged UV exposure generates reactive oxygen species (ROS), which disrupt the integrity of lens crystallins and lipid membranes, leading to UV-induced lens damage. Concurrently, hyperglycemia activates the polyol pathway, leading to sorbitol accumulation and osmotic stress within lens fibres, thereby impairing transparency—diabetic cataract pathways. Hypertension further compounds this damage by inducing microangiopathy, which compromises nutrient delivery to the lens and amplifies oxidative stress (Li et al., 2024). Collectively, these factors overwhelm endogenous antioxidant defences (e.g., glutathione), accelerating irreversible lens opacification, multi-factor lens damage. This mechanistic triad highlights the increased risk of cataracts in populations exposed to environmental and metabolic stressors, such as those in coastal communities (Varma et al., 2011).

The study found that only one patient each

with diabetes mellitus and hypertension exhibited increased intraocular pressure (IOP), a known risk factor for glaucoma. Given these minimal occurrences, the data do not support a clear association between diabetes mellitus or hypertension and the incidence of glaucoma in the coastal population studied. This suggests that, within this community, these systemic conditions may not be significantly linked to glaucoma risk, though larger studies with greater sample sizes are needed to explore potential relationships more definitively. Diabetes mellitus and glaucoma are prominent public health concerns, particularly within the aging population. Numerous epidemiological studies have indicated that individuals with diabetes mellitus have an increased risk of developing glaucoma. Moreover, emerging evidence suggests potential pathophysiological mechanisms that may underlie the association between these two conditions, highlighting shared pathways such as microvascular dysfunction and neurodegenerative processes (Zhao et al., 2015; Ko et al., 2016; Song et al., 2016).

Conclusion

The concurrent exposure to ultraviolet (UV) radiation, diabetes mellitus, and hypertension creates a pathogenic triad that significantly exacerbates oxidative damage to the ocular lens, predisposing individuals to cataract formation. Together, these factors overwhelm the lens's antioxidant defences, accelerating irreversible opacification. The lack of findings between IOP elevation and systemic conditions highlights the need for further investigation into other local risk factors that influence glaucoma development in coastal populations.

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