Instituto Nacional
de Ciências e Tecnologia de Timor-Leste

Relatório de Investigação Científica
INCT 2025

Prevalence of Anterior Segment Diseases on Timor-Leste: A Telemedicine Based Study Using the Smart Eye Camera.

Investigador Responsável: Valério A. Espírito Santo

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December 2025

DECLARATION

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Title of the INCT 2025 Scientific Research: Prevalence of Anterior Segment Diseases on Timor-Leste: A Telemedicine-Based Study Using the Smart Eye Camera.

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Principal Investigator's Signature:_____.

Acknowledgement

We thank the participating communities and the Timor-Leste ophthalmology and optometry teams who conducted fieldwork, and the remote graders. We also acknowledge the support of local health authorities. We also thank Ms. Rika Fukutomi for professional English support.

Data availability De-identified data and analysis code can be made available upon reasonable request to the corresponding author.

RESUMO

Objetivo: Estimar a prevalência de doenças do segmento anterior em Timor-Leste utilizando uma lâmpada de fenda baseada em smartphone (Smart Eye Camera, SEC) dentro de um fluxo de trabalho de telemedicina, e avaliar diferenças relacionadas à idade e à gravidade da caarata.

Métodos: Estudo comunitário realizado entre março e junho de 2025, envolvendo adultos (≥18 anos) em várias regiões de Timor-Leste. A acuidade visual (AV) foi medida em logMAR, e imagens do segmento anterior foram capturadas com a SEC por clínicos treinados e avaliadas remotamente.

Resultados: Entre 82 participantes (164 olhos; idade média 58,9 ± 14,0 anos), a AV não corrigida média foi 0,55 ± 0,65 logMAR, melhorando para 0,42 ± 0,66 com orifício estenopeico. Prevalência: blefarite 7,4%, conjuntivite 25,9%, pterígio 12,3%, catarata 37,1%. A catarata foi mais comum em indivíduos ≥50 anos (44,7% vs 0%, $p<0,01$). O grau nuclear correlacionou-se fortemente com AV ($r=0,79$, $p<0,01$). Conclusões: A teleoftalmologia baseada em smartphone mostrou-se viável e eficaz para triagem em Timor-Leste, revelando alta carga de catarata e doenças oculares relacionadas à radiação UV.

Palavras-chave: Timor-Leste, segmento anterior, telemedicina, Câmera de lente Inteligente (Smart Eye Camera), inteligência artificial.

ABSTRACT

Purpose: To estimate the prevalence of anterior segment diseases in Timor-Leste using a smartphone-based slit-lamp (Smart Eye Camera, SEC) within a telemedicine workflow and assess age-related differences and cataract severity.

Methods: A community-based study (March–June 2025) recruited adults (≥18 years) across Timor-Leste. Visual acuity (VA) was measured using logMAR charts, and anterior segment images were captured with the SEC by trained clinicians and remotely graded.

Results: Among 82 participants (164 eyes; mean age 58.9 ± 14.0 years), mean uncorrected VA was 0.55 ± 0.65 logMAR, improving to 0.42 ± 0.66 with pinhole. Disease prevalence: blepharitis 7.4%, conjunctivitis 25.9%, pterygium 12.3%, cataract 37.1%. Cataract was significantly more common in those ≥50 years (44.7% vs 0%, $p<0.01$). Nuclear grade correlated strongly with VA ($r=0.79$, $p<0.01$).

Conclusions: Smartphone-based teleophthalmology is feasible and effective for screening in Timor-Leste, revealing a high burden of cataract and UV-related ocular surface disease.

Keywords: Timor-Leste, anterior segment, telemedicine, Smart Eye Camera, artificial intelligence.

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1. Introduction

1.1. Contextualization

Timor-Leste faces a high burden of avoidable visual impairment. The *Rapid Assessment of Avoidable Blindness* (RAAB 2016) reported an age- and sex-adjusted blindness prevalence of 2.8% among individuals aged ≥ 50 years, low cataract surgical coverage (48.6% among cataract-blind persons), and persistently suboptimal surgical outcomes, reflecting barriers such as limited access, poor follow-up, and logistical constraints (Correia et al., 2017). Earlier analyses confirmed similar patterns, with cataract and uncorrected refractive error identified as the leading causes of blindness and visual impairment in the country (Correia et al., 2017).

Community-based surveys have provided further evidence of the country's ophthalmic challenges. In a population study of adults aged ≥ 40 years, functional blindness affected 4.1% and moderate-to-severe visual impairment 17.7% of participants, with cataract responsible for approximately 73% of blindness and uncorrected refractive error as the major cause of visual impairment (Povey et al., 2007). Geographic and gender inequities persist, as women and rural residents experience lower rates of cataract surgery and poorer visual outcomes, often due to financial barriers, cultural perceptions, and long travel distances to eye-care facilities (Lee, Ramke, Blignault, & Casson, 2013).

Following the country's independence, the national eye-care system was rebuilt from a minimal baseline. The East Timor Eye Program (ETEP) and partnerships with regional academic and non-governmental organizations have progressively developed local capacity, establishing ophthalmology training programs and outreach clinics (Wing et al., 2018). Despite these advances, the density of ophthalmic professionals remains among the lowest in Southeast Asia, and access to specialist care is limited in remote districts. These workforce shortages highlight the need for technology-enabled solutions such as teleophthalmology and mobile screening models.

Geographically, Timor-Leste lies within the "pterygium belt" (± 30° latitude), where intense ultraviolet (UV) exposure and outdoor occupations are associated with higher rates of pterygium and other ocular-surface disorders. Studies from nearby low-latitude regions including Indonesia, the Riau Archipelago, and northern Australia have consistently demonstrated age-related increases in pterygium and substantial population burdens

(Gazzard et al., 2002; Tan et al., 2006). Given Timor-Leste's latitude (~ 8–10° S), evaluating the prevalence of anterior-segment diseases can inform prevention, service planning, and future vision-care policy. However, community-level data on anterior-segment pathology in Timor-Leste remain scarce.

Recent advances in portable ophthalmic imaging now allow high-quality anterior-segment documentation using smartphone-based slit-lamp attachments such as the *Smart Eye Camera* (SEC). The SEC has been validated against conventional slit-lamp microscopes in clinical environments (Shimizu et al., 2019; Andhare et al., 2023) and successfully implemented in remote-island studies, enabling trained non-specialists to capture standardized images for remote grading by ophthalmologists (Kuroiwa et al., 2025; Shimizu et al., 2024). Moreover, telemedicine-based evaluation of anterior-segment images facilitates cross-border collaboration, allowing diagnosis and triage even in resource-constrained or geographically isolated settings (Nishimura et al., 2024; Shimizu et al., 2025).

In this context, we conducted a prospective, community-based screening in Timor-Leste using the SEC within a telemedicine workflow to:

(i) Estimate the prevalence of common anterior-segment diseases;
(ii) Compare visual function and disease prevalence between adults aged < 50 years and ≥ 50 years; and
(iii) Describe the clinical characteristics and visual outcomes in eyes with nuclear cataract, including correlations between nuclear grade and visual acuity.

1.2. Literature Review

Blindness is one of the most serious global issues. The World Health Organization (WHO) estimates that at least one billion people suffer from visual impairments that could be prevented or treated. More than half of all blindness cases are caused by cataracts. A significant challenge contributing to blindness is the lack of diagnostic devices in areas where its prevalence is increasing.

The growing popularity of smartphones with detection capabilities is providing researchers with the opportunity to design and develop mobile applications. Mobile technologies are creating new opportunities in healthcare by offering accessible solutions and scalable

approaches to care, ultimately improving patient health outcomes. Portable devices and smartphones have become promising platforms due to their mobility. With the emergence of new-generation mobile operating systems such as iOS, and Android, there has been a substantial increase in the development and adoption of mobile applications.

In this context, the company Oui Inc developed the **Smart Eye Camera (SEC)** to aid in diagnosing anterior segment eye diseases. According to the developers, the SEC allows for online diagnosis, facilitating access to eye care for the population. The Smart Eye Camera accessory can modify the phone's light source into three types of illumination (slit, diffuse white, and diffuse blue), enabling the diagnosis of conditions such as blepharitis, chalazion, stye, meibomian gland dysfunction, allergic conjunctivitis, dry eye disease, infectious keratitis, filamentous keratitis, corneal dystrophies, trachoma, corneal perforation, cataracts, glaucoma, uveitis, and many other anterior segment disorders.Blindness is one of the most serious global issues, (Friedenwald, 1929). The World Health Organization (WHO) estimates that at least one billion people suffer from visual impairments that could be prevented or treated, (World Health Organization, 2019). More than half of all blindness cases are caused by cataracts, (Tate & Safir, 1981). A significant challenge contributing to blindness is the lack of diagnostic devices in areas where its prevalence is increasing.

The growing popularity of smartphones with detection capabilities is providing researchers with the opportunity to design and develop mobile applications. Mobile technologies are creating new opportunities in healthcare by offering accessible solutions and scalable approaches to care, ultimately improving patient health outcomes. Portable devices and smartphones have become promising platforms due to their mobility. With the emergence of new-generation mobile operating.

Currently, there are more than 10,000 medical and health applications available for smartphones, along with hundreds of portable diagnostic devices. Mobile technology makes it possible to provide care in almost any location. In medical fields like patient monitoring, it is increasingly feasible to collect biological data or monitor patients without requiring a doctor's physical presence,(International Telecommunication Union, 2012).

This research is motivated by the potential of ophthalmological studies focusing on the use of smart mobile devices to diagnose diseases of the anterior segment of the human eye. Specifically, it employs slit-light technology to analyze images of the anterior eye segment

(eyelids to lens) and diagnose associated conditions.

1.3. Problem Formulation

There are numerous anterior segment eye conditions, but according to the WHO, cataracts and trachoma are the leading causes of blindness. The 2019 World Report on Vision states that approximately 65.2 million people worldwide suffer from cataracts, 4.2 million are affected by corneal opacities, and 2 million have trachoma. All these conditions are located in the anterior segment of the eye, and their diagnosis is typically performed using slit-lamp microscopy.

The slit-lamp is a crucial tool for diagnosing ocular conditions, particularly those affecting the anterior segment. However, the primary limitation of this equipment is its lack of mobility.

In response, several companies are focusing on developing portable slit-lamps or devices, such os smartphones, that can be used to diagnose eye diseases. The **Smart Eye Camera (SEC)** is one such innovation—a smartphone accessory that connects to the phone's light source and camera lens.

The SEC has been approved as a medical device in Japan (Japan Medical Device Registration Number: 13B2X10198030101). It emits a blue light at a wavelength of 488 nm when an acrylic resin blue filter (PGZ 302K 302, Kuraray Co., LTD., Tokyo, Japan) is placed over the smartphone's light source. Additionally, a convex macro lens (focal distance: 20 mm; magnification: ×20) is positioned over the camera to focus on the anterior segment of the eye. The accessory's structure is manufactured using polyamide 12 with 3D printing technology (Multi Jet Fusion).

These advancements highlight the growing potential of mobile diagnostic tools like the SEC to address the challenges posed by traditional slit-lamp microscopy, particularly in remote or resource-limited areas.

1.4. Objetives

1.4.1. General objective

Develop an applicable telemedicine model applicable to Timor Leste using Smart Eye Camera for ophthalmic diagnosis.

1.4.2. Specific Objectives

1. Evaluate the performance of the Smart Eye Camera (SEC) in diagnosis.
2. Assess the clinical performance of the device as a programmed medical learning tool for each type of disease.
3. Integrate diagnostic algorithms for each disease and the API into a single application.
4. Develop an AI-powered application that enables automatic diagnosis of multiple eye diseases in a single imaging session.

1.5. Importance of the Invetigation

Our personal and professional motivation is to protect the health of patients all over the world through our technologies and solutions focused on ophthalmology. We invented Smart Eye Camera (SEC), a smartphone attachment medical device which uses light source and camera function of the smartphone to observe the anterior segment of the eye with equal function to Slit-Lamp Microscope. There are 43 million people blind worldwide, and the figure is going to increase to 120 million by the year 2050. More than half of these patients are blind because of the reasons which are preventable and curable, since they are residents in the marginalized areas suffering from access to eyecare itself. We aim to make a difference to this situation with our Smart Eye Camera. In collaboration with ophthalmologists, non-ophthalmologist medical doctors, and healthcare workers all around the world, we deliver proper eye care to these patients and overcome 50% of the world blindness.

1.6. Organization of the Work

This research was organized into four sequential phases:

- ✓ **Phase 1** focused on a comkprehensive literature reveiw and the development of the theoretical framework related to Cataract and Pterygium eye conditions.
- ✓ **Phase 2** involved data collection, including patient records riview, direct observation during eye surgery activities, and structured interviews or surveys with patients and health personnel.
- ✓ **Phase 3** consisted of data analysis using both quantitative descriptive analysis to interpret the findings.
- ✓ **Phase 4** focused on the interpretation of results, formulation of recommendations, and the final perparation of the research report.

1.7. Geographic Location

The study was conducted in Baucau Municipality, Timor-Leste. Baucau was selected as the study area because it is one of the municipalities with a high number of cataract and pterygium cases. In addition, the National Eye Centre team conducts annual eye surgery outreach program in Baucau, making it a suitable location for thgis research.

2. Methodology

2.1. Research Methods

1. The study adopts a quantitative method, where results are expressed in numerical form and analyzed using statistical techniques to classify and interpret the data.
2. The study is of a **basic nature** as it aims to produce or generate new knowledge useful in the fields of artificial intelligence and ophthalmology. The findings will be used to assess the effectiveness of the Smart Eye Camera (SEC) and intervene if abnormalities are detected during the process.
3. Based on its objectives, the study is characterized as:
    - **Observational:** Limited to observing, measuring, and analyzing data without researcher interference.
    - **Descriptive:** Focused on describing phenomena and characteristics of the population.
    - **Prospective:** Analyzing current situations or problems with a forward-looking approach.

Prospective observational study conducted at community screening events across Timor-Leste (March – June 2025). Ethical and technical approval was obtained from the National Institute of Science and Technology (Instituto Nacional de Ciências e Tecnologia, INCT), which oversees research approvals and ethical review procedures in Timor-Leste (Ref:051/Pres. Exec/INCT/IV/2025). Written informed consent was obtained from all participants in accordance with the Declaration of Helsinki.

2.2. Population and Sample

2.2.1. Population

The population for the administrative posts of Venilale, Quelicai, Baguia and Vemasse, located in the Baucau Municipality of Timor-Leste, based on the 2022 census, are as follows: Venilale, 18,447 population; Quelicai, 17,450 population; Baguia, 11,718 population and Vemasse, 9,643 population.

2.2.2. Sample

Residents aged ≥18 years were recruited consecutively at community screening events. Inclusion criteria: ability to provide consent and undergo anterior segment imaging. Exclusion criteria: acute ocular emergency requiring immediate referral (these participants were triaged out and referred). A total of 82 adults were enrolled: 39 men

and 43 women; mean age 58.95 ± 14.03 years (range 29–87). Examinations were conducted by Timor-Leste ophthalmologists and optometrists trained on the SEC capture protocol (anterior segment imaging) [1]. Procedures and measures, demographics, ocular history (e.g., prior cataract or pterygium surgery).

2.3. Data Collection Techniques and Instruments

Visual acuity (VA) was measured monocularly at 4 m using a standardized logMAR chart under ambient room lighting. Uncorrected VA (UCVA) was recorded for all eyes; pinhole VA was additionally recorded when UCVA ≥0.0 logMAR or if the participant reported blur. The better of two consistent readings was entered as the final value. VA ranges were captured to match the distributions reported in Results (UCVA and pinhole 0.0–2.0 logMAR). Ocular examinations are external inspection, and anterior segment imaging using the Smart Eye Camera (SEC; OUI Inc., Tokyo, Japan) attached to a compatible iPhone 8 (Apple Inc., CA, USA), capturing diffuse and slit-illumination videos/images for each eye.

2.4. Data Analysis Method Cohort

A cohort study is an observational research design in which a defined group of individuals sharing common characteristics (in this study the common characteristic is the location), is followed over time to assess the occurrence of specific outcomes. This approach allows researchers to observe natural patterns of disease, identify risk factors, and examine associations between exposures and health outcomes within a real world population. Cohort studies are particularly useful for understanding prevalence, progression, and determinants of conditions in a specific community.

All statistical analyses were conducted using SPSS (Statistics version 29 (IBM Corp., Armonk, NY, USA). SPSS (Statistical Package for the Social Sciences) SPSS is a widely used statistical analysis software developed by IBM (International Business Machines) for managing, analyzing, and interpreting complex datasets. It provides tools for descriptive statistics, hypothesis testing, regression modeling, and data visualization, enabling researchers to perform rigorous quantitative analyses with high reliability. In this study, SPSS version 29 was used to organize the dataset and conduct all statistical procedures, ensuring standardized and reproducible analytical methods.

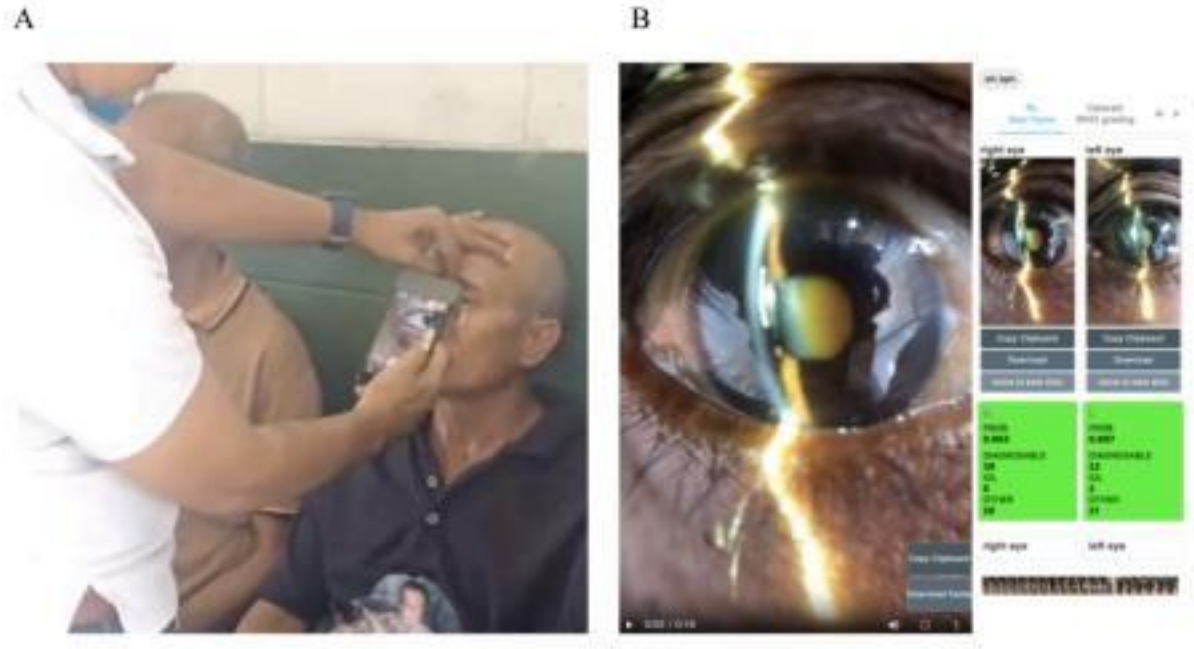
3. Analysis and Discussion of Result

3.1. Analysis of Data

3.1.1. Disease Identification in Optology

The identified media were uploaded to a secure data base. A Timor-Leste ophthalmologist independently graded each eye for: blepharitis, conjunctivitis, scleritis, keratitis, corneal opacity, pterygium, cataract, and other anterior-segment conditions, using pre-specified presence/absence criteria. A small subset was double-checked for image gradability (blur, poor illumination, inadequate coverage); ungradable eyes were excluded from per-endpoint analyses but retained for demographic summaries (Figure 1).

Figure 1. Smartphone-based anterior segment imaging in Timor-Leste and telemedicine interface.



3.1.2. Treatment of Ophtalmological Diseases

Cataract and Ptergium are refer to National Eye Center or Hospital Nacional Guido Valadares to continue plan for surgery and other disease give medication and give

advice how to prevention to the eye.

Table 1 Demographics of the subjects

Age, years of age	58.95±14.03
	(29-87)
n, people	39/43
n, eyes	164
Post cataract surgery, %	1.37%
Post pterygium surgery, %	0.69%
UCVA, logMAR	0.55±0.65
	(2.0-0.0)
Pinhole, logMAR	0.42±0.66
	(2.0-0.0)
Pinhole<1.9, %	12.81%
Blepharitis, %	7.41%
Conjunctivitis, %	25.93%
Scleritis, %	0.62%
Keratitis, %	2.47%
Corneal opacity, %	3.66%
Pterygium, %	12.27%
Cataract, %	37.11%
Others, %	13.61%
UCVA: Uncorrected visual acuity	

A total of 82 adults (39 men and 43 women; 164 eyes) were examined, with a mean age of 58.95 ± 14.03 years (range, 29–87). The baseline characteristics are summarized in Table 1.

The mean uncorrected visual acuity (UCVA) was 0.55 ± 0.65 logMAR (range, 0.0–2.0), which improved to 0.42 ± 0.66 logMAR (range, 0.0–2.0) with pinhole correction. The overall prevalence of anterior segment diseases was as follows: blepharitis, 7.41%; conjunctivitis, 25.93%; scleritis, 0.62%; keratitis, 2.47%; corneal opacity, 3.66%; pterygium, 12.27%; cataract, 37.11%; and other conditions, 13.61% (Table 1).

The proportion of participants with a history of ocular surgery was low: 1.37% had undergone cataract surgery and 0.69% had undergone pterygium excision.

Among 59 examined eyes (mean age, 69.5 ± 9.9 years), the mean UCVA was 1.19 ± 0.61 logMAR and improved to 1.04 ± 0.71 logMAR with pinhole correction (Figure 2A).

Nuclear cataract grading showed that 20.3% of eyes were classified as NUC1, 37.3% as NUC2, and 42.4% as NUC3 (Figure 2B). Representative slit-lamp photographs for each grade are shown in Figure 2D.

Correlation analysis demonstrated a strong positive association between nuclear cataract severity and visual impairment. Both UCVA ($r = 0.79$, 95% CI: 0.67–0.87, $p<0.01$) and pinhole visual acuity ($r = 0.88$, 95% CI: 0.81–0.93, $p<0.01$) were significantly correlated with nuclear grade, whereas age was not significantly associated ($r = –0.07$, $p=0.96$) (Figure 2C).

Figure 2. Clinical characteristics and visual outcomes in eyes with nuclear cataract.

Describe table and Diagram

A

n, eyes	59
Age, years of age	69.53±9.87
UCVA, logMAR	1.19±0.61
Pinhole, logMAR	1.04±0.71
NUC 1, %	20.34
NUC 2, %	37.29
NUC 3, %	42.37

UCVA: Uncorrected visual acuity.
NUC: Nuclear cataract

B

C

	r*	p	95%CI	
Age	-0.07	0.96	-0.27	0.26
UCVA	0.79	<0.01	0.67	0.87
Pinhole	0.88	<0.01	0.81	0.93

UCVA: Uncorrected visual acuity.
*Spearman's correlation

D

(A) Baseline characteristics of the study population (n = 59 eyes), including mean age, UCVA, pinhole visual acuity, and distribution of nuclear cataract grades (NUC1–3).

(B) Pie chart showing the distribution of nuclear cataract grades: NUC1, 20.3%; NUC2, 37.3%; and NUC3, 42.4%.

(C) Correlation analysis between nuclear grade and clinical parameters. Significant correlations were observed for UCVA and pinhole visual acuity, but not for age.

(D) Representative slit-lamp photographs of each nuclear grade: NUC1 (56-year-old male), NUC2 (61-year-old female), and NUC3 (76-year-old female).

3.1.3. Comparison between aged ≥50 years and those <50 years

Table 2. Comparison between aged ≥50 years and those <50 years

	<50 years	≥50 years	p*
n, eyes	32	132	
Post cataract surgery, %	0.00%	1.71%	0.16
Post pterygium surgery, %	0.00%	0.85%	0.32

UCVA, logMAR	0.09±0.11	0.09±0.11	**<0.01**
Pinhole, logMAR	0.65±0.67	0.52±0.70	**<0.01**
Blepharitis, %	22.58%	3.79%	**0.02**
Conjunctivitis, %	22.58%	26.52%	0.65
Scleritis, %	0.00%	0.76%	0.32
Keratitis, %	9.68%	0.76%	0.11
Corneal opacity, %	16.13%	6.02%	0.16
Pterygium, %	6.45%	13.64%	0.19
Cataract, %	0.00%	44.70%	**<0.01**
Others, %	27.59%	10.17%	0.06
UCVA: Uncorrected visual acuity. *unpaired t test.			

When participants were stratified by age (<50 years vs. ≥50 years), several significant differences emerged (Table 2). The mean UCVA was poorer in the ≥50-year group compared with the <50-year group (0.94 ± 0.11 vs. 0.09 ± 0.11 logMAR, p<0.01), and a similar difference was observed for pinhole visual acuity (0.52 ± 0.70 vs. 0.65 ± 0.67 logMAR, p<0.01). The prevalence of cataract was markedly higher in those aged ≥50 years than in those <50 years (44.70% vs. 0.00%, p<0.01). In contrast, blepharitis was significantly more frequent in the younger group (22.58% vs. 3.79%, p=0.02). No significant age-related differences were detected for other anterior segment conditions, including conjunctivitis, scleritis, keratitis, corneal opacity, pterygium, or other ocular surface diseases.

3.2. Discussion of Result

This prospective community screening showed that teleophthalmology using the SEC was feasible in Timor-Leste, enabling local capture by ophthalmologists/optometrists and remote subspecialist grading. In this community-based cohort from Timor-Leste, cataract (37.1%) and pterygium (12.3%) were prominent, and cataract prevalence rose sharply

among adults ≥50 years. Visual acuity was poorer in older adults, and nuclear cataract grade correlated strongly with both UCVA and pinhole VA. These patterns are consistent with RAAB 2016 observations of high age-related vision loss and low surgical coverage in the country [1], supporting the face validity of our sample and workflow.

The observed spectrum of anterior segment disease including UV-related surface disease and age-related lens opacity fits the country's RAAB-documented burden of avoidable blindness and low CSC (1.37% in our cohort) [1].

These consistencies suggest that our cohort is representative of low-latitude, underserved populations in the region. Similar SEC-enabled telemedicine studies have reported high detection rates of age-related anterior segment conditions in remote island populations, reinforcing the approach's practicality outside tertiary clinics [7,8]. RAAB 2016 reported blindness prevalence of 2.8% (≥50 years) and low CSC in Timor-Leste, with barriers dominated by accessibility; our field deployment leveraged community-low.

Among all eyes assessed, 12.8% had a pinhole visual acuity of 1.9 logMAR or worse, exclusively in participants aged ≥50 years. This prevalence is higher than that documented in the 2016 survey [1].

In nearby, latitude settings within the "pterygium belt," pterygium prevalence is typically elevated—e.g., ~10% in a Sumatra cohort and ~17% on a tropical Riau archipelago island—consistent with UV exposure as a driver; Indigenous-Australian datasets also show substantial burdens in central Australia. These contextual data support vigilance for ocular-surface disease in Timor-Leste [3].

The prevalence of pterygium in this cohort was 12.3%, comparable to that reported in prior surveys. The strong correlations between nuclear grade and visual acuity (UCVA, pinhole) in our 59-eye subset mirror relationships reported in regional cataract populations, where nuclear sclerosis is a principal determinant of distance VA [11]. The lack of correlation with age likely reflects the restricted age range of the cataract subset (mean ~70 years) rather than a true absence of age-disease association.

Our study demonstrates that SEC-based capture by trained local clinicians coupled with

remote grading is feasible in Timor-Leste. This corroborates prior SEC deployments in remote Japanese islands and field screenings, which reported high interpretability and practical integration into outreach models [7,8]. Technologically light, smartphone-attachable imaging can extend documentation and triage to communities far from tertiary facilities. A telemedicine pathway can (1) quantify community-level disease burden; (2) channel referrals for cataract/pterygium surgery; and (3) support surveillance in rural sucrose; especially relevant where the workforce and equipment density remain limited [2]. Integration with national strategies and outreach camps can help address the CSC gap highlighted by RAAB [1].

Evidence from teleophthalmology programs indicates improved access and referral completion in underserved settings [9]. Moreover, emergent AI tools can estimate anterior chamber depth from anterior-segment photos and automate nuclear cataract grading, offering quantitative triage signals (e.g., primary angle-closure glaucoma risk, surgery prioritization) without biometry or AS-OCT [11−13]. Integration of SEC + AI may therefore enhance screening throughput, consistency, and referral quality in remote districts. Strengths include a prospective design, community setting, standardized SEC protocol, and age-stratified analyses aligned to public-health needs. Limitations include a modest sample size/cohort, single-country setting, lack of posterior-segment assessments, and absence of on-site refraction/biometry for validation.

Nevertheless, the agreement with regional epidemiology and internal consistency between nuclear grade and visual function support the external plausibility of our estimates. Given the pilot sample size (n=82), analyses were primarily descriptive. For subgroup analyses, participants were stratified into two age groups (<50 years and ≥50 years). Differences in visual acuity and disease prevalence between age groups were compared using the unpaired t-test for continuous variables and Fisher's exact test for categorical variables.

In eyes with nuclear cataract, the severity was graded as NUC1, NUC2, or NUC3 using slit-lamp examination images. The association between nuclear cataract grade and visual acuity parameters (UCVA and pinhole) or age was examined using Spearman's rank correlation coefficient. Results are presented as correlation coefficients (r) with 95% confidence intervals (CIs). A two-sided p value <0.05 was considered statistically significant.

Primary outcomes: UCVA and pinhole VA (logMAR) distributions and prevalence of anterior-segment conditions in the overall cohort. Secondary outcomes: age-stratified comparisons (<50 vs ≥50 years) of VA and disease prevalence; in eyes with nuclear cataract, the distribution of grades (NUC1–3) and correlations between nuclear grade and VA.

The prevalence of blepharitis, conjunctivitis, scleritis, keratitis, corneal opacity, pterygium, cataract, and other anterior segment conditions was determined, as well as the proportion of eyes with a history of cataract or pterygium surgery.

4. Conclusions and Recommendations

4.1. Conclusion

Community screening in Timor-Leste using the Smart Eye Camera within a telemedicine workflow was feasible and clinically informative, revealing an anterior-segment disease profile consistent with the region's epidemiology and the country's known surgical coverage gaps. The cohort revealed a substantial burden of avoidable, age-related eye disease, particularly cataract and pterygium, with prevalence patterns mirroring national (RAAB 2016) data. Visual acuity impairment was strongly correlated with nuclear cataract severity, underscoring the importance of early detection and surgical intervention. The SEC enabled workflow successfully linked local capture with remote specialist evaluation, showing potential to overcome geographic and workforce barriers in eye care delivery.

4.2. Recommendations

These findings highlight an urgent need to transform feasibility into sustained system wide impact. While the SEC enabled teleophthalmology workflow proved effective in identifying disease and bridging specialist gaps, scaling this model requires deliberate strengthening of community screening, referral pathways, workforce capacity, and digital infrastructure. To address the high burden of avoidable eye disease revealed in this cohort and to ensure that early detection translates into timely treatment the following recommendations outline practical, policy-aligned steps for integrating teleophthalmology into national eye health systems.

1. **Scale-Up of Community Teleophthalmology:**
   Expand SEC based community screening within national eye health programs to identify cataract and pterygium cases early, especially in rural and coastal districts.
2. **Integration with Referral Pathways:**
   Establish standardized tele-referral systems linking primary screening sites to regional surgical centers to improve cataract surgical coverage and follow-up outcomes.
3. **Capacity Building and Task Sharing:**
   Train local clinicians, nurses, and optometrists in portable anterior-segment imaging and telemedicine data flow to strengthen local service sustainability.
4. **AI Assisted Screening:**

Integrate artificial intelligence tools for automated cataract grading and anterior chamber assessment to enhance screening efficiency and consistency, especially where ophthalmologists are scarce.

5. **Policy and Infrastructure Support:**

   Embed teleophthalmology in the Ministry of Health's national blindness prevention strategy, ensuring internet connectivity, data security, and cost-effectiveness monitoring.

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