Original Article

Association of sunlight exposure with visual impairment in an Indian fishing community

Shwetha V Puthran[1], Sayantan Biswas[1,2], Siddharth K Karthikeyan[1], Jyothi Thomas[1]

Purpose: Indian fishermen belong to a marginalized population and are continuously exposed to extreme occupational hazards and sunlight. A high prevalence of visual impairment (VI) is reported in the coastal fishing community. We aimed to investigate the association between VI and sunlight exposure measurement (SEM). **Methods:** In this cross-sectional observational study, 270 eyes of 135 participants were enrolled from a coastal fishing village. Participants underwent a comprehensive ophthalmic examination, which included best-corrected visual acuity (BCVA), and anterior and posterior segment examination. Ocular Surface Disease Index (OSDI) and SEM questionnaire were administered to estimate the level of dry eye and ultraviolet-B (UV-B) exposure, respectively. VI was defined as presenting visual acuity worse than 6/12 (logarithm of the minimum angle of resolution [logMAR] > 0.3). **Results:** The mean age and spherical equivalent were 50.56 ± 11.72 years (range: 18–80 years) and 0.36 ± 1.68 diopters (D) (range: -7.0 to +3.0 D), respectively. Age, SEM, OSDI, fishing as an occupation, and cataract were significantly associated with higher odds of VI in univariate analysis. Refraction, gender, education level, smoking status, amblyopia, systematic, and other ocular diseases were not significantly associated with VI. In the multivariate analysis, age, SEM, and presence of cataract remained significantly associated with a higher risk for VI. The area under the receiver operating characteristic curve values for age and SEM scores demonstrate a fair index of discrimination for the detection of VI. **Conclusion:** SEM level is directly associated with a higher risk of VI among fishermen. The fishing community might benefit from regular eye examinations and awareness about the harmful effects of sunlight exposure and preventive measures.

Key words: Cataract, fishermen, fishing community, ocular disease, sunlight exposure, ultraviolet-B, visual impairment

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Visual impairment (VI) is a public health concern worldwide. With the growing population and aging, the prevalence of VI is predicted to increase from 553 million in 2020 to 834 million by 2050.[1] It is associated with poor quality of life, reduced education, unemployment, fewer financial opportunities, and an increased risk of death.[1] The economic burden of VI caused by ocular disease is higher compared to refractive error.[2] The foremost cause of VI in adults aged ≥50 years is cataract, followed by under-corrected refractive error, glaucoma, and retinal diseases.[3] Sunlight exposure has been associated with various ocular diseases,[4] which lead to VI worldwide. Ultraviolet (UV) component in sunlight contains energy higher than infrared or visible light; hence, it is more liable for biological damage. Long-term ocular exposure to UV radiation can cause early cataract, pterygium, keratopathy, and pinguecula to name a few.[4] Rosmini *et al*.[5] found a dose–response effect of sunlight exposure on the cataract grading, whereas others found sunlight exposure of higher quintile[6,7] and longer duration (≥ 5 h per day)[8] to be associated with cataract. Even though the relationship between UV and cataract is established to be positive, there are reports of no association between lifetime occupational sunlight exposure and cataract.[9] This is probably because studies mostly involve the general population and not specifically those with high sun exposure at greater risk of VI.

Fishermen are a marginalized population in India who reside near the seashore and are exposed to prolonged sunlight throughout their life more than other occupations. Marmamula *et al*.[10] reported that 30% of fishermen in coastal Andhra Pradesh have VI mainly due to cataract and under-corrected refractive error. A study conducted on Hong Kong fishermen indicated that greater daily sunlight exposure has a non-significant, yet higher nuclear cataract grading.[11] Despite the coastal fishing community being an important target group at risk of VI, its association with sunlight exposure remains to be investigated. Moreover, none has attempted to establish the diagnostic performance of sunlight exposure measurement (SEM) for the detection of VI. Considering the gap in the literature, we aim to investigate the association of SEM with the risk of VI among a fishing community in coastal Karnataka.

[1]Department of Optometry, Manipal College of Health Professions, Manipal Academy of Higher Education, Manipal, Karnataka, India, [2]School of Optometry, College of Health and Life Sciences, Aston University, Birmingham, United Kingdom

Correspondence to: Dr. Sayantan Biswas, School of Optometry, College of Health and Life Sciences, Aston University, Aston Triangle, Birmingham, B4 7ET, United Kingdom. E-mail: s.biswas2@aston.ac.uk

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Methods

This cross-sectional study was conducted between July 2018 and April 2019. The study was approved by the Institutional Research Committee and Institutional Ethics Committee and adhered to the guidelines of the Declaration of Helsinki, 1975. Study participants were recruited by inviting the adult population (≥18 years) of the entire Kadipatna village, Karnataka. Written informed consent was obtained from all eligible subjects. All participants were invited for a detailed ophthalmic examination, which included measuring visual acuity and performing refraction if the visual acuity is <6/12 or improved with a pinhole. Objective refraction was performed with a retinoscope, followed by subjective refraction. The anterior segment was evaluated using torchlight and a high plus lens (+10 D). Cataract was defined as the opacity of crystalline lens in the pupillary area as observed with a torch and causing VI (presenting VA <6/12 and not improving with pinhole). Fundus was viewed using a direct ophthalmoscope, and retinal photographs of the disc and macula were obtained with a non-mydriatic Bosch Smartscope fundus camera (40-degree field of view). Diagnosis of the ocular pathology and diseases was confirmed by a trained expert (ophthalmologist) at a base hospital after conducting a dilated fundus examination and using the Goldmann applanation tonometer. VI was defined as presenting visual acuity worse than 6/12 (logarithm of the minimum angle of resolution [logMAR] >0.3).[12]

Detailed questionnaires were used to elicit information regarding the personal, lifestyle, environmental variables, systemic, and ocular history. It was read out to the participants and their responses were recorded by the person administering it. The associated factors evaluated were: (1) personal information such as age, sex, occupation, educational level, and self-reported smoking/alcohol, (2) environmental variables including long-term SEM and use of spectacles or protective gear, (3) ocular symptoms related to dry eye disease (DED), (4) self-reported systemic disease, and (5) ocular factors including the history of any ocular morbidity/disease/surgery/trauma.

Study participants

Due to the lack of eye disease awareness and barriers to proper eye care,[10] we expected poor compliance and non-participation from those without ocular morbidity or those already following up with a specific eye hospital or physician. To overcome this challenge, we took help from the local administrative body that not only assisted in obtaining permission but also in raising awareness about the camp to the entire fishing community. Two camps were conducted, each for 2 days, separated by 4 months and only during the weekends. The entire village was made aware of the need for the study through a general body meeting. Fifteen days before the camp, the people of the village were made aware of it through handbills, which contained the date, venue, and timing of the event. Handbills were distributed door-to-door and covered the entire village. Banners were also put up near the village temple and also near the venue of the camp. Door-to-door surveys of all households were also conducted. Moreover, we provided flexibility in scheduling their eye examination based on their convenience and availability throughout the entire 2 days. Possible issues of refusals and dropouts were addressed by counseling and explaining the benefits of the study to the participants plus sending reminders via telephone or a personal visit by a team member.

Questionnaires

Subjects were asked to fill out the Ocular Surface Disease Index (OSDI) questionnaire, which was a self-administered questionnaire assessed on a scale of 0 to 100, with higher scores representing severe DED. The final score for an individual was obtained by the formula (OSDI = [sum of scores]−25)/ number of questions answered. It was classified as mild (> 12), moderate (> 23), and severe DED (>33).[13]

A validated SEM questionnaire (SEM-Q)[14] was administered by the investigators fluent in the local language. The questionnaire measures the long-term sun exposure (specifically UV-B exposure) data with a reference period of 1 year. Because personal and atmospheric factors may affect UV-B exposure, the questionnaire included domains such as sunlight exposure duration, use of sunscreen, sun-protection practices such as seeking shade, clothing, use of hat/scarf, weather (sunny or cloudy), occupational behavior, and season (summer and winter). An algorithm for item weightage was created by giving different weights to the domains and calculating an average score based on UV-B percentage. Each domain received a score ranging between 0 and 1. For example, a fully covered face gets a score of 0 as it receives 0% UV-B; however, a partially covered face scores 0.5 (50% UV-B), and completely exposed will be 1 (100% UV-B exposure). A detailed scoring system is available elsewhere for each of the domains. The final SEM score was obtained by multiplying the proportions of each domain by the time spent (min) in the sun and subsequently adding up the score of each domain to arrive at the final score for the individual.

Statistics

Statistical analysis was carried out using STATA 12.0 (Stata Corporation, College Station, TX, USA). Significance was assessed at $P < 0.05$ for all parameters. Categorical variables between groups are compared using the Chi-square or Fisher's exact test; an independent *t*-test was used for continuous variables. Univariable and multivariable mixed-effects logistic regression analyses were performed to investigate factors associated with VI with adjustment of correlation between fellow eyes.[15] Both eyes were considered for analysis in this study. Significant factors with a *P* value of less than 0.05 in the univariable model were analyzed in the multivariable model. The strength of associations with variables such as age, gender, refractive error, education level, occupation, OSDI score, SEM score, and ocular morbidities such as cataract and pterygium was estimated by odds ratio (OR) and its 95% confidence interval (CI).

NCSS 2022 (NCSS, LLC, Kaysville, Utah, USA) was used to generate the area under the receiver operating characteristic (AUROC) curve, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for the detection of VI determined. We used three different criteria[16,17] to determine the cut-off for age, SEM, and OSDI score to detect VI: (1) Maximum Youden Index, (2) sensitivity and specificity almost equal to each other, and (3) minimum distance from the left-upper corner of the unit square.

Results

Tables 1 and 2 summarize the demographics and ocular characteristics of the study subjects. A total of 270 eyes from

Table 1: Demographics and ocular measurements of study subjects

Parameter	All	VI	No VI	*P**
	Mean±SD (range)	Mean±SD (range)	Mean±SD (range)	
Subjects/eyes	135/270	52/83	104/187	-
Gender (Male/female)	65/70	22/30	36/68	-
Age (years)	50.56±11.72 (18 to 80)	56.31±10.07 (42 to 80)	48.01±11.51 (18 to 75)	**<0.001**
SEQ (Diopters)	0.36±1.68 (-7.0 to +3.0)	-0.1±2.05 (-7.0 to +2.5)	0.58±1.44 (-3.0 to +3.0)	0.118
SEM score	770.86±456.98 (100 to 1480)	1001.71±449.39 (120 to 1480)	668.39±422.67 (100 to 1464)	**<0.001**
OSDI score	32.70±17.87 (0 to 66)	39.17±15.33 (0 to 66)	29.83±18.20 (0 to 65)	**0.0001**
Visual acuity (logMAR)	0.24±0.29 (0.00 to 1.30)	0.41±0.32 (0.00 to 1.30)	0.17±0.25 (0.00 to 1.00)	**<0.001**

VI: Visual impairment, SD=Standard deviation; SEQ=Spherical equivalent; SEM=Sunlight exposure measurement; OSDI=Ocular Surface Disease Index.
*Independent *t*-test to compare means between eyes with and without visual impairment. Bold values are statistically significant

Table 2: Characteristics of study subjects and associations between potential risk factors and visual impairment

Variable	Categorization	VI (*n*=83 eyes)	No VI (*n*=187 eyes)	*P**
		n (%)	*n* (%)	
Gender	Female	42 (26)	118 (74)	0.054
	Male	41 (37)	69 (63)	
Dry eye	No	6 (11)	50 (89)	**<0.001**
	Mild	7 (17)	35 (83)	
	Moderate	20 (36)	36 (64)	
	Severe	50 (43)	66 (57)	
Occupation	Fishing	48 (42)	66 (58)	**<0.001**
	Selling fish	19 (37)	33 (63)	
	Housewife	16 (17)	78 (83)	
	Others	0 (0)	10 (100)	
Education level	Illiterate	5 (62.5)	3 (37.5)	**0.009**
	Primary	11 (37)	19 (63)	
	Secondary	29 (38)	47 (62)	
	Higher secondary	38 (27)	104 (73)	
	Tertiary	0 (0)	14 (100)	
Cataract	Yes	44 (51)	42 (49)	**<0.001**
	No	39 (21)	145 (79)	
Pterygium	Yes	40 (62.5)	24 (37.5)	0.180
	No	59 (29)	147 (71)	

VI: Visual impairment, *n*=Number of eyes. *Chi-square test to assess the relationship between categorical variables. Bold values are statistically significant

135 subjects with spherical equivalent between + 3.0 and − 7.0 D (mean ± SD: 0.36 ± 1.68 D) were consecutively recruited. We can infer that a subject with VI was more likely to be an older fisherman, with a higher level of SEM, DED (high OSDI score), with a low level of education and cataract.

In Table 3, the potential risk factors for VI were first assessed with univariate analysis. When age was entered in the logistic regression as a covariate, for each year (unit) increase of age, there was a 1.18 (95% CI: 1.08–1.29, $P < 0.001$)-fold increase of VI in the study population. In other words, an increase in 1 year in age had an 18% (95% CI: 8%–29%) increase in odds of having VI. A unit increase in SEM had a 2% increase in the odds of having VI. Likewise, a unit increase in OSDI score was associated with 7% (95% CI: 2%–13%) increased odds of VI. The presence of cataract compared to its absence is 11.12 (95% CI: 3.01–31.13) times more likely to cause VI. Notably, only fishing as an occupation was significantly associated with higher odds of VI (1.77, 95% CI: 1.15–2.71, $P = 0.009$). This indicates that fishermen were 1.77 times more likely to have VI compared to other occupations. Spherical equivalent, amblyopia, gender, education level, presence of pterygium, glaucoma, corneal or retinal disease, self-reported systemic disease, and smoking status were not significantly associated with VI in the univariate analysis.

In the multivariable analysis, only age, SEM, and cataract were associated with VI. The OR for age, SEM, and cataract were 1.11 (95% CI: 1.01–1.22, $P = 0.032$), 1.01 (95% CI: 1.00–1.02, $P = 0.031$), and 3.80 (95% CI: 1.01–14.28, $P = 0.048$) for each unit increase, respectively. With every unit increase in age and SEM, there was an 11% and 1% increase in odds of having VI after adjusting for various factors, respectively. The presence of a cataract was 3.80 times more likely to cause VI than the absence of it.

Table 3: Factors associated with visual impairment (*n*=83 eyes) analyzed with univariable and multivariable mixed-effects logistic regression analysis

Parameter	Univariable analysis, odds ratio (95% CI)*	*P*	Multivariable analysis, odds ratio (95% CI)	*P*
Age (years)	1.18 (1.08 to 1.29)	**<0.001**	1.11 (1.01 to 1.22)	**0.032**
SEQ (Dioptre)	0.61 (0.28 to 1.31)	0.204	-	-
SEM score	1.02 (1.00 to 1.04)	**<0.001**	1.01 (1.00 to 1.02)	**0.031**
OSDI score	1.07 (1.02 to 1.13)	**0.005**	0.94 (0.86 to 1.03)	0.182
Gender: Female	1	-	-	-
Gender: Male	3.02 (0.60 to 15.13)	0.179	-	-
Occupation: Housewife	1	-	-	-
Occupation: Fishing	1.77 (1.15 to 2.71)	**0.009**	-	-
Occupation: Selling fish	1.02 (0.95 to 1.12)	0.592	-	-
Occupation: Others	0.96 (0.94 to 1.01)	0.131	-	-
Education level: Illiterate	1	-	-	-
Education level: Primary	0.82 (0.64 to 10.30)	0.310	-	-
Education level: Secondary	0.96 (0.11 to 8.73)	0.309	-	-
Education level: Higher secondary	0.62 (0.29 to 2.33)	0.112	-	-
Education level: Tertiary	0.75 (0.46 to 1.78)	0.282	-	-
Cataract: No	1		-	-
Cataract: Yes	11.12 (3.01 to 31.13)	**<0.001**	3.80 (1.01 to 14.28)	**0.048**
Pterygium: No	1		-	-
Pterygium: Yes	2.57 (0.41 to 16.11)	0.314	-	-

SD=Standard deviation; CI=Confidence interval; SEQ=Spherical equivalent; D=Dioptres; SEM=sunlight exposure measurement; OSDI=Ocular Surface Disease Index. *1 is a reference with which the odds ratio is calculated. Statistically significant *P* values are in bold

Prediction of visual impairment

From the coefficient estimates of the mixed effect logistic regression model,[18] probability of VI = $1/(1 + e^{-z})$, where, $z = -8.99 + (0.102 \times \text{age}) + (0.004 \times \text{SEM-Q score}) + (1.335 \times \text{Cataract (1)})$. For a 60-year-old person with an SEM-Q score of 1400 and a cataract, we obtained a z-score of 4.065 and $e^{-z} = 0.017$. Hence, probability (VI) = $1/(1 + 0.017) = 0.98$; the subject was extremely likely to have VI. Contrastingly, a 60-year-old with an SEM score of 300 and no cataract has probability (VI) = $1/(1 + 5.312) = 0.16$, quite unlikely for this person to develop VI.

Area under the receiver operating characteristic curve, sensitivity, specificity, positive, and negative predictive values to discriminate visual impairment

AUROC curve was fair for age (0.709) and SEM (0.728), whereas, it was poor for OSDI (0.652) and cataract (0.653) [Fig. 1].

For age, the highest sensitivity (95%) and NPV (94.9%) were observed using criterion 1 (maximum Youden Index). However, the specificity and PPV were low at 39.6% and 41.2%, respectively. Criterion 2 (sensitivity almost equal to specificity) and criterion 3 (minimum distance from the left-upper corner) were observed to be the same with moderately high sensitivity and NPV of 63.9% and 80.5%, respectively.

For SEM score criterion 1, low sensitivity (50.6%) was observed but with high specificity (91.4%), PPV 72.4%, and NPV 80.7%. Criteria 2 and 3 were similar, with moderate sensitivity of 61.5%, specificity of 63.1%–70.6%, low PPV of 42.5%–48.1%, and high NPV of 78.7–80.5%.

Similar to age, OSDI had high sensitivity (81.9%) and NPV (85.9%), but low specificity (48.7%) and PPV (41.5%) with criterion 1. Criteria 2 and 3 were again similar, with moderate sensitivity (60.2%–69.9%) and specificity (59.4%–64.7%), high NPV (78.6%–81.6%) but low PPV (43.1%–43.3%).

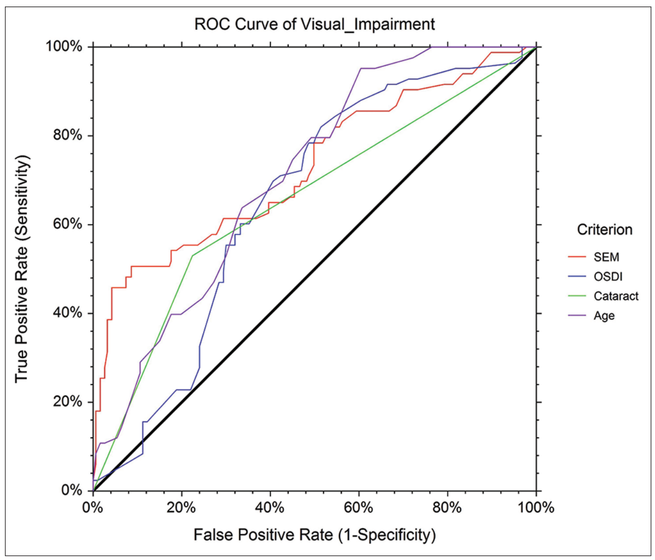

Figure 1: Receiver operating characteristic (ROC) curve of visual impairment. Note: SEM: Sunlight exposure measurement, OSDI: Ocular Surface Disease Index

Discussion

UV radiation from the sun is widely studied and associated with the development of various ocular diseases in the general population.[4] Yet, there are limited occupation-focused studies related to high levels of sunlight exposure, and its relationship to the resultant VI. We specifically designed this study to elucidate the UV-B exposure and estimate its association with the VI in a fishing community. To our knowledge, this is the first study to demonstrate the positive association between the two in this community.

The reported prevalence of VI among fishermen varies from 20.8% to 54.5%,[10,19–21] which is much higher compared to the general population (1.8% to 24.5%).[22,23] This is consistent with the higher risk of skin disorders reported by Burke *et al*.[24] among fishermen, probably because of the longer duration of UV exposure and unhindered reflection of sunlight at sea. We used an established and validated questionnaire[14] to estimate the long-term SEM among our study participants and found higher SEM was associated with increased odds of VI. Greater lifetime UV exposure is a known risk factor for the development of cataract, and corneal, and retinal diseases that cause VI.[4,8,25] As hypothesized, we found the presence of cataract to increase the risk of VI. A study on Hong Kong fishermen[11] similarly provided limited evidence that daily SEM might be related to the incidence of cataract. The association of SEM with VI, even after adjusting for cataract indicates significant involvement of ocular diseases other than cataract. Other ocular diseases, such as glaucoma ($n = 2$), age-related macular degeneration (AMD) ($n = 4$), diabetic retinopathy ($n = 3$), corneal opacity ($n = 2$), and amblyopia ($n = 6$), individually failed to show significant association with VI in our study population. An underestimation of ocular diseases could be possible due to limited visibility of the peripheral retina of the undilated eye, especially with media opacity during screening. The subsequent dropouts (10%) from dilated fundus examination at the base hospital might have added to this underestimation. Furthermore, the association of UV-B with AMD is controversial with some reporting no relationship between the mean annual UV-B exposure and the incidence or progression of AMD.[26] Excessive sunlight exposure is known to be associated with a myriad of ocular[4] and systemic diseases,[27] especially among the elderly population. Given the relatively young to middle age of our study participants (mean ± SD: 50.56 ± 11.72 years), it is likely that ocular disease could be still at their pre-clinical stage and remained undetected during clinical examination, and it requires high-resolution optical coherence tomography to identify the earliest changes in the retina.[28,29] Concurrently, the majority (~70%) of our study participants were in the mild VI stage. In addition, the SEM-Q measured sun exposure for the past year and not lifetime exposure,[14] the latter may have given more meaningful associations and relationships with VI.

Higher age was correlated with a greater risk of developing VI. This age-related increase in odds of VI is well recorded in population-based epidemiological studies and was reflected in our study as well.[30,31] Correspondingly, the mean age of our study participants with VI was also higher than that of those without VI [Table 1].

Although the risk of pterygium is reported to be higher in most studies, we did not find a significant association with SEM in our study population. This was probably due to the lower mean age (50.56 vs. 55.53 years) among our study participants, which is a risk factor for pterygium.[32] Although SEM is a known risk factor for the development of DED.[33] the contradictory reports suggest no association of sunlight with DED and even lower SEM associated with DED.[34] Unlike the reported agreement.[35] between DED and VI, we did not observe any association between the OSDI score and VI, probably again because of the relatively younger study population (50.56 vs. 54.50 years)[33] and low level of smoking.[36] reducing the strength of association [Table 2].

Unlike the association between under-corrected refractive error and VI observed in the general urban population, we could not find an association between the two in this population. Possibly, the greater time spent outdoors,[37] longer exposure to sunlight,[38] and higher serum concentrations of 25-hydroxyvitamin-D.[39] were protective against myopia development. The use of refractive correction in this rural population was minimal possibly due to the lack of penetration of ophthalmic services and/or differences in the perceived need for the use of spectacles in the population.[40] Awareness of the use of sunlight protective gear, especially among outdoor workers, could help in reducing UV-B exposure.

The predictive model using the significant factors of the multivariate logistic regression model showcases SEM as an important factor in predicting VI alongside age and cataract status. Fairly high NPV and low PPV values for each of the three criteria of age, SEM, and cataract indicate that we are 78.8%–94.9% and 41.2%–72.4% confident about the model's negative and positive predictions about VI, respectively [Table 4]. The sensitivity and specificity based on each of the three optimal cut-off points for age, SEM, OSDI, and cataract indicate fair diagnostic accuracy of the variables. This is the first attempt in finding an optimal cut-point value for predicting VI. The indexes were not high probably because of data variability owing to our limited sample size. The AUROC curve values for age and SEM scores demonstrate a fair index of discriminating (diagnostic accuracy) between VI and no VI [Table 4].

The use of ocular protective factors such as sunglass or hats is reported to reduce the amount of UV radiation entering the eye,[41] thus reducing the risk of ocular disease-induced VI. However, the habit of wearing sunglasses or other devices to protect from sunlight was not a common practice in the study population. None of the participants reported wearing protective gear such as turbans, hats, sunglasses, and shields while working in the outdoor sun.

Though we may not be able to match or compare the SEM with other studies due to differences in the SEM tool, we can hypothesize that because those studies were urban population-based,[8,42] the participants were exposed to lower levels of sunlight compared to the fishermen. This was consistent with the higher proportion and odds of VI among fishermen compared to other occupations [Tables 2 and 3]. Nevertheless, there was no difference in the risk of VI based on the gender or education level of the participants. This probably indicates both men and women were equally involved in all occupations with similar education levels.

There are certain limitations of this study as only one village was included in the study setting, and it is difficult to generalize the results for the entire fishing population. Moreover, torch light examination with a +10 D lens to screen cataract might have resulted in a false-positive error by a small percentage. Nonetheless, the examination was

Table 4: Area under the curve, sensitivity, specificity, positive, and negative predictive values for detection of visual impairment

Variable	AUROC curve (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Age					
Criterion 1 ≥ 44.5	0.709 (0.648-0.771)	95.2 (88.1-98.7)	39.6 (32.5-47.0)	41.2 (38.1-44.2)	94.9 (87.5-98.0)
Criterion 2 ≥ 50.5		63.9 (52.6-74.1)	66.3 (59.1-73.0)	45.7 (39.4-52.1)	80.5 (75.3-84.9)
Criterion 3 ≥ 51.0		63.9 (52.6-74.1)	66.3 (59.1-73.0)	45.7 (39.4-52.1)	80.5 (75.3-84.9)
SEM score					
Criterion 1 ≥ 1235.5	0.728 (0.659-0.798)	50.6 (39.4-61.8)	91.4 (86.5-95.0)	72.4 (61.1-81.5)	80.7 (77.0-83.9)
Criterion 2 ≥ 910.0		61.5 (50.1-71.9)	63.1 (55.8-70.0)	42.5 (36.5-48.8)	78.7 (73.3-83.2)
Criterion 3 ≥ 1020.0		61.5 (50.1-71.9)	70.6 (63.5-77.0)	48.1 (41.2-55.1)	80.5 (75.6-84.6)
OSDI score					
Criterion 1 ≥ 23.5	0.652 (0.585-0.719)	81.9 (72.0-89.5)	48.7 (41.3-56.1)	41.5 (37.4-45.7)	85.9 (79.0-90.8)
Criterion 2 ≥ 32.5		60.2 (48.9-70.8)	64.7 (57.4-71.5)	43.1 (36.9-49.6)	78.6 (73.4-83.0)
Criterion 3 ≥ 32.0		69.9 (58.8-79.5)	59.4 (52.0-66.5)	43.3 (37.9-48.8)	81.6 (75.8-86.3)
Cataract (present)	0.653 (0.579-0.726)	53.0 (41.7-64.1)	77.5 (70.9-83.3)	51.2 (42.9-59.4)	78.8 (74.5-85.6)

AUROC curve= Area under the receiver operating characteristic curve; CI=Confidence interval; SEM=Sunlight exposure measurement; OSDI=Ocular Surface Disease Index; PPV=Positive predictive value, NPV=Negative predictive value

performed by a trained optometrist and the findings were confirmed at the base hospital (~90% of participants followed up) by an ophthalmologist. Overall, we tried to address any random error or bias in the data by standardizing the study subject recruitment and data collection. Other limitations include the SEM-Q measuring UV-B only for the past year and not lifetime exposure, underestimation of systemic disease due to a lack of medical check-ups and diagnoses by a medical practitioner, and sample size limitation because of which we could not perform sub-group analysis between the type/grade of ocular disease and the levels of VI with different quintiles of SEM. However, the estimated power for a two-sample comparison of proportions of the study for the presence of VI (83 eyes, 31%) and no VI (187 eyes, 69%) was calculated to be 100% (1.0) using STATA 12.0 (StataCorp). Despite the limitations, we found an association between the two, proving our hypothesis that the SEM has a positive association with VI among fishermen. Although we did not have any control group to compare the SEM of the fishing community, Humayun *et al.*[14] can be a reference who used the same SEM-Q on students, faculty, and staff working at a university. The levels of sun exposure were categorized as 69.5 (± 32) for low, 83.5 (± 29.7) for moderate, and 329 (± 115) for high exposure groups. Most of our study participants had an SEM-Q score starting from moderate and going beyond the high exposure group.

Conclusion

We report a significant direct association of SEM with VI in the coastal Indian fishing community. This association of different levels of VI and SEM needs to be verified with a larger population-based or case–control study. Based on the associated factors, we recommend regular eye examinations and screening for the fishing community. Health awareness and education concerning the deleterious effects of sunlight exposure and the use of protective gear such as sunglasses, and wide-brimmed hats may reduce the risk of ocular morbidity and VI.

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Conflicts of interest

There are no conflicts of interest.

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