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ENVIRONMENTAL DETERMINANTS AND CATARACT VULNERABILITY PROFILE AMONG RICE FARMERS IN WEST NIAS REGENCY

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ABSTRACT

Background: As a largely preventable cause of blindness, cataract places rice farmers in equatorial tropical settings among the populations most at risk, given the substantial cumulative ultraviolet exposure they sustain over their working lives. **Objective:** This study set out to characterise the environmental, behavioural, and metabolic determinant profile alongside the ocular health status of rice farmers in West Nias Regency, providing an empirical basis for developing a cataract risk-mitigation model**. Methods:** A descriptive cross-sectional design was applied to 30 purposively selected rice farmers in West Nias Regency. Information on demographic characteristics, work patterns, ocular complaints, smoking habits, comorbidities, and protective behaviour was gathered through structured interviews and examined descriptively. **Results:** Women made up the majority of respondents (63.3%), with a mean age of 47.6 years; 56.7% were aged 45 years or older. Most respondents worked 7–9 hours daily in open paddy fields, with a working tenure ranging from 20 to over 40 years. Ninety percent reported ocular complaints, none used any form of eye protection, and the majority displayed low risk perception. Smoking history was present in 26.7% of respondents, diabetes mellitus in 10%, and hypertension in 16.7%. **Conclusions:** Rice farmers in West Nias simultaneously bear a convergence of cataract risk determinants, pointing to an urgent need for a multilevel mitigation model that targets both risk perception and protective behaviour.

Keywords: cataract; environmental determinants; rice farmers; ultraviolet radiation; risk mitigation

INTRODUCTION

To date, cataract-related blindness has not been successfully controlled globally, despite the fact that this condition is actually preventable. Current data indicate that cataracts account for approximately 17.0 million cases of blindness in 2020, equivalent to 39.6% of all blindness worldwide—the highest proportion among all causes. Ironically, although age-adjusted prevalence rates have actually declined, the absolute number of affected individuals continues to rise, because the rate of new cases due to population growth and aging outpaces the rate of expansion in cataract surgical service capacity (VLEG/GBD, 2024).

The distribution of cataract burden is also uneven. The majority of individuals with cataract-related visual impairment reside in low- and middle-income countries, with rural populations, women, and the elderly bearing the largest share. This pattern indicates that cataract cannot be understood solely as a biological process resulting from aging; it also reflects inequalities in access to healthcare services and unequal distribution of environmental exposures. Consequently, efforts to control this condition must account for the social context in which affected individuals live and work (WHO, 2023).

From a mechanistic perspective, lens opacity in senile cataract originates from oxidative damage that continuously accumulates in lens crystalline proteins. Once the lens's antioxidant capacity can no longer counterbalance the oxidative burden it receives, lens proteins undergo denaturation and aggregation, resulting in lens opacity (MacFarlane et al., 2024). This condition is exacerbated in low-income populations, who commonly experience antioxidant deficiency, thereby rendering cellular defence mechanisms vulnerable more rapidly and accelerating cataract formation (Asbell et al., 2023).

Among all modifiable determinants, ultraviolet radiation exposure (particularly UV-B spectrum) is consistently recorded as the strongest environmental factor associated with cataract incidence. The cumulative nature of UV exposure and its dose-response relationship render lifetime dose accumulation the primary determinant of individual susceptibility; consequently, outdoor workers experience radiation doses far exceeding those of the general population (Modenese et al., 2023). Because UV-B intensity is directly proportional to proximity to the equator, outdoor workers in equatorial tropical zones—including Indonesia—bear a greater exposure burden despite similar work duration compared to workers at higher latitudes (MacFarlane et al., 2024).

Farmers occupy a distinctive position regarding ocular vulnerability, as they face continuous exposure to a combination of UV radiation, airborne particles, pesticide residues, and mechanical hazards, while access to protective equipment and ocular healthcare services is typically limited (Alawneh et al., 2025). Rice farmers in particular experience reflected solar radiation from standing water on paddy fields, whereby UV reaches portions of the eye normally shielded by the orbital rim under overhead exposure (MacFarlane et al., 2024). Consistent with this, recent studies report higher cataract prevalence among farming populations, with outdoor work identified as the most dominant risk factor (OR=3.72)—surpassing diabetes, low education, female gender, and smoking habits (Rohmah, 2024).

As an agrarian nation, Indonesia recorded approximately 29.3 million agricultural sector workers in 2023 (BPS, 2023). Nationally, cataract represents the dominant cause of blindness (Ministry of Health RI, 2018); the Rapid Assessment of Avoidable Blindness (RAAB) survey documents blindness prevalence of approximately 3.0% among individuals aged 50 years or older, with untreated cataract accounting for the largest share, namely 71.7–

95.5% of all cases (Halim et al., 2021). This context is relevant to West Nias Regency, an island regency located nearly on the equator with high sunlight exposure year-round and a population predominantly dependent on rice farming—conditions placing farmers in this region at high environmental-related cataract vulnerability (BPS Kabupaten Nias, 2025).

METHODS

This study employed a descriptive cross-sectional design, conducted in West Nias Regency, North Sumatra Province—an equatorial tropical island region receiving high sunlight exposure year-round. Preliminary survey respondents consisted of 30 purposively selected rice farmers, aimed at obtaining a contextual picture of environmental determinants and ocular health status in this target population.

Data collection was conducted through structured interviews encompassing demographic characteristics (gender, age, and education level), work patterns and duration, farming tenure, history of and complaints regarding eye disease, smoking habits, comorbidities (diabetes mellitus and hypertension), secondary outdoor employment, eye protective equipment use, perception of environmental factor influence, and drinking habits while working in the field. Broadly, investigated variables were grouped into three categories: environmental determinants (solar radiation exposure, daily work duration, length of farming tenure, and cumulative exposure from secondary employment), behavioural determinants (smoking habits, protective behaviour, and risk perception), and metabolic determinants (diabetes mellitus and hypertension).

All collected data were processed descriptively, encompassing frequency distribution, percentages, and—specifically for numerical variables—measures of central tendency (mean) and dispersion (range). Results were presented in tabular form accompanied by explanatory narrative to portray respondent vulnerability profiles comprehensively. Research implementation consistently adhered to ethical principles, including obtaining informed consent and maintaining respondent confidentiality.

RESULTS

Demographic Characteristics and Work Patterns

The 30 respondents comprised 11 males (36.7%) and 19 females (63.3%). Mean respondent age was 47.6 years (range: 28–76 years); 17 individuals (56.7%) were aged 45 years or older—an age group entering the cataract vulnerability threshold. Regarding education, the majority of respondents had completed or not completed primary school. Concerning employment, most respondents spent 7–9 hours daily working in open paddy fields (maximum 12 hours), and their farming tenure ranged from 20 years to over 40 years, with some exceeding five decades (Table 2).

Table 2. Summary of Preliminary Survey Results for 30 Rice Farmers in West Nias Regency

No	Variable	Survey Results (n=30)
1	Gender	Male 11 (36.7%); Female 19 (63.3%)
2	Age	Mean ±47.6 years (range 28–76); ≥45 years: 17 individuals (56.7%)
3	Education	Majority ≤ primary school completion
4	Daily work duration	Majority 7–9 hours/day (max 12 hours)
5	Farming tenure	Primarily 20–40+ years
6	Ocular complaints	27 of 30 (90%): red eyes, heat, blurred vision, itching, photophobia
7	Smoking history	8 (26.7%); ~7 of 11 males
8	Comorbidities	Hypertension 5 (16.7%); Diabetes 3 (10%)
9	Secondary outdoor employment	Rubber tapping, coconut picking, livestock
10	Eye protective equipment	No respondents used any
11	Risk perception	Majority show habituation
12	Drinking habits	All carried >2 liters/day

DISCUSSION

Overall, this preliminary study's findings depict a population bearing nearly all cataract risk determinants simultaneously. The 90% ocular complaint prevalence among respondents far exceeds rates typically reported in general populations, and this finding aligns with research among farmers worldwide, which similarly identifies agricultural workers as bearing the highest occupational ocular disorder burden (Alawneh et al., 2025).

The combination of 7–9 hour daily work duration with 20 to over 40 years farming tenure among most respondents necessarily produces very substantial ocular UV radiation dose accumulation throughout their working lives. This aligns with UV exposure's cumulative nature and dose-response relationship, such that farming tenure length serves as a strong indicator of cumulative ocular exposure received (MacFarlane et al., 2024; Modenese et al., 2023). Geographic factors further compound conditions: West Nias's location nearly on the equator with high sunlight intensity makes farmers here experience greater exposure doses compared to higher-latitude counterparts despite equal work duration (BPS Kabupaten Nias, 2025).

The distinctive characteristics of rice farming work further reinforce this vulnerability profile. Water flooding paddy fields acts as a reflective surface directing UV radiation toward eyes from below, thereby exposing orbital edge areas normally protected under overhead exposure (MacFarlane et al., 2024). Furthermore, because nearly all respondents engaged in secondary outdoor employment, their accumulated radiation exposure actually derives from multiple sources, not solely rice farming (Modenese et al., 2023).

Beyond environmental determinants, behavioural and metabolic factors similarly heighten respondent cataract vulnerability. The 26.7% smoking prevalence—with higher proportions in males—is known to deplete lens antioxidant reserves while increasing systemic oxidative stress (Ivanescu et al., 2024). Similarly, presence of diabetes mellitus (10%) and hypertension (16.7%) adds metabolic and oxidative pathways accelerating lens opacity.

CONCLUSIONS

Overall, rice farmers in West Nias Regency simultaneously bear convergent various cataract risk determinants, ranging from ages entering vulnerability thresholds, intense equatorial UV exposure, very long work duration and tenure, cumulative secondary outdoor employment exposure, male respondent smoking habits, diabetes and hypertension comorbidities, low education levels, to low risk perception and minimal protective behaviour. The high ocular complaint prevalence identified (90%) further confirms genuine occupational ocular burden in this population.

Based on these findings, it can be concluded that more systematic environmental determinant analysis and multilevel cataract risk-mitigation model development suited to local context are required, with primary leverage points being risk perception increase and protective behaviour strengthening among farmers. Should mitigation efforts commence early—while most at-risk cohort have not yet experienced advanced-stage lens opacity—then potentially substantial prevention of avoidable blindness burden escalation in this region is achievable.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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AUTHOR CONTRIBUTIONS

Author contribution roles: conceptor, data curation, investigation, methodology, formal analysis, validation, visualization, writing original draft, writing review and editing.

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