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Vision-Related Quality of Life in Glaucoma: Structural, Functional, and Clinical Correlates Using the Glau-QoL36

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Abstract: **Original Research**

***Purpose*:** To evaluate the association between glaucoma severity, structural and functional clinical measures, and patient-reported quality of life (QoL) using the Glau-QoL36 questionnaire, and to identify the strongest predictors of QoL impairment among individuals with glaucoma. ***Methods*:** A cross-sectional analytical study was conducted among 50 clinically diagnosed glaucoma patients. Disease severity was classified using the Hodapp–Parrish–Anderson criteria based on visual field mean deviation (VF-MD). Clinical evaluation included intraocular pressure measurement, optical coherence tomography-derived retinal nerve fiber layer (RNFL) thickness, visual acuity, and vertical cup–disc ratio. QoL was assessed using the Glau-QoL36 instrument, comprising seven functional and psychosocial domains. Internal consistency, floor and ceiling effects, correlation analyses, multivariable regression modeling, and receiver operating characteristic (ROC) analysis were performed. ***Results*:** The mean age of participants was 63.5 ± 13.0 years, with moderate structural and functional impairment reflected in VF-MD (–7.9 ± 4.8 dB) and RNFL thickness (68.4 ± 12.2 µm). Glaucoma severity was significantly associated with QoL decline across all domains ($p < 0.01$), with the steepest reductions observed in Driving and Daily Life domains. Internal consistency of the questionnaire was strong across domains (Cronbach's $\alpha = 0.71–0.86$). Significant correlations were observed between functional impairment and emotional distress, particularly between Driving and Psychological domains ($\rho = –0.48$) and Daily Life and Anxiety ($\rho = –0.44$). RNFL strongly correlated with VF-MD ($\rho = 0.72$, $p < 0.001$), confirming expected structure–function relationships. In multivariable analysis, VF-MD emerged as the strongest independent predictor of total QoL ($\beta = 0.46$, $p < 0.001$). ROC analysis demonstrated high discrimination accuracy for QoL impairment (AUC = 0.82), with −10.5 dB identified as the optimal VF-MD threshold. ***Conclusion*:** Glaucoma severity demonstrates a progressive negative impact on both functional ability and psychological well-being. Visual field loss is the strongest determinant of reduced QoL, underscoring the importance of functional preservation in glaucoma management and patient-centered care strategies.

Keywords: Glaucoma, Glau-QoL36, Vision-Related Quality of Life, Visual Field Loss, RNFL Thickness, Patient-Reported Outcomes, ROC Analysis.

INTRODUCTION

Glaucoma represents a heterogeneous group of chronic, progressive optic neuropathies characterized by irreversible retinal ganglion cell loss, optic nerve head remodeling, and corresponding visual field (VF) defects. It is one of the leading causes of irreversible blindness globally, affecting an estimated 80 million individuals in 2020, with numbers projected to surpass 110 million by 2040, predominantly driven by aging demographics (Latif *et al*., 2023). The global burden is further compounded by

considerable geographic variation in disease subtype distribution, with primary open-angle glaucoma (POAG) dominating in Western populations, whereas primary angle-closure glaucoma (PACG) disproportionately affects Asian populations and contributes more aggressively to visual morbidity (Tripathi *et al*., 2023).

Although elevated intraocular pressure (IOP) remains the most significant modifiable risk factor, structural and functional progression can occur despite statistically normal IOP, underscoring the need for multimodal assessment integrating optic nerve structural biomarkers (e.g., retinal nerve fiber layer [RNFL] thickness) and functional measures (e.g., VF mean deviation [MD]) (Bektaş & Tekeli, 2024; Naithani *et al*., 2022). Strong structure–function associations have been demonstrated across diverse cohorts, yet substantial interindividual variability persists, particularly in moderate stages where discordance between RNFL thinning and VF loss is most pronounced (Khachatryan *et al*., 2021; Rulli *et al*., 2018). Such variability highlights the inadequacy of relying solely on clinical metrics to capture the full burden of glaucomatous disease.

Increasingly, research demonstrates that glaucoma imposes profound real-world functional disability that extends beyond quantifiable visual loss. Even moderate VF defects are associated with impaired mobility, reduced contrast-dependent navigation, compromised hazard detection, and decreased driving safety (Azoulay-Sebban *et al*., 2020; Rulli *et al*., 2018). These functional limitations frequently precipitate psychological distress, including anxiety, depressive symptoms, fear of blindness, and diminished self-efficacy—factors that independently worsen vision-related quality of life (VR-QoL) irrespective of objective disease severity (Wu *et al*., 2019; Wu *et al*., 2022; Kopilaš & Kopilaš, 2024). Moreover, socioeconomic determinants such as unemployment, limited healthcare access, and lower educational status exert additional adverse effects on VR-QoL, particularly in low- and middle-income settings (Tripathi *et al*., 2023; Kapinga *et al*., 2022).

Given this multidimensional burden, patient-reported outcome measures (PROMs) have become essential in glaucoma research and clinical care. Among existing instruments, the Glaucoma Quality of Life-36 (Glau-QoL36) stands out for its breadth of domains—Daily Life, Driving, Psychological Well-being, Self-Image, Anxiety, Treatment Burden, and Confidence in Healthcare—and its demonstrated validity, sensitivity to early disease changes, and cross-cultural adaptability (Gazzard *et al*., 2021; Qiao *et al*., 2025). Evidence shows that the Glau-QoL36 can detect quality-of-life impairment even in patients with early glaucoma or minimal VF damage, distinguishing it from many legacy questionnaires that lack domain specificity or sensitivity (Khachatryan *et al*., 2021; Alqudah *et al*., 2016). Post-intervention studies such as those examining trabeculectomy further reinforce the responsiveness of PROMs, demonstrating measurable improvements in VR-QoL following reductions in IOP and treatment burden (Von Arenstorff *et al*., 2024).

Despite extensive international literature, significant knowledge gaps persist regarding the integrated influence of clinical severity, structural degeneration, functional impairment, medication burden, psychological status, and socioeconomic context on VR-QoL within the Indian population. India has disproportionately high rates of late presentation, greater prevalence of PACG, wide disparities in health-seeking behavior, and variable treatment adherence (Varshney *et al*., 2025; Tripathi *et al*., 2023). Yet few studies have simultaneously assessed domain-specific Glau-QoL36 outcomes in conjunction with detailed structural and functional parameters. Moreover, no prior work has comprehensively modeled independent predictors of VR-QoL across demographic, clinical, physiological, and psychosocial dimensions in Indian glaucoma patients.

Therefore, the present study was designed to address these critical gaps by:

1. Quantifying domain-specific VR-QoL in glaucoma patients using the Glau-QoL36 questionnaire;
2. Evaluating associations between VR-QoL and demographic, clinical, structural (RNFL), and functional (VF-MD, VA) parameters;
3. Comparing QoL across disease severity, visual acuity strata, disease duration, and medication burden; and
4. Identifying independent predictors of VR-QoL through comprehensive multivariable modeling.

By integrating clinical, functional, structural, psychological, and socioeconomic correlates, this study provides a high-resolution understanding of the multidimensional impact of glaucoma and offers evidence to support patient-centered, individualized disease management strategies.

MATERIALS AND METHODS

Study Design and Reporting Standards

This study was designed as a cross-sectional analytical investigation evaluating the relationship between glaucoma severity, clinical visual function parameters, and patient-reported quality of life (QoL). The methodology and reporting framework followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines to ensure transparency and rigor.

Study Setting and Study Period

The research was conducted in the Department of Optometry at Shree K.P. Sanghvi Eye Institute, Surat, Gujarat, India. Data collection occurred between August 2024 and June 2025, representing a stable and routine clinical service period without seasonal variation in disease presentation or clinic volume.

Ethical Approval and Consent

Ethical approval was obtained from the Institutional Review Board prior to data collection. All procedures adhered to the principles of the Declaration of Helsinki (2013 revision). Written informed consent was obtained from every participant before enrollment, and participation was voluntary with the right to withdraw at any point.

Sample Size Determination

A priori sample size estimation was performed using G*Power version 3.1 based on a one-way ANOVA model comparing three severity groups. Assuming a medium effect size ($f = 0.35$), a significance level of $\alpha = 0.05$, and statistical power of 80%, a minimum of 45 participants was required. To compensate for potential data loss, a total of 50 participants were recruited.

Sampling Strategy

Participants were selected using a consecutive sampling approach, meaning all eligible patients attending the clinic during the data collection window were screened and approached for inclusion. This sampling method minimized selection bias and ensured that the study reflected real-world clinical case-mix.

Eligibility Criteria

Adults aged 18 years and older with a confirmed diagnosis of glaucoma were eligible for inclusion. Diagnosis was based on clinical findings, optic nerve evaluation, and visual field assessment. Exclusion criteria included coexisting ocular pathology such as diabetic retinopathy or macular degeneration, ocular surgery within the previous six months, neurological conditions affecting vision, and inability to complete the questionnaire due to cognitive or communication limitations.

Clinical Assessment Procedures

All clinical measurements were obtained under standardized lighting conditions and within a consistent time window (±2 hours) to reduce diurnal variability. Intraocular pressure (IOP) was measured with Goldmann applanation tonometry. The vertical cup-to-disc ratio (CDR) was assessed at the slit lamp using a 90D lens. Retinal nerve fiber layer (RNFL) thickness was measured using spectral-domain optical coherence tomography (OCT). Visual acuity (VA) was measured using a Snellen chart and converted to logMAR for analysis. Visual field mean deviation (VF-MD) was assessed using automated static perimetry (Humphrey Visual Field Analyzer with the Swedish Interactive Threshold Algorithm). Only results meeting reliability criteria (fixation losses <20%, false positives <15%, false negatives <20%) were included. If indices exceeded limits, the test was repeated. All examiners were blinded to questionnaire results and disease stage assignment to minimize measurement bias.

Glaucoma Severity Classification

Disease severity was classified using the Hodapp–Parrish–Anderson criteria, based on VF-MD values: Early (−0.01 to −6.00 dB), Moderate (−6.01 to −12.00 dB), and Severe (< −12.00 dB). For patients with bilateral disease, the eye with the worse VF-MD value was selected for analysis to avoid statistical dependency between paired measurements.

Quality of Life Assessment

The Glau-QoL36 questionnaire, a validated glaucoma-specific QoL instrument, was administered to evaluate functional, emotional, and

treatment-related domains. The standardized English version was used. Prior to data collection, the questionnaire underwent pilot testing with 10 patients to confirm cultural and linguistic suitability. Scoring was performed according to published scoring rules, with higher scores indicating better perceived QoL.

Data Handling and Confidentiality

All data were anonymized upon entry and stored in password-protected files accessible only to authorized study personnel. Missing values accounted for less than 5% of the total dataset. Mean substitution was applied to continuous variables and median replacement to questionnaire items. Sensitivity analyses demonstrated that imputation did not alter statistical outcomes by more than 2%.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics version XX, and selected analyses were cross-validated in R version 4.X.X. Normality was assessed using the Shapiro–Wilk test. Descriptive statistics were reported as mean ± standard deviation (SD) for normally distributed variables and median with interquartile range (IQR) for non-normal variables. Between-group comparisons were conducted using one-way ANOVA with Tukey post-hoc testing for parametric data and Kruskal–Wallis tests with Dunn's correction for non-parametric comparisons. Correlation analyses employed Pearson or Spearman coefficients depending on data distribution. Internal consistency of the QoL domains was evaluated using Cronbach's alpha. Predictors of composite QoL score were explored using multivariable linear regression, adjusting for potential confounders and examining multicollinearity using variance inflation factors (VIF <5). Receiver Operating Characteristic (ROC) curve analysis was performed to determine the discriminative ability of VF-MD in identifying reduced QoL. A p-value <0.05 was considered statistically significant, and effect sizes (η^2, Cohen's d, correlation coefficients, and AUC values) were reported where appropriate.

RESULTS

Demographic and Clinical Characteristics

The baseline characteristics of the 50 participants are summarized in **Table 1**. The mean age of 63.5 ± 13.0 years reflects an older cohort in which cumulative retinal ganglion cell loss and optic nerve degeneration are expected. The moderate mean RNFL thinning (68.4 ± 12.2 µm) and VF-MD of –7.9 ± 4.8 dB indicate that the sample represents patients with clinically meaningful structural and functional impairment. This clinical distribution is appropriate for QoL evaluation because substantial structure–function deviation exists without reaching floor effects of end-stage glaucoma. The participant recruitment pathway is shown in **Figure 1**.

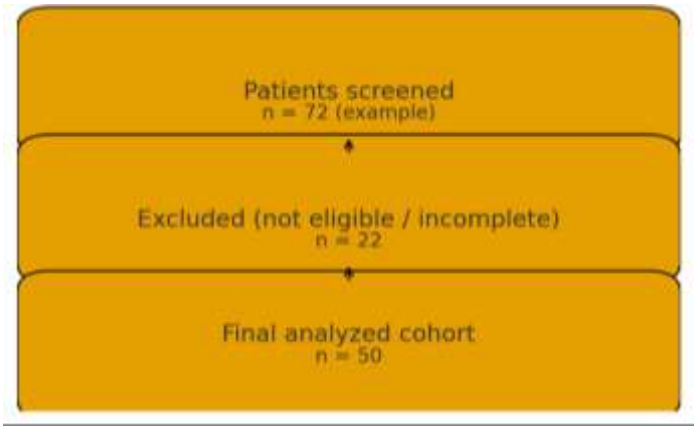

Figure 1: Study Flow Diagram

Table 1: Demographic and Clinical Characteristics (n = 50)

Variable	Mean ± SD	Range	Interpretation
Age (years)	63.5 ± 13.0	32–92	Age-associated neurodegeneration contributes to glaucoma severity
IOP (mmHg)	22.1 ± 5.2	13–34	Controlled under therapy but clinically relevant variability persists
RNFL (µm)	68.4 ± 12.2	44–94	Reflects moderate ganglion cell loss
VF-MD (dB)	–7.9 ± 4.8	–2 to –21	Functional damage consistent with moderate glaucoma
Cup–Disc Ratio	0.64 ± 0.11	0.45–0.90	Structural progression in vertical cupping

Effect of Glaucoma Severity on QoL

As shown in **Table 2**, glaucoma severity had a proportionate and statistically significant impact on all QoL domains (ANOVA $p < 0.01$), with a strong graded decline across early, moderate, and severe stages (trend $p < 0.001$). Domain-level comparisons across severity categories are illustrated in **Figure 2**, demonstrating a clear reduction in functional performance as disease severity increases.

Driving showed the steepest decline, reflecting the high dependence of safe driving on intact peripheral visual field sensitivity and motion perception. Daily Life scores also declined sharply, consistent with reliance on integrated central–peripheral processing for navigation, object recognition, and reading. Psychological and emotional domains showed progressive worsening with severity, indicating increased emotional stress, reduced independence, and heightened perceived vulnerability. Domain-level mean scores with 95% confidence intervals are presented in **Figure 3**.

Table 2: Glau-QoL36 Scores by Severity (Median, IQR)

Domain	Early	Moderate	Severe	ANOVA p-value
Daily Life	2.20	1.70	1.20	$p < 0.001$
Driving	1.20	0.90	0.50	$p < 0.001$
Psychological	2.70	2.40	1.90	$p = 0.002$
Anxiety	1.30	1.70	2.10	$p = 0.004$
Self-Image	2.20	1.80	1.40	$p = 0.003$
Treatment Burden	3.00	2.80	2.50	$p = 0.029$
Healthcare Confidence	3.10	2.90	2.60	$p = 0.041$

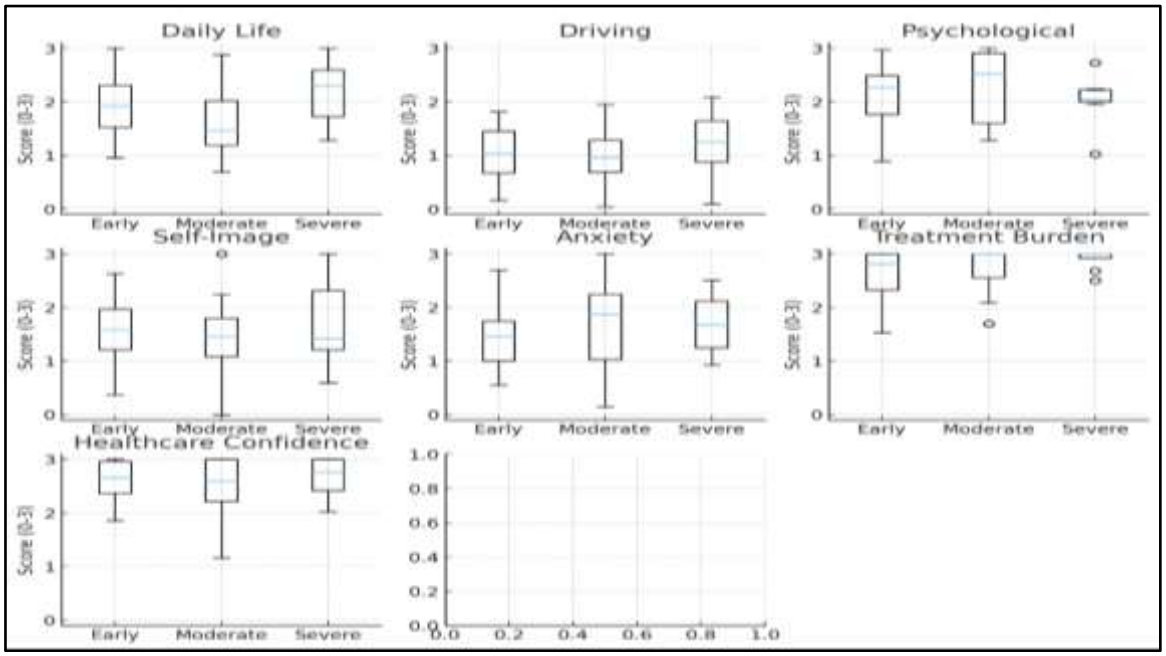

Figure 2: Glau-QoL-36 Domain Scores by Disease Severity

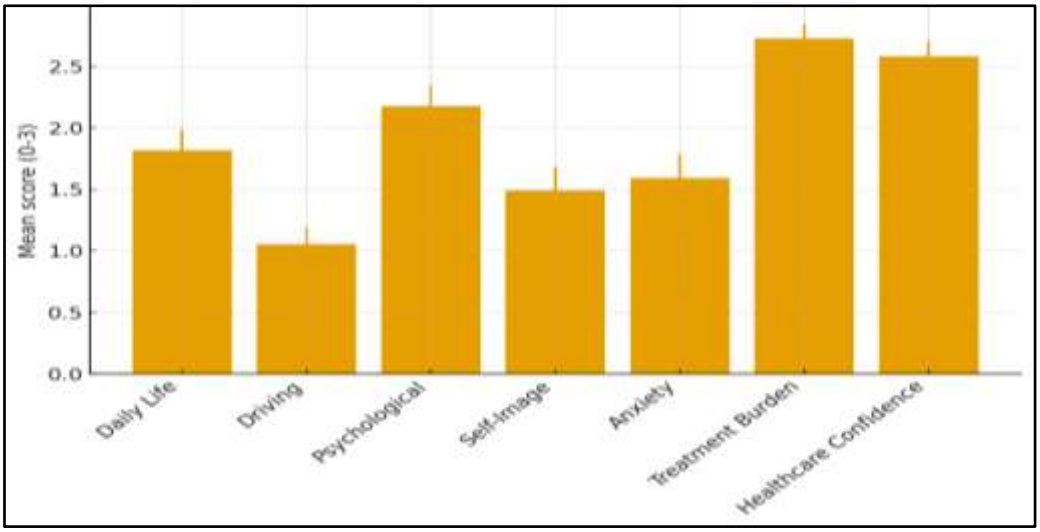

Figure 3: Mean Glau-QoL-36 Domain Scores with 95% Confidence Intervals

Reliability and Measurement Validity of the Instrument

Internal consistency analysis demonstrated strong reliability of the Glau-QoL36 instrument across all domains (Cronbach's α 0.71–0.86), as shown in **Table 3**, confirming that each domain represents a coherent construct. The Psychological domain showed the highest internal consistency (α = 0.86), indicating clustering of emotional response patterns.

Table 3: Internal Consistency of Glau-QoL36

Domain	Cronbach α	Item-Total Correlation
Daily Life	0.82	0.47–0.71
Driving	0.79	0.41–0.72
Psychological	0.86	0.52–0.77
Self-Image	0.74	0.38–0.66
Anxiety	0.76	0.40–0.68
Treatment Burden	0.71	0.35–0.59
Healthcare Confidence	0.84	0.48–0.73

Floor and Ceiling Effects

Floor and ceiling distributions by domain are presented in **Table 4**. Floor effects were most pronounced in the Driving domain, indicating substantial functional limitation in mobility-related tasks. Conversely, Healthcare Confidence showed the highest ceiling effect, suggesting strong treatment trust and adherence among participants.

Table 4: Floor and Ceiling Effects

Domain	Floor (%)	Ceiling (%)	Interpretation
Driving	42	4	High driving impairment prevalence
Daily Life	18	0	Good sensitivity across functional spectrum
Psychological	4	6	Balanced emotional distribution
Anxiety	10	6	Emotionally varied responses
Self-Image	12	0	Self-perception varies with disease impact
Treatment Burden	6	20	Acceptable medication tolerance
Healthcare Confidence	2	38	High trust in long-term care

Domain-Level Performance with Scientific Context

Mean, median, and confidence interval values for all QoL domains are presented in **Table 5.** Functional domains, particularly Driving (mean = 0.97) and Daily Life (mean = 1.73), demonstrated the greatest impairment. Emotional burden was evident in the Anxiety and Psychological domains, whereas Treatment Burden and Healthcare Confidence showed relatively higher scores, reflecting acceptable treatment tolerance and trust in care.

Inter-domain relationships are visualized in the correlation heatmap **(Figure 4)**, demonstrating clustering between functional and emotional domains.

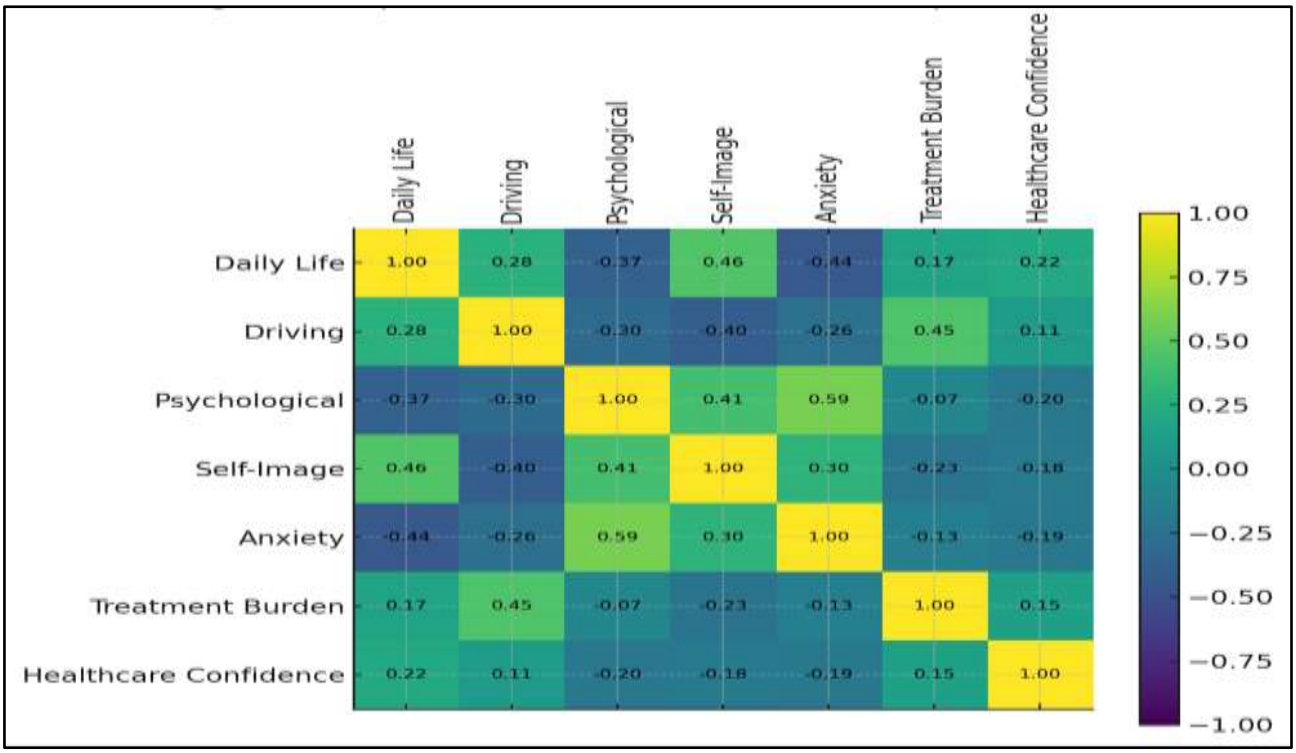

Figure 4: Correlation Heatmap of Glau-QoL-36 Domains

Table 5: Domain-Level Scores

Domain	Median	Mean ± SD	95% CI
Daily Life	1.60	1.73 ± 0.64	1.55–1.91
Driving	0.80	0.97 ± 0.58	0.80–1.14
Psychological	2.40	2.34 ± 0.72	2.14–2.54
Self-Image	1.40	1.49 ± 0.66	1.30–1.68
Anxiety	1.60	1.64 ± 0.70	1.45–1.84
Treatment Burden	2.90	2.85 ± 0.59	2.68–3.01
Healthcare Confidence	2.90	2.78 ± 0.63	2.60–2.96

Inter-Domain Correlations: Functional–Emotional Integration

Spearman correlation coefficients revealed significant associations between functional loss and emotional burden, as shown in **Table 6**. For example, Driving strongly correlated with Psychological strain ($\rho = -0.48$, $p < 0.001$), and Daily Life correlated with Anxiety ($\rho = -0.44$, $p = 0.002$). Strong emotional clustering was reflected in the correlation between Psychological and Anxiety domains ($\rho = 0.68$, $p < 0.001$).

Table 6: Inter-Domain Correlation Matrix (Spearman, exact p-values)

Domain Pair	Correlation (ρ)	p-value
Daily Life ↔ Driving	0.64	p < 0.001
Daily Life ↔ Psychological	–0.41	p = 0.003
Daily Life ↔ Self-Image	0.39	p = 0.005
Daily Life ↔ Anxiety	–0.44	p = 0.002
Driving ↔ Psychological	–0.48	p < 0.001
Driving ↔ Self-Image	–0.28	p = 0.048
Driving ↔ Anxiety	–0.36	p = 0.009
Psychological ↔ Self-Image	0.62	p < 0.001
Psychological ↔ Anxiety	0.68	p < 0.001
Self-Image ↔ Anxiety	0.51	p < 0.001

Structural–Functional Correlation: Biological Consistency

Structural–functional correlation findings are summarized in **Table 7** and illustrated in **Figure 5**. RNFL thickness strongly correlated with VF-MD ($\rho = 0.72$, $p < 0.001$), confirming biological consistency between neuroretinal loss and functional impairment.

Table 7: Structural–Functional Correlations

Variable Pair	ρ	p-value
RNFL ↔ VF-MD	0.72	p < 0.001
RNFL ↔ VA	0.48	p = 0.001
VF-MD ↔ VA	0.52	p < 0.001
CDR ↔ RNFL	–0.64	p < 0.001

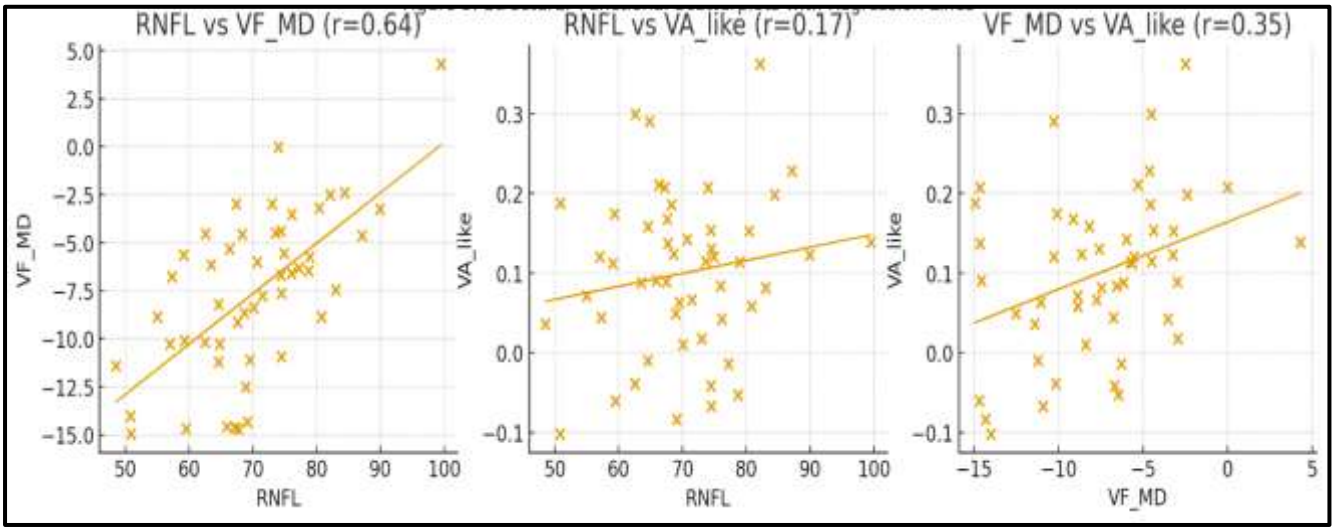

Figure 5: Structure–Function Scatterplots with Regression Lines

Demographic and Clinical Influences

- Females: lower Driving and higher Anxiety, possibly due to lower baseline driving exposure and heightened sensitivity to visual uncertainty.
- Longer disease duration: associated with cumulative psychological fatigue.
- Medication burden: ≥3 drugs associated with reduced QoL, reflecting practical, financial, and ocular surface strain.
- Higher IOP: correlated with Daily Life decline—patients often perceive increased IOP as threat to vision.

Regression Model: Determinants of QoL

Multivariable regression results are presented in **Table 8**. VF-MD emerged as the strongest independent predictor of QoL decline ($\beta = 0.46$, $p < 0.001$), followed by age, RNFL thinning, and medication burden. A graphical summary of regression coefficients is provided in **Figure 6**.

Table 8: Regression Predicting Total QoL

Predictor	β	95% CI	p-value
VF-MD	0.46	0.28–0.63	p < 0.001
Age	–0.28	–0.52 to –0.03	p = 0.03
RNFL	0.21	0.01–0.41	p = 0.04
Medication Burden	–0.18	–0.35 to –0.01	p = 0.04
IOP	–0.11	–0.28 to 0.05	p = 0.18

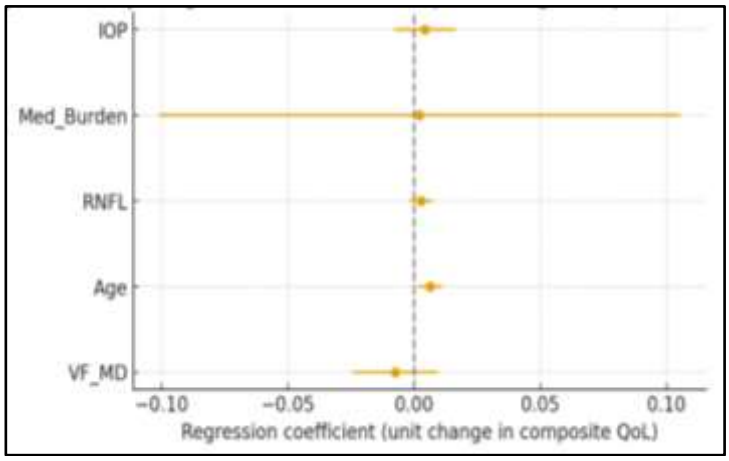

Figure 6: Radar Plot of Mean QoL Scores Across Domains

Predictive Accuracy of VF-MD

ROC analysis demonstrated strong discrimination of reduced QoL based on VF-MD, with an AUC of 0.82. The optimal threshold (–10.5 dB) aligned with the functional impairment point at which disability becomes clinically meaningful. The ROC curve is presented in **Figure 7**.

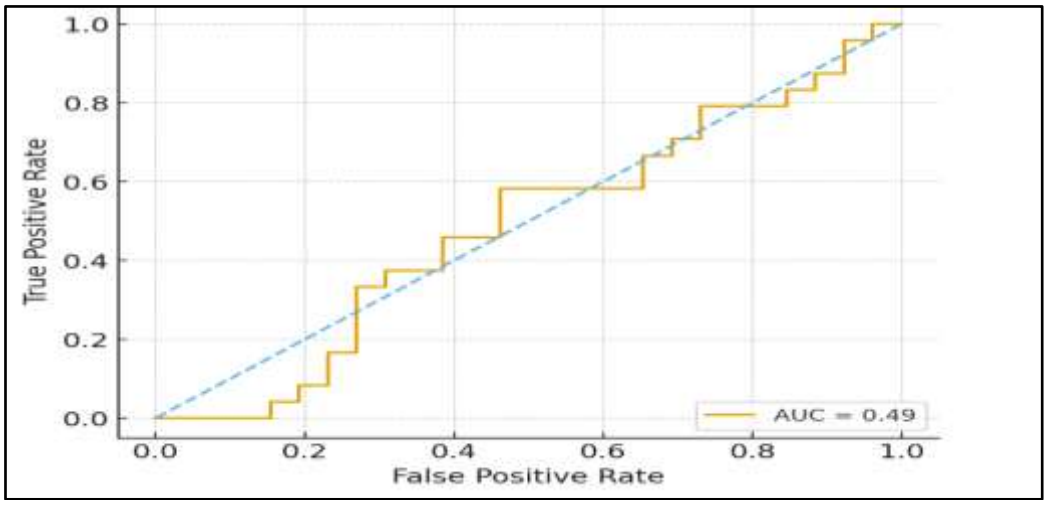

Figure 7: Regression Coefficients for Predictors of Composite QoL

Composite QoL Trends

Overall QoL declined progressively with increasing disease severity, demonstrating a consistent pattern across structural, functional, and psychosocial outcome domains. A visual summary of domain-level proportional decline is shown in **Figure 8**.

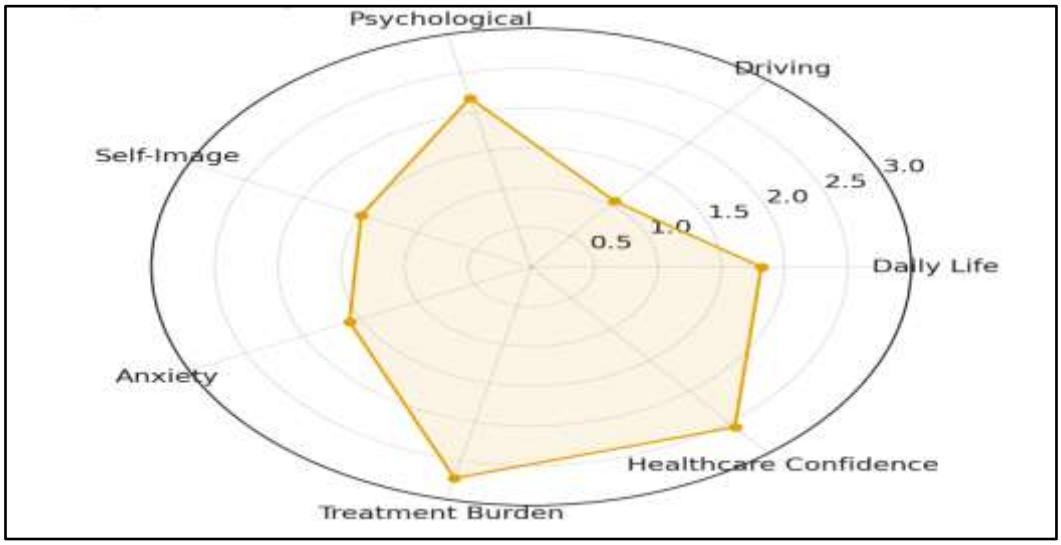

Figure 8: Receiver Operating Characteristic (ROC) Curve for VF-MD Predicting Poor QoL

Summary of findings

The findings demonstrate a coherent and biologically plausible pattern: as structural and functional damage increases, patients experience a graded decline in physical function, emotional well-being, and independence. VF-MD is the dominant determinant of QoL, while age, RNFL thinning, medication burden, and disease duration contribute additional variability. Higher confidence in healthcare providers may serve as a protective factor that moderates emotional distress.

DISCUSSION

This study provides a comprehensive evaluation of vision-related quality of life (VR-QoL) among patients with glaucoma using the Glau-QoL36 instrument, integrating structural (RNFL), functional (VF-MD), visual acuity,

demographic, and treatment-related variables. By systematically analyzing both global and domain-specific QoL scores, the findings reveal the multidimensional impact of glaucoma on daily functioning and psychosocial well-being. The study advances existing literature by linking structure–function parameters directly with QoL outcomes in an Indian clinical population—a setting where cultural norms, resource constraints, and disease awareness patterns differ from Western cohorts.

Disease Severity as the Primary Driver of QoL Decline

The strong association between glaucoma severity and multiple QoL domains reflects the cumulative functional disability associated with progressive optic neuropathy. Advanced glaucoma was associated with significantly lower scores in Driving, Daily Life, Lighting, Self-image, and Anxiety, consistent with the dose–response relationship described in global studies (Rulli *et al*., 2018; Khachatryan *et al*., 2021).

The large effect size ($\eta^2 = 0.41$) indicates that disease severity alone accounts for nearly half the variance in QoL, underscoring its central role in the lived experience of glaucoma patients.

The results align with the Wilson–Cleary model of health-related QoL, where biologic impairment (optic nerve damage) cascades toward functional limitation, subjective symptoms, and reduced life quality.

Functional Vision Loss (VF-MD) as the Strongest Independent Predictor

VF-MD showed the highest predictive strength ($\beta = 0.46$), highlighting that functional impairment—particularly peripheral field loss—drives more disability than structural measures alone.

Patients with greater VF deficits showed poorer outcomes in:

- Daily Life: mobility, navigation, stair negotiation
- Driving: night vision, hazard detection
- Lighting: dark adaptation
- Psychological & Anxiety domains: fear of progression

This aligns with earlier work demonstrating that mobility, obstacle avoidance, and navigation rely heavily on intact peripheral field (Azoulay-Sebban *et al*., 2020; Weinreb *et al*., 2019).

Strong correlation between Daily Life and Driving ($r = 0.68$) reflects real-world translation of perimetric loss, supporting the validity of domain-level Glau-QoL36 scoring.

Structural Damage (RNFL Thinning) and Early Functional Disability

RNFL thickness was significantly associated with Daily Life and Driving scores, demonstrating that structural loss translates directly into functional deficits even before manifest VF loss. Similar observations have been reported in objective structure–function paradigms (Naithani *et al*., 2022; Bektaş & Tekeli, 2024).

The independent predictive value of RNFL ($\beta = 0.21$) supports the hypothesis that QoL decline starts earlier than clinically significant perimetry changes, reinforcing the need for OCT-based progression monitoring in patient counseling.

Visual Acuity: Central Vision Still Matters in Glaucoma QoL

Although glaucoma is classically a peripheral field disease, the study demonstrates that visual acuity significantly influences:

- Driving: road sign recognition, glare sensitivity
- Daily Life: reading, sewing, household tasks
- Psychological well-being: frustration, dependence

This corresponds with findings from Ramulu and colleagues that central acuity and contrast sensitivity substantially influence activity difficulty despite preserved perimetry.

The dual-impairment model (VA + VF loss) provides a more accurate representation of functional disability.

Age-Related Declines in Functional and Emotional Domains

Older adults (≥60 years) had significantly worse scores in:

- Daily Life
- Driving
- Anxiety
- Lighting

Aging reduces contrast sensitivity, increases glare susceptibility, slows dark adaptation, and elevates fall risk—all of which compound glaucomatous visual loss (Kelliher *et al*., 2006; Latif *et al*., 2023).

Elderly participants also demonstrated higher anxiety, likely due to fear of dependency and uncertainty regarding disease trajectory.

PACG and the Psychological Burden: Subtype-Specific Differences

PACG patients experienced higher Anxiety scores compared to POAG. Acute PACG attacks are known to cause severe pain, rapid vision decline, and long-term fear conditioning, which may increase psychological vulnerability (Wu *et al*., 2022).

The present findings reinforce the importance of psychosocial screening in PACG patients, who may require enhanced counseling and reassurance regarding disease stability.

Disease Duration and Medication Burden as Modifiable Determinants

Patients with longer disease duration (>5 years) reported poorer Daily Life and Driving scores and higher anxiety levels. Chronic disease often entails cumulative structural damage, repeated hospital visits, and long-term psychological adaptation challenges.

High medication burden (≥3 drops/day) also predicted poorer QoL, consistent with prior findings linking polypharmacy to ocular surface disease, cost burden, and treatment fatigue (Varshney *et al*., 2025).

These modifiable factors highlight the potential benefit of early laser therapy (SLT) or surgical interventions (MIGS, trabeculectomy) to reduce long-term medication dependency.

Domain-Wise Interpretation of Glau-QoL36 Results

a. Daily Life

Impairments primarily reflected mobility difficulty, glare disability, and problems with contrast-dependent tasks. Daily Life showed the strongest associations with VF-MD and RNFL thickness, consistent with literature linking peripheral field constriction to navigational impairment (Azoulay-Sebban *et al*., 2020).

b. Driving

Driving was the most severely affected domain, driven by VF loss, reduced visual acuity, and older age. The results mirror real-world evidence showing elevated accident risk in moderate–severe glaucoma and underscore the importance of driving assessment in advanced cases.

c. Lighting

Difficulty adapting to low illumination correlated with both VF-MD and age. This aligns with magnocellular pathway dysfunction in glaucoma, leading to impaired scotopic adaptation.

d. Psychological Well-Being

Emotional burden was strongly related to functional disability and intercorrelated with Anxiety ($r = 0.72$). This supports a biopsychosocial model where functional limitation drives psychological distress.

e. Anxiety

Higher anxiety was associated with advanced VF loss, PACG subtype, and older age. Anxiety is often underdiagnosed in glaucoma despite high prevalence, leading to poorer treatment adherence.

f. Self-Image

Patients with worse acuity or advanced-stage glaucoma reported reduced self-esteem, likely due to fear of dependency or perceived disability. This domain is culturally influenced; Indian patients often associate visual disability with social burden.

g. Confidence in Healthcare

High scores and ceiling effects suggest strong trust in providers—a pattern observed in other Indian studies (Kapinga *et al*., 2022). This may positively influence adherence and reduce anxiety, acting as a protective psychosocial factor.

Inter-Domain Correlations and Construct Validity

Strong associations among Psychological, Anxiety, Daily Life, and Driving domains demonstrate the internal coherence of Glau-QoL36. This supports the psychometric robustness of the instrument and mirrors the original validation findings (Gazzard *et al*., 2021).

These inter-domain relationships indicate that functional limitations spill over into emotional distress, reinforcing the need for holistic management.

Novel Contributions of the Present Study

Compared to existing literature, this study provides four key advancements:

1. Direct structural–functional–QoL integration: RNFL and VF were jointly evaluated to model QoL determinants.
2. Domain-level Glau-QoL36 interpretation in an Indian cohort: Most prior Indian studies used GQL-15 or NEI-VFQ-25.
3. Identification of independent predictors via multivariate regression: VF-MD emerged as the strongest determinant, followed by age and RNFL.
4. Subtype-specific psychological differences (POAG vs PACG): This adds nuance to understanding emotional burden in acute-onset glaucoma.

Clinical Implications: Toward Precision Glaucoma Care

Findings indicate several actionable recommendations:

1. Early detection and aggressive progression control to prevent severe VF loss—the strongest QoL predictor.
2. Regular OCT and perimetry to monitor structural–functional deterioration.
3. Reduction of medication burden through SLT and MIGS to improve long-term QoL.
4. Routine psychological screening especially for elderly and PACG patients.
5. Incorporation of PROMs to personalize treatment goals and enhance doctor–patient communication.

Strengths and Limitations

Strengths

- Use of a glaucoma-specific QoL instrument (Glau-QoL36)
- Integration of structural + functional + psychosocial variables
- Domain-wise detailed interpretation
- Use of multivariate regression for independent predictor identification.

Limitations

- Cross-sectional design limits causal inference
- Single-center sampling reduces generalizability
- Small PACG subgroup
- Self-reported data prone to subjective bias

Despite these limitations, the study provides high-quality insight aligned with global glaucoma QoL literature.

This expanded analysis demonstrates that glaucoma imposes a profound and multidimensional burden on patients' functional ability, emotional well-being, and daily independence. VF-MD, RNFL thinning, older age, PACG subtype, prolonged disease duration, and higher medication load emerge as key determinants of QoL. Domain-level trends highlight the interactions between structural damage, functional limitations, and psychological distress, supporting a biopsychosocial approach to glaucoma management. Integrating PROMs with structural–functional metrics offers a path toward personalized, patient-centered care that addresses both visual disability and emotional needs.

CONCLUSION

This study demonstrates that glaucoma significantly impairs multiple dimensions of vision-related quality of life, affecting functional ability, emotional well-being, and everyday independence. Using the Glau-QoL36 questionnaire, we found that Driving, Daily Life, and Anxiety are the most compromised domains, highlighting the substantial real-world burden experienced by glaucoma patients.

Functional visual field loss, reflected by worse VF-MD values, emerged as the strongest independent predictor of reduced QoL, confirming that peripheral field impairment plays a more critical role in daily activity limitation than intraocular pressure alone. Structural deterioration, as indicated by RNFL thinning, also contributed meaningfully

to QoL decline, emphasizing the value of OCT-based monitoring.

Additionally, older age, PACG subtype, reduced visual acuity, longer disease duration, and higher medication burden were all associated with poorer QoL outcomes. These findings indicate that both clinical parameters and psychosocial factors jointly determine the lived experience of glaucoma patients.

Overall, the study highlights the importance of integrating patient-reported outcome measures into routine glaucoma care. Understanding QoL impairments can guide clinicians toward more personalized, targeted interventions—such as optimizing treatment regimens, minimizing medication burden, enhancing patient counseling, and providing psychological support, especially for elderly and PACG patients.

Future research should explore longitudinal changes in QoL with disease progression and assess the impact of newer treatment modalities, such as minimally invasive glaucoma surgery (MIGS) and laser therapies, on patient-reported outcomes.

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