Observational Study

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Evaluation of socioeconomic status as a risk factor of pterygium using the Korean National Health and Nutrition Examination Survey 2010 to 2011

A STROBE-compliant article

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Abstract

Pterygium is a common conjunctival disorder. The socioeconomic risk factors of pterygium have not been systematically evaluated in Korea. The study investigated risk factors of pterygium considering socioeconomic status.

Participants were 9839 adults aged 19 to 74 years, who underwent ophthalmic slit-lamp examinations as part of the Korean National Health and Nutrition Examination Survey 2010 to 2011. Pterygium was diagnosed as a growth of fibrovascular tissue over the cornea. The socioeconomic risk factors were analyzed in association with the presence of pterygium. Multiple logistic regression analysis was used to evaluate the odds ratios for differences in socioeconomic status.

The presence of pterygium was associated with diabetes mellitus, hypertension, metabolic syndrome, and sun exposure time (>5 h/d). The blood level of 25-hydroxyvitamin D was higher in the pterygium group than in the control group, but both groups were deficient in 25-hydroxyvitamin D compared with the normal reference level. Pterygium was almost 3 times as frequent among persons who worked outdoors, such as skilled agricultural, forestry, and fishery workers, than among those who worked indoors (odds ratio 3.061, 95% confidence interval 1.946–4.813). Low educational status and longer working hours were also significantly associated with pterygium.

This study used a nationwide population-based survey conducted by the Korean Centers for Disease Control and Prevention to reveal that pterygium is associated with low socioeconomic status. Efforts should be made to reduce the risk of pterygium by changing modifiable risk factors, especially among people with low socioeconomic status.

Abbreviations: CI = confidence interval, KNHANES = Korean National Health and Nutrition Examination Survey, OR = odds ratio, SE = standard error, UV = ultraviolet.

Keywords: epidemiology, health policy, medical statistics, ophthalmology

1. Introduction

Pterygium is a triangular abnormal fibrovascular growth of conjunctival tissue on the cornea. It is a common ocular disease, with an incidence of up to 33% among older people (≥50 years old) in Asia.[1] The prevalence of pterygium in South Korea was reported to be 6.2%, 8.8%, and 8.9% in previous studies.[2–4] Although it usually causes inconsequential cosmetic problems in mild cases, visual loss can occur in severe cases through irregular cornea astigmatism, cornea scarring, and obscuration of the visual axis.[5]

The exact pathogenesis of pterygium is unclear. The prevalence of pterygium varies from 2.8%[6] to 33.0% worldwide.[1]

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Although several risk factors of pterygium have been reported in epidemiologic studies, controversy remains about contributing or predisposing factors. The association of sex and age with the development of pterygium is debatable. Some studies have reported that pterygium is more common in older men. Other epidemiologic studies demonstrated that female subjects had a higher risk of pterygium than male patients in China and Tibet,[1,7] and an Indonesian study found no sex difference.[8] The incidence of pterygium has been reported to be the greatest among people aged 20 to 40 years.[9,10] In a Virgin Island study, people 15 to 25 years of age showed the highest incidence of pterygium.[9]

Among the known risk factors, ultraviolet (UV) radiation has been suggested as the most important factor in the pathogenesis of pterygium. Living in the so-called *pterygium belt* between 37° north and south of the equator is a risk factor of pterygium because UV radiation is more common there. Protecting the eyes from UV radiation by wearing sunglasses can decrease the development of pterygium. In a Barbados eye study, pterygium was twice as frequent in people who worked outdoors than in those who worked indoors; however, it was only one-fifth as likely in people who always wore sunglasses outdoors.[11] Korea is in the pterygium belt, and its incidence of pterygium implies that a domestic policy is needed to control and prevent pterygium.

Recently, several epidemiologic studies of pterygium have been reported in Korean populations. Pyo et al[4] reported that, in Korea, pterygium is related to older age, males, rural residence, lower level of education, and a nonsmoking lifestyle. Whether ophthalmic diseases are associated with vitamin D insufficiency has been controversial. Vitamin D has generally been considered to have protective effects against chronic inflammatory diseases through its anti-inflammatory and antioxidative actions.[12] Several studies have suggested that vitamin D is inversely associated with ophthalmic diseases such as myopia,[13] age-related macular degeneration,[14] diabetic retinopathy,[15] and cataracts. However, Bonakdaran and Shoeibi[16] reported that vitamin D insufficiency was not related to risk factors of diabetic retinopathy. Furthermore, Jee et al[17] reported that high blood levels of 25-hydroxyvitamin D were positively associated with pterygium. Considering the extra sun exposure in outdoor workers, deficient levels of 25-hydroxyvitamin D in outdoor workers seems unlikely.

The association between pterygium and socioeconomic status has not previously been systematically evaluated. This study aims to examine that association among adults in South Korea using survey data obtained from the Korean National Health and Nutrition Examination Survey (KNHANES) V (2010–2011).

2. Materials and methods

2.1. Study population and data collection

We used data from the KNHANES V-1 and 2, conducted from January 2010 to December 2011 by the Korean Centers for Disease Control and Prevention. The study design followed the tenets of the Declaration of Helsinki for biomedical research. The KNHANES was conducted after approval from the Institutional Review Board of the Korean Centers for Disease Control and Prevention (IRB No. 2010–02CON-21-C, 2011–02CON-06-C). The KNHANES is a nationwide, population-based, cross-sectional health examination and survey conducted by the Divisions of Chronic Disease Surveillance of the Korean Centers for Disease Control and Prevention in the Ministry of Health and Welfare to examine the health, physical, and nutritional status of the general population of South Korea. It is performed using a rolling sampling design that involves a complex, stratified, multistage, probability cluster survey of a representative sample of the civilian population of South Korea. For the fifth KNHANES, a total of 192 sampling units were randomly selected from primary sampling units encompassing the target population. Each sampling unit contained 20 households, with a total of 3800 households surveyed by 4 survey teams. The survey consisted of 3 components: a health interview, a nutrition interview, and a health examination.

All questionnaires were administered by physicians or trained interviewers in person at the participants' homes. Subjects had the right to refuse participation, according to the National Health Enhancement Act. All participants who agreed to take part provided written informed consent. The Korean Centers for Disease Control and Prevention obtained participant agreement to use blood samples collected during the health interview survey for further research.

2.2. Risk factor assessment by questionnaire interview

Collected data included information such as marital status, education, occupation, and lifestyle. Education level was categorized into 4 groups: elementary school or less, middle school, high school, and college/university or more. The revised household income was calculated from the total household income divided by family size. A participant was considered to be a drinker if s/he drank more than once per month during the past year. Smoking status was divided into current smoker and nonsmoker. Sunlight exposure time was evaluated by asking whether subjects have sunlight exposure of more than 5 h/d or not. Occupations were categorized into 10 groups: 1, supervisors and general managers; 2, professionals and related workers; 3, clerks; 4, service workers; 5, sales workers; 6, skilled agricultural and fishery workers; 7, craft and related trade workers; 8, equipment, machine operators, and assembly workers; 9, elementary workers (construction and mining); 10, unemployed. Working hours per week was divided into 4 groups: 1, no work; 2, 1 to 40 h/wk; 3, 41 to 60 h/wk; 4, more than 61 hours. Household income was divided into quartiles. Education status was divided into 4 groups: 1, elementary school ($\leq$6); 2, middle school (7–9); 3, high school (10–12); 4, university or more ($\geq$13).

2.3. Anthropometry and laboratory measurements

Trained medical staff performed the physical examinations following standardized procedures. Body weight was measured to the nearest 0.1 kg with subjects wearing light indoor clothing, and height was measured to the nearest 0.1 cm without shoes. Body mass index (BMI) was calculated as the ratio of weight in kilograms to height in meters squared. Blood pressure was measured twice on the right arm at 5-minute intervals using a standard mercury sphygmomanometer (Baumanometer; Baum, Copiague, NY) and recorded as an averaged value. After overnight fasting, blood samples were obtained from participants' antecubital veins. Levels of total cholesterol, glucose, and triglycerides were measured enzymatically using a Hitachi Automatic Analyzer 7600 (Hitachi High-Technologies Co., Tokyo, Japan). The analysis of blood 25-hydroxyvitamin D level was obtained by a radioimmunoassay kit (DiaSorin Inc., Stillwater, MN) using a gamma counter (1470 Wizard, Perkin-Elmer, Finland), followed by the standardized vitamin D procedure.[18] The measurement of 25-hydroxyvitamin D had a detection limit of 1.2 ng/mL. Interassay coefficients for variation were 1.9% to 6.1% for KNHANES 2010 to 2011. Health-related lifestyle information was obtained from a self-reported questionnaire during the interview portion of each survey. Diabetes mellitus was considered to be present among subjects taking antiglycemic medication or a fasting blood glucose level of more than 126 mg/dL. Hypertension was considered to be present among subjects taking antihypertensive medication or having a systolic and diastolic blood pressure of more than 140 and 90 mm Hg, respectively. Hypercholesterolemia was defined as total cholesterol over 200 mg/dL.

2.4. Definition of metabolic syndrome

Metabolic syndrome was defined using guidelines from the National Cholesterol Education Program Adult Treatment panel III.[19] In detail, subjects who met at least 3 of the following criteria were considered to have metabolic syndrome: blood pressure ≥130/85 mm Hg or antihypertensive drug use; triglycerides ≥150 mg/dL or taking triglyceride-lowering medications; high-density lipoprotein (HDL) concentration ≤40 mg/dL in men and ≤50 mg/dL in women or taking HDL-raising drugs; waist circumference ≥90 cm in men and ≥80 cm in women; and fasting blood glucose ≥100 mg/dL or use of antidiabetic medication.

2.5. Examination methods for anterior segment of the eye

Ophthalmologists conducted structured slit-lamp examinations (Haag-Streit model BQ-900; Haag-Streit AG, Koeniz, Switzerland) to test for diseases in the anterior segment of the eye such as pterygium and cataract. Standardized Lens Opacities Classification System III photographs were used to assess cataract. Pterygium was defined as a radially oriented fibrovascular lesion crossing the nasal or temporal limbus. A subject was defined as positive for pterygium if at least 1 pterygium lesion was confirmed in either eye.

2.6. Statistical analysis

All continuous variables are presented as means and standard deviations (SDs). All categorical variables are presented as percentage and standard error (SE). To compare patients' demographic characteristics, we used Student *t* tests or chi-square tests. The odds ratios (ORs) and corresponding 95% confidence intervals (CIs) for the risk of pterygium were calculated using weighted multivariate logistic regression analyses. To evaluate confounding effects, we calculated 2 ORs: adjusted for age and sex (model 1) and adjusted for age, sex, BMI, smoking, alcohol drinking, regular exercise, vitamin D, and sun exposure (model 2). All analyses were performed using SAS (Statistical Analysis System, Version 9.3, SAS Institute Inc., Cary, NC). All statistical tests were 2-tailed, and statistical significance was set at $P<0.05$.

3. Results

3.1. Demographics

We obtained our data from the KNHANES 2010 to 2011, which enrolled 17,476 individuals. Of those, we excluded 1681 participants aged <18 or >75 years, 4406 participants without an ophthalmologic examination, and 1550 participants without blood 25-hydroxyvitamin D level. Thus, we used data from 9839 subjects in the final analysis (Fig. 1), 586 of whom had pterygium in at least 1 eye. The incidence of pterygium was 5.96% in this study. The characteristics of the study participants are summarized in Table 1. The mean age of the control group (42.9 ± 0.3 years) was significantly lower than that of the pterygium group (59 ± 0.5 years; $P<0.001$). There was no sex difference between the pterygium group and the control group.

3.2. Assessment of life habit investigation

The pterygium group had a significantly lower percentage of current smokers ($P=0.0232$) and current alcohol drinkers ($P=0.006$). The pterygium group was also significantly different from the control group in exercise status and habitat. Participants in the pterygium group exercised more than those in the control group, and more participants in the pterygium group lived in suburban areas. The participants in the pterygium group thus had better life habits than those in the no-pterygium group.

3.3. Risk factor assessments for metabolic syndrome and vitamin D

The pterygium group had a significantly higher percentage of comorbidities, such as diabetes mellitus (13.3 ± 1.9% vs 7.7 ± 0.4%;

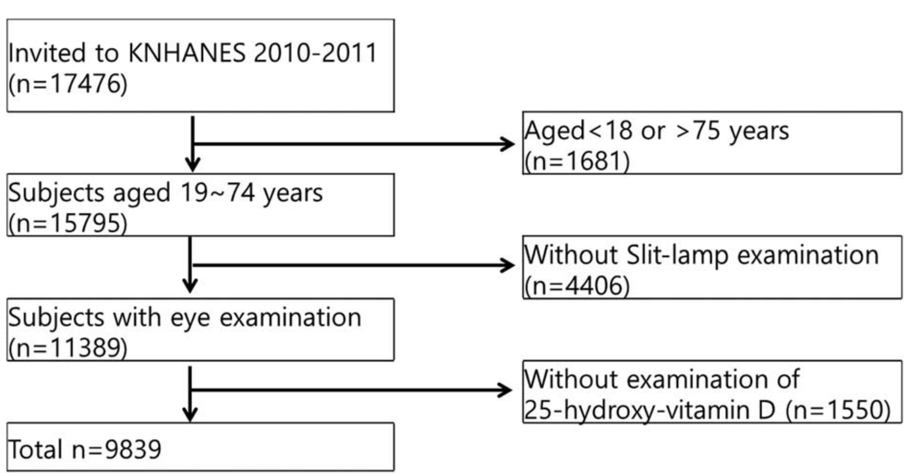

Figure 1. Flow diagram showing the selection of study participants.

Table 1

Characteristics of the study population.

	No pterygium (n=9253)	Pterygium (n=586)	P
Sex (male, %)	49.5±0.5	48.5±2.5	0.7032
Age, y	42.9±0.3	59.0±0.5	<0.0001
Present smoking, %	24.7±0.6	19.7±2.0	0.0232
Drinking (>1 time/mo, %)	61.2±0.7	52.9±2.5	0.0006
Regular exercise (>3 times/wk, %)	20.8±0.6	26.3±2.2	0.006
Habitat (urban, %)	81.4±2.1	56.2±4.6	<0.0001
Spouse, %	80.1±1.0	83.0±1.9	0.2134
Metabolic syndrome, %	23.5±0.5	42.4±2.8	<0.0001
Diabetes, %	7.7±0.4	13.3±1.9	0.0004
Hypertension, %	24.4±0.6	44.5±2.6	<0.0001
Body mass index, kg/m^2	23.6±0.1	24.0±0.2	0.0456
Waist circumference, cm	80.9±0.2	83.8±0.5	<0.0001
Stress, %	28.5±0.6	23.9±2.1	0.0505
Cataract, %	19.5±0.9	50.8±3.2	<0.0001
Sun exposure (>5 h/d, %)	13.0±0.8	30.3±3.1	<0.0001
25-hydroxyvitamin D, ng/mL	17.3±0.2	19.9±0.4	<0.0001

$P=0.0004$), hypertension (44.5±2.6% vs 24.4±0.6%; $P<0.0001$), and metabolic syndrome (42.4±2.8% vs 23.5±0.5%; $P<0.0001$). The prevalence of cataract in the pterygium group (50.8±3.2%) was significantly higher than in the control group (19.5±0.9%; $P<0.0001$). Sun exposure of more than 5 hours a day was higher in the pterygium group (30.3±3.1% vs 13.0±0.8%; $P<0.0001$). Blood level of 25-hydroxyvitamin D was significantly higher in the pterygium group (19.9±0.4 vs 17.3±0.2 ng/mL; $P<0.0001$); however, the level of 25-hydroxyvitamin D was below the normal range in both the pterygium group and the control group.

3.4. Association between socioeconomic status and pterygium

The incidence of pterygium by occupation is shown in Table 2. The professionals and related workers group showed the lowest prevalence of pterygium (0.66±0.22%), followed by the supervisors and general manager group (1.49±1.20%). The highest prevalence of pterygium was observed in skilled agricultural and fishery workers (16.52±1.51%), followed by elementary workers (8.63±1.16%; Table 2).

We next performed weighted logistic regression analyses to examine whether socioeconomic status is associated with prevalence of pterygium (Table 3). For this purpose, we combined the occupational groups into 4 groups: 1, unemployed; 2, nonmanual workers (supervisors and general managers, professionals and related workers, and clerks); 3, service worker and sales workers; 4, manual workers (skilled agricultural and fishery workers, craft and related trades workers, equipment, machine operating and assembling workers, and elementary workers). The age and sex-adjusted OR (95% CI) of pterygium was significantly higher risk in the service worker and sales worker group (OR 1.849, 95% CI 1.101–3.103) and the manual worker group (OR 3.292, 95% CI 2.1–5.16) than among nonmanual workers in model 1. After fully adjusting for additional covariates (age, sex, BMI, exercise, smoking, drinking status, serum vitamin D levels, and sun exposure), the OR (95% CI) was 1.888 (1.076–3.31) in the service worker and sales worker group, and 3.061 (1.946–4.813) in the manual worker group (Table 3).

Working hours per week was also significantly associated with the prevalence of pterygium. The group working more than 60 h/wk had a significantly higher risk of pterygium (OR 2.325, 95% CI 1.663–3.25 in model 1; and OR 1.958, 95% CI 1.379–2.779 in model 2) than people with no work. The OR of pterygium decreased as household income increased ($P<0.0001$). The highest quartile of household income was associated with the lowest prevalence of pterygium. Educational status was significantly associated with pterygium: people who attended university had a significantly lower risk of pterygium than people who graduated only from elementary school (OR 0.179, 95% CI 0.104–0.306 in model 1; OR 0.204, 95% CI 0.120–0.347 in model 2; Table 3).

Table 2

Prevalence of pterygium in each occupation group (mean± standard error).

Occupation	Pterygium, %
Supervisors and general managers	1.49±1.20
Professionals and related workers	0.66±0.22
Clerks	1.67±0.44
Service workers	2.18±0.72
Sales workers	3.87±0.89
Skilled agricultural, forestry, and fishery workers	16.52±1.51
Craft and related trades workers	4.97±1.21
Equipment or machine operating and assembling workers	3.77±0.92
Elementary workers (construction and mining)	8.64±1.16
Unemployed	4.29±0.41
	$P<0.0001$

4. Discussion

In this study, we showed that socioeconomic status is an independent risk factor of pterygium after adjustment for other risk factors in the KNHANES database: sun exposure, blood 25-hydroxyvitamin D level, smoking, drinking status, age, sex, and BMI. The KNHANES survey provides objective, standardized data to establish, develop, monitor, and evaluate the national health programs and policies for diseases common in South Korea.

Several hypotheses have been suggested for the formation of pterygium. Among them, excessive sun exposure is considered to be the leading cause of pterygium. Other causes include chronic infection and thrombosis of conjunctival veins,[10,20] invasion of cornea by subconjunctival fibroblasts,[21] the presence of pterygium angiogenesis factors,[22] and immunologic dysregulation of lymphocyte infiltration.[23] Based on previous studies, pterygium is considered a proliferative disorder, not a degenerative process that occurs with age. Finding risk factors associated with pterygium through a systematic epidemiologic study could be useful for its prevention.

We observed higher comorbidities of hypertension, diabetes mellitus, and metabolic syndrome in the pterygium group than in the control group. The higher incidence of metabolic diseases in the pterygium group might be explained by the older age of the pterygium group. Another explanation could be a positive correlation between metabolic disease and pterygium, which was demonstrated in previous studies. Ang et al[24] reported that high blood pressure and high cholesterol level were associated with the development of pterygium. Another study reported a high expression of low-density lipoprotein (LDL) receptors in pterygium tissues.[25] Although those results cannot be interpreted as a cause-and-effect relationship, this study also supports

Table 3

Association between socioeconomic status and pterygium.

	Pterygium (%)			OR (95% CI)	
	No	Yes	P	Model 1	Model 2
Occupation			<0.0001		
Unemployed	33.2±0.7	30.9±2.6		1.51 (0.969, 2.353)	1.544 (0.996, 2.394)
Non-manual workers*	25.3±0.7	5.9±1.1		1 (ref.)	1 (ref.)
Service and sales workers	14.8±0.6	9.8±1.9		1.849 (1.101, 3.103)	1.888 (1.076, 3.31)
Manual workers†	26.8±1.0	53.4±3.1		3.292 (2.1, 5.16)	3.061 (1.946, 4.813)
Working hours per week			0.0005		
None	24.0±0.6	25.0±2.2		1 (ref.)	1 (ref.)
1–40	32.9±0.6	37.4±2.4		1.87 (1.448, 2.414)	1.711 (1.315, 2.226)
41–60	31.9±0.6	22.8±2.1		1.611 (1.199, 2.166)	1.412 (1.039, 1.92)
61+	11.1±0.5	14.8±1.8		2.325 (1.663, 3.25)	1.958 (1.379, 2.779)
Household income			<0.0001		
Q1	13.6±0.6	28.8±2.2		1 (ref.)	1 (ref.)
Q2	28±0.9	28.6±2.5		1.08 (0.797, 1.464)	1.06 (0.776, 1.447)
Q3	30.6±0.9	23.2±2.1		1.069 (0.797, 1.434)	1.097 (0.814, 1.479)
Q4	27.9±1.0	19.4±2.4		0.949 (0.666, 1.351)	0.921 (0.641, 1.324)
Education			<0.0001		
Elementary: ≤6	14.6±0.7	49.0±2.6		1 (ref.)	1 (ref.)
Middle: 7–9	10.3±0.4	20.5±2.2		0.938 (0.69, 1.274)	0.966 (0.712, 1.311)
High: 10–12	40.1±0.8	25.2±2.5		0.602 (0.442, 0.821)	0.621 (0.449, 0.857)
University: ≥13	35.0±0.9	5.3±1.2		0.179 (0.104, 0.306)	0.204 (0.12, 0.347)

Model 2: adjusted for sex, age, BMI, smoking, alcohol drinking, regular exercise, vitamin D, and sun exposure.
Model 1: adjusted for sex and age.
CI=confidence interval, OR=odds ratio.
* Nonmanual workers include supervisors and general managers, professionals and related workers, and clerks.
† Manual workers include skilled agricultural and fishery workers, craft and related trades workers, equipment or machine operating and assembling workers, and elementary workers.

the association between metabolic diseases and pterygium. The affliction might result from long-term complications in metabolic syndrome that induce microangiopathy and fibrosis. More studies will be needed to evaluate the effects of metabolic syndrome on the development of pterygium.

The presence of cataract was significantly higher in the pterygium group than in the control group. The older age of the pterygium group might explain the higher comorbidity of cataract. Also, UV radiation is a common risk factor of both cataract and pterygium. However, a previous Barbados eye study showed no association between lens opacities and pterygium.[11] The association between cataract and pterygium needs to be elucidated in further epidemiologic studies.

In this study, the rates of current smoking and drinking were significantly lower in the pterygium group. This result accords with those of previous studies, which found that smoking protected against pterygium.[4,6,8,11] The mechanism of the beneficial effect of smoking is not understood and needs to be elucidated.

The association between vitamin D and pterygium was recently reported in a Korean population.[17] Jee et al reported a positive association between blood 25-hydroxyvitamin D level and pterygium even after controlling for sun exposure time. Although they adjusted for sun exposure time, the authors hypothesized that the residual confounding factor of sun exposure was strong and affected the level vitamin D.[17] However, in the previous study, the levels of blood 25-hydroxyvitamin D were insufficient in both the pterygium and control groups. Any comparison between 2 groups that are both deficient in vitamin D could cause misinterpretation of the association between pterygium and vitamin D. In our study also, although the levels of 25-hydroxyvitamin D in the pterygium group were higher than those in the no-pterygium group, both groups were vitamin D-deficient according to the reference range (20–100 ng/mL). Considering that the pterygium group was significantly associated with outdoor occupations and longer sun exposure times, their 25-hydroxyvitamin D levels would be expected to be higher than the reference level. A low level of vitamin D is also considered to be a risk factor of metabolic syndrome, such as insulin resistance, obesity, and diabetes mellitus.[26] In the present study, participants in the pterygium group had a significantly higher rate of metabolic syndrome than the control group. The importance of vitamin D level in the development of pterygium among outdoor workers with metabolic syndrome should be elucidated in future studies.

Occupational status was significantly associated with pterygium. People working in outdoor occupations, especially skilled agricultural, forestry, and fishery workers, showed a high prevalence of pterygium, up to 16.5±1.5% (Table 2). We also found a significant difference of habitat in the pterygium group (56.2% living in an urban area). People working more than 60 h/wk had the highest risk of pterygium. Prolonged sun exposure among outdoor workers can be a strong risk factor of pterygium.

A higher educational background was negatively associated with pterygium. Previous studies have demonstrated similar results.[11,27] People with a low level of education in rural areas often work in outdoor occupations. Although lower economic status carried a higher risk of pterygium, that OR does not decrease with statistical significance with an increase in household income.

The present study has both strengths and limitations. Its major strength is the large number of participants drawn from a nationwide cross-sectional study with stratified, multiclustered sampling. A limitation of this study is that we did not consider seasonal variations. Occupational exposure to allergens, noxious chemicals, and irritants such as wind, dirt, and air pollution is known to be associated with pterygium, but we did not consider it in this study. In addition, we did not perform any further analysis of 25-hydroxyvitamin D level to determine the role of vitamin D deficiency in the development of pterygium in each occupational group. Lastly, this study design is cross-sectional and therefore cannot support allegations of causality.

Our systematic study revealed associations between socioeconomic status and pterygium to help identify potentially modifiable risk factors and educate people in certain occupations who have those risk factors, such as metabolic syndrome, vitamin D insufficiency, and sun exposure. The present study suggests the importance of such educational interventions among people with low socioeconomic status. Efforts should be made to reduce the risk of pterygium by controlling metabolic syndrome and vitamin D deficiency, and encouraging people with low socioeconomic status to wear sunglasses.

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