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Cataract: An Article Review

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Abstract
Introduction: *Cataract, the leading cause of global visual impairment, affects over 13 million individuals with blindness, and its prevalence is expected to rise due to population aging and lifestyle changes. Cataracts significantly impact vision, mental well-being, quality of life, and increase mortality rates and economic burdens.* ***Objective:*** *This study reviews the prevalence, risk factors, and treatment outcomes of cataracts, assessing the influence of demographic changes and lifestyle factors on their incidence and progression.* ***Methods:*** *This study reviewed English literature from 2019 to 2024, excluding editorials, reviews from the same journal, and submissions without a DOI. Literature sources included PubMed, SagePub, SpringerLink, and Google Scholar.* ***Results and Discussion:*** *The global prevalence of cataracts increases significantly with age, from 3.9% in individuals aged 55-64 to 92.6% in those aged 80 and above. Cataracts remain a major cause of blindness in low-income countries, accounting for 50% of cases compared to only 5% in developed nations. Cataract types vary, with nuclear cataracts primarily affecting distance vision and posterior subcapsular cataracts impairing near visual acuity. Surgical innovations, such as premium intraocular lenses and femtosecond laser-assisted cataract surgery, enhance outcomes but complications persist. Limited accessibility to cataract surgery in low-income countries remains a significant challenge.* ***Conclusion:*** *Cataracts continue to pose a significant global health burden, particularly in aging populations and low-income regions. Despite advancements in treatment, addressing accessibility and improving surgical outcomes are crucial for reducing cataract-related vision impairment.*
Keyword: Cataract; Cataract Epidemiology; Cataract Surgery; Vision Impairment;

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Introduction

Cataract is the leading cause of visual impairment globally, affecting over 13 million individuals with blindness. In Western countries, the prevalence of cataract and related vision loss is expected to rise due to population aging and lifestyle changes.(Hashemi *et al.*, 2016) Cataract poses significant health challenges in aging populations, impacting vision, mental well-being, and quality of life while also increasing mortality rates and economic burdens. Cataracts are characterized by the clouding of the eye's lens, resulting in vision impairment. WHO estimates suggest that approximately 95 million individuals were visually impaired due to cataracts in 2014.(Cicinelli *et al.*, 2023)

Studies show that the prevalence of cataracts increases significantly with age, ranging from 3.9% in individuals aged 55-64 to 92.6% in those aged 80 and above.(Purola *et al.*, 2022) Over the past two decades, the prevalence of cataracts has decreased due to advancements in surgical techniques and increased access to surgery. Nonetheless, cataracts remain a leading cause of blindness in middle and low-income countries, accounting for 50% of blindness, compared to only 5% in developed nations.(Deng *et al.*, 2023)

Various types of cataracts cause different visual symptoms. Patients commonly report blurred vision, glare, and haloes around lights. Nuclear cataracts primarily affect distance vision more than near vision, while posterior subcapsular cataracts often impair near visual acuity more than distance vision. Progressive changes in nuclear sclerotic cataracts lead to an increase in the lens refractive index, resulting in increased light refraction and potential myopia. Certain patients may only experience visual difficulty during daily activities such as reading or driving, indicating visual disability.(Porth *et al.*, 2019)

This study aims to conduct a article review to explore the prevalence, risk factors, and treatment outcomes of cataract in the general population. It seeks to understand the influence of demographic changes and lifestyle factors on the incidence and progression of cataract. Additionally, the study aims to assess the effectiveness of current treatment methods and identify potential strategies to mitigate the impact of cataract-related vision impairment.

Method

This article review investigate the prevalence, risk factors, and treatment outcomes of cataract in the general population based on literatures of the last 5 years. This study meticulously analyzed data on literatures to provide insights and enhance patient treatment strategies. The primary objective of this paper is to highlight the collective significance of the identified key points.

For this study, the inclusion criteria are twofold: firstly, papers must be written in English, and secondly, they must have been published between 2019 and 2024. Conversely, exclusion criteria encompass several factors: editorials, submissions lacking a DOI (Digital Object Identifier), previously published review articles, and duplicate

entries in journals. These criteria serve to ensure the selection of relevant, recent, and high-quality literature while excluding duplicative or non-peer-reviewed content.

The literature review on cataract was initiated with a systematic search of relevant scientific databases such as PubMed, Scopus, and Web of Science. Keywords and phrases including "cataract," "cataract epidemiology," "cataract surgery," and "vision impairment" guided the search. Boolean operators were employed to refine the search, ensuring a comprehensive yet focused collection of studies.

Following the selection process, the methodological quality of the included studies was assessed using established tools such as the Newcastle-Ottawa Scale (NOS) for observational studies. This critical appraisal identified biases, assessed validity, and ensured reliability. Data extraction involved systematically recording key information from each study, such as objectives, population characteristics, interventions, outcomes, and findings, providing a cohesive overview of the current understanding of cataract.

Results and Discussion

Epidemiology

The global prevalence of age-related cataract and its types, assessed through the Lens Opacities Classification System (LOCS), revealed an age-standardized prevalence proportion estimate (ASPPE) of cataract at 17.20%. Regional variations were notable, with the Southeast Asia Region (SEARO) displaying the highest ASPPE at 36.55%, contrasting with the Americas Region (AMRO) where the prevalence was lowest at 9.08%. Despite geographical differences, no significant gender-related disparities were observed in cataract prevalence, challenging previous assumptions and suggesting a need for further investigation into the role of gender in cataract occurrence.(Hashemi *et al.*, 2016)

Nuclear cataract emerged as the most prevalent type globally, followed by cortical and posterior subcapsular (PSC) cataracts, with prevalence rates showing geographic variability. The association between age and cataract occurrence was consistent across all types, underscoring the direct correlation between advancing age and cataract development. Despite expectations of an upward trend in prevalence due to lifestyle changes, stable rates were observed, possibly attributed to improved access to surgical interventions. This stability highlights the effectiveness of global initiatives aimed at expanding cataract surgery services and reducing avoidable blindness.(Hashemi *et al.*, 2016)

The prominence of nuclear cataract and its association with advancing age underscore the importance of age as a key determinant in cataract development. Stable prevalence rates, despite expectations of increase, suggest the efficacy of efforts to enhance access to cataract surgery services globally, emphasizing the ongoing need for concerted action to address cataract-related vision impairment.(Hashemi *et al.*, 2016)

Etiology of Cataract

Cataract is the primary cause of blindness worldwide that manifests as a loss of lens transparency. There are two primary types of cataract that exhibit distinct damage patterns, namely cortical and nuclear cataracts. Cortical cataracts present as wedge-shaped opacifications, prevalent in the elderly and diabetic patients. These opacities are linked to asymmetrical refractive index changes within the lens cortex, likely caused by fluid accumulation, leading to cell swelling and tissue liquefaction. Animal models, like STZ rats, shed light on the mechanisms of diabetic cortical cataract formation, emphasizing osmotic and oxidative stress roles.(Braakhuis *et al.*, 2019) The characteristics and pathophysiology of cortical cataract are shown in Figure 1 and 2.

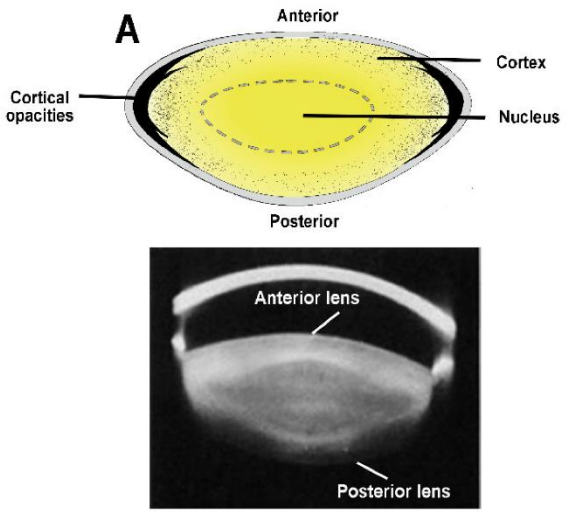

Figure 1. Cortical cataracts within the lens cortex. The diagram in the top panel showcases the opacities characteristic of this cataract subtype. Meanwhile, the lower panel presents a Scheimpflug slit-lamp photographic image depicting a cortical cataract.(Braakhuis *et al.*, 2019)

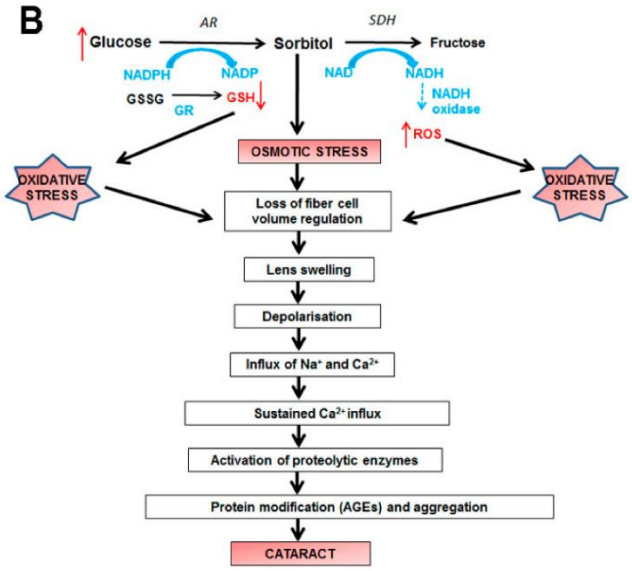

Figure 2. Pathogenesis of diabetic cortical cataract. Elevated glucose levels lead to decreased levels of glutathione (GSH) and increased reactive oxygen species (ROS), triggering osmotic and oxidative stress. These stresses synergistically inhibit fiber cells' ability to regulate volume, leading to cell swelling, depolarization, and an influx of sodium and calcium ions. Accumulation of calcium ions activates calcium-dependent proteases, targeting cytoskeletal and crystallin proteins. Additionally, proteins undergo modification through the formation of advanced glycation end (AGEs) products, altering crystallin structure and function. This results in increased insoluble proteins, high molecular weight aggregates, and ultimately, cataract formation.(Braakhuis *et al.*, 2019)

In contrast, age-related nuclear (ARN) cataract initiates in the lens core, resulting in lens nucleus browning. Unlike cortical cataracts, ARN cataracts involve significant loss of protein sulfhydryl groups and protein-thiol mixed disulfides. This leads to protein aggregation and light scattering, primarily attributed to oxidative stress. Despite the lens's glutathione concentration gradient, ARN cataracts result from significant GSH depletion in the nucleus.(Braakhuis *et al.*, 2019) The characteristics and pathophysiology of ARN are shown in Figure 3 and 4.

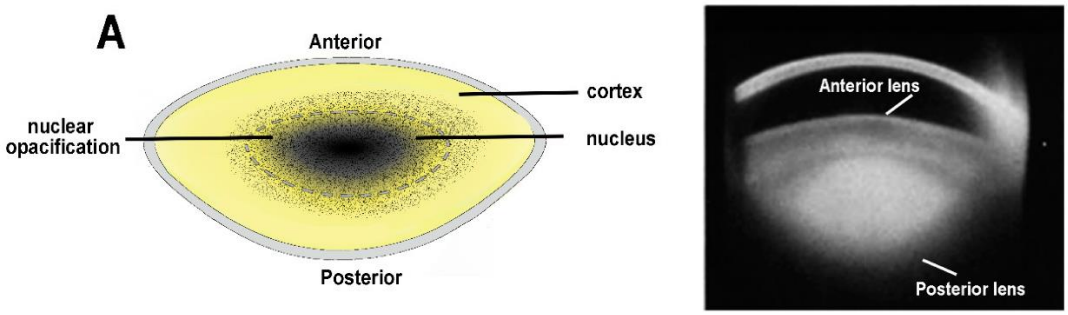

Figure 3. Nuclear cataract (ARN). The left panel of the figure presents a diagram illustrating the opacities that develop in the lens nucleus. Meanwhile, the right panel showcases a Scheimpflug slit-lamp photographic image revealing a nuclear cataract.(Braakhuis *et al.*, 2019)

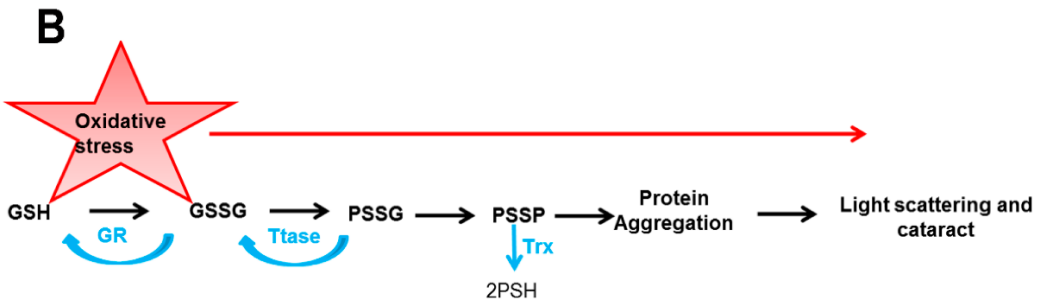

Figure 4. Age-related nuclear cataract pathogenesis involves molecular mechanisms related to glutathione (GSH) depletion. GSH, maintained at high levels within the lens, undergoes regeneration from oxidized GSH (GSSG) via glutathione reductase (GR). Repair enzymes like thioltransferase (Ttase) and thioredoxin (TrX) dethiolate protein mixed disulfides, such as protein-bound GSH (PSSG) and protein-protein disulphides (PSSP). However, in age-related nuclear cataract, GSH depletion occurs specifically in the nucleus, leading to significant protein oxidation, increased protein mixed disulphides, and the formation of protein-protein disulfide bonds. Consequently, protein aggregation, loss of protein solubility, increased yellowing of the lens nucleus, and eventual nuclear cataract formation ensue.(Braakhuis *et al.*, 2019)

Risk Factors of Cataract

Cataracts, the clouding of the eye's natural lens, represent a complex ocular condition influenced by a multitude of factors spanning congenital predispositions, age-related changes, lifestyle habits, metabolic dysregulations, and systemic diseases. This intricate interplay underscores the diverse etiological landscape contributing to cataract development and progression.(Ang and Afshari, 2021)

Congenital cataracts, arising from genetic mutations or maternal influences during pregnancy, manifest either in isolation or as part of systemic genetic syndromes. Genetic aberrations disrupt the normal developmental processes of the lens, leading to structural abnormalities and compromised transparency. Maternal factors such as malnutrition or infections further exacerbate the risk, emphasizing the importance of prenatal care and maternal health in preventing congenital cataracts.(Nalbandyan *et al.*, 2021)

Age-related cataracts, the most prevalent form, gradually evolve over time due to cumulative cellular changes within the lens. Protein denaturation, oxidative stress, altered metabolic pathways, and the accumulation of cellular debris contribute to lens opacification, impairing visual function. As individuals age, the risk of developing cataracts increases, highlighting the progressive nature of this age-related ocular disorder.(Hugosson and Ekström, 2020; Tan *et al.*, 2020)

Lifestyle choices, notably smoking, exert a significant influence on cataract formation through oxidative stress. Exposure to cigarette smoke accelerates lens ageing, exacerbating cellular damage and predisposing individuals to various cataract subtypes. Disruptions in lipid metabolism, observed in conditions like Smith-Lemli-Opitz syndrome, further disrupt lens homeostasis, fostering cholesterol accumulation within lens cells and heightening cataract susceptibility.(Garg *et al.*, 2020)

Traumatic injuries to the eye or underlying inflammatory conditions exacerbate cataract risk by compromising lens integrity and triggering aberrant cellular responses. Moreover, systemic diseases such as diabetes, hypertension, and metabolic syndrome significantly impact cataract pathogenesis. Chronic hyperglycemia in diabetes, for instance, instigates multiple pathways, including the polyol pathway and oxidative stress, fostering lens opacification and visual impairment.(Drinkwater, Davis and Davis, 2019)

Hypertension, characterized by elevated blood pressure levels, emerges as another formidable risk factor for cataracts, particularly posterior subcapsular cataracts. Metabolic syndrome, encompassing a cluster of cardiovascular risk factors like obesity and dyslipidemia, exacerbates cataract vulnerability, particularly the posterior subcapsular variant. Renal impairment, including chronic kidney disease and end-stage renal disease, amplifies cataract risk, correlating with the severity of renal dysfunction.(Trott *et al.*, 2022)

Hepatitis, celiac disease, systemic lupus erythematosus, and atopic dermatitis intricately intertwine with cataract pathophysiology. These diseases may directly impact lens health or indirectly influence cataract formation through hepatic dysfunction, inflammatory cascades, or autoimmune processes. Moreover, metabolic disorders and genetic syndromes like Wilson disease, galactosemia, Fabry disease, and Lowe syndrome exhibit distinctive ocular manifestations, contributing to cataractogenesis through aberrations in metabolic pathways or genetic mutations.(Lindblad, Håkansson and Wolk, 2019; Yuan, Wolk and Larsson, 2022)

Nutrients play a critical role in the development of cataracts. Oxidative stress and damage to lens proteins are key factors in initiating and advancing cataract formation. Diets rich in fruits, vegetables, Vitamin C, E, A, and multivitamin-mineral supplements are associated with lower cataract incidence. Lutein and zeaxanthin intake have been linked to reduced nuclear cataract risk. However, high-dose single-nutrient supplements, particularly Vitamin C and E, may be less effective and even harmful.(Broadhead *et al.*, 2021; Falkowska *et al.*, 2023)

Surgery and Management

Cataract surgery is the most common ophthalmic procedure worldwide, with over 26 million surgeries performed annually. The evolution of surgical techniques has progressed from intracapsular cataract extraction (ICCE) to extracapsular cataract extraction (ECCE) and now to phacoemulsification (PCS), which is the mainstream method in developed countries. However, in developing countries, small incision cataract surgery (SICS) is gaining popularity due to its lower cost and simplicity.(Chen *et al.*, 2021)

The introduction of premium intraocular lenses (IOLs) has transformed cataract surgery from vision restoration to vision improvement, leading to the era of refractive cataract surgery (RCS). Multifocal and toric IOLs have shown significant advantages over monofocal IOLs, providing improved distance and near vision with reduced dependence on spectacles. Extended depth-of-focus (EDOF) IOLs offer a compromise

between monofocal and multifocal IOLs, enhancing intermediate distance vision and contrast sensitivity.(Grzybowski and Kanclerz, 2020; Marcos *et al.*, 2021)

Advancements in surgical technology, such as femtosecond laser-assisted cataract surgery (FLACS), have further improved the accuracy and safety of cataract surgery. FLACS enables precise lens fragmentation, anterior capsulotomy, and astigmatism correction, resulting in better visual and refractive outcomes compared to PCS. Although some skepticism remains, meta-analyses and clinical trials have demonstrated the superiority of FLACS in reducing endothelial cell loss and postoperative complications.(Roberts, Day and O'Brart, 2020; Narayan *et al.*, 2023)

Postoperative management practices following cataract surgery exhibit considerable variability across institutions and countries. While approximately 36% of patients are discharged shortly after surgery, the majority are observed for at least an hour post-surgery. Social activity restrictions lasting 5 days are common in 51% of cases. Key practices include blood testing and ECG for about half of the patients, continuation of antiplatelet drugs, and preoperative antibiotic prophylaxis. Prophylactic measures for endophthalmitis such as povidone iodine and intra-cameral cefuroxime are widely used.(Rossi *et al.*, 2021)

Despite these advancements, access to cataract surgery remains limited in many regions, particularly in low-income countries. Complications such as posterior capsule rupture, endophthalmitis, and posterior capsule opacification are risks associated with cataract surgery, highlighting the importance of careful patient selection and postoperative management. Additionally, attention to dry eye symptoms is crucial, especially in patients undergoing FLACS. Overall, while cataract surgery continues to evolve, addressing access issues and improving patient outcomes remain key priorities.(Aristodemou, Sparrow and Kaye, 2019; Aaronson *et al.*, 2020)

Conclusion

Cataracts continue to pose a significant global health burden, particularly in aging populations and low-income regions. Despite advancements in treatment, addressing accessibility and improving surgical outcomes are crucial for reducing cataract-related vision impairment. Future strategies should focus on enhancing access to cataract surgery and addressing underlying risk factors to mitigate the impact of cataracts on global health.

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