Clinical Ophthalmology

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Prevalence of Solar Keratopathy, Pterygium and Cataract in the Islands of Northern Red Sea Zone, Eritrea: Cross-Sectional Study, 2021

Berhe Tesfai[1]
Samuel Kebede[1]
Fitsum Kibreab[2]
Kahsay Fessehatsion[3]
Sium Asmelash[4]
Yohannes Guelay[4]

[1]Ministry of Health, Northern Red Sea Zone, Massawa Hospital, Massawa, Eritrea; [2]Ministry of Health, Health Research and Resources Center Division, Asmara, Eritrea; [3]Ophthalmologist, Ministry of Health, Berhan Ayni National Referral Hospital, Asmara, Eritrea; [4]Ministry of Health, Medical Service Division, Northern Red Sea Zone, Massawa, Eritrea

Background: Everybody is exposed to ultraviolet radiation and the natural source of ultraviolet radiation is sunlight. The objective of this study was to determine the prevalence of solar keratopathy, pterygium and cataract and further to evaluate other factors that cause blindness to the inhabitants of the Northern Red Sea Zone islands of Eritrea.

Methods: It was a community-based cross-sectional study of all people aged 40 years and above, with a census sampling method. Study participants were screened for presence of solar keratopathy and other ocular diseases, and data were collected by a checklist from March 20 to April 20, 2021. Data were entered on an Excel sheet and transported to SPSS version 21. Results were presented with frequencies and percentages and chi-squared bivariable analysis was carried. *P*-value less than 0.05 was considered significant.

Results: The prevalence of solar keratopathy and cataract was 19.6% and 15.8%, respectively. Pterygium (40%) and pinguecula (32.1%) were also commonly found in the community. Participants aged 70 years and above ($P<0.001$), fishermen ($P<0.001$), housewife ($P<0.001$) and females ($P<0.001$) had a higher rate of blindness. The prevalence of solar keratopathy was higher with increased age and work experience ($P<0.001$). Fishermen and housewives had higher rates of solar keratopathy (44.6%) and cataract (30.2%), respectively, ($P<0.001$). Respondents aged 40 to 49 years had the highest prevalence of pterygium (44.1%) and pinguecula (39.1%) ($P<0.001$).

Conclusion: The prevalence of solar keratopathy, cataract, pterygium and pinguecula was high in the community. Fishermen with increased work experience were having the highest prevalence of blindness and solar keratopathy. Age, occupation, work experience, sex, vision problems and history of eye operations had showed significant association with visual acuity, solar keratopathy, cataract, pterygium, and pinguecula. Community awareness about the preventive aspects of these diseases is highly recommended.

Keywords: solar keratopathy, pterygium, cataract, pinguecula, prevalence, Dahlak

Introduction

The human eye is exposed daily to ultraviolet radiation (UVR). In the eye, UVR is strongly associated with the development of pterygium, photokeratitis, climatic droplet keratopathy, and cataracts.[1] Photobiological effects upon the human retina, cornea and lens are highly dependent on the optical exposure geometry as well as spectral characteristics of the exposure.[2]

The effect of UVR intensity on the eye can be linked to solar elevation, time of day, latitude, altitude, longitudinal changes, climate, ground reflection, and geographic directions.[1]

Correspondence: Berhe Tesfai
Massawa Hospital, Northern Red-Sea Zone, Ministry of Health, Massawa, Eritrea
Email berhetesfai04@gmail.com

Received: 28 May 2021
Accepted: 6 July 2021
Published: 13 July 2021

Although UVR peaks around noon, UVR reaching the eyes depends mainly on solar elevation. Ocular damage due to UVR can occur in the early morning and afternoon because of solar elevation in relation to the eyes at those times.[3] Solar keratopathy or climatic droplet keratopathy (CDK) is an acquired and potentially handicapping degenerative disease of the cornea that is highly prevalent in certain rural communities around the world. It predominantly affects males over their forties.[4]

Constant intense winds, lack of shade, low humidity, and UVR exposure in hot as well as cold arid climates are the more common environmental factors observed in areas with high prevalence of the disease.[5] Clinical presentation and severity of lesions may vary significantly according to a particular region and its climate conditions. More severe forms of CDK have been described in regions with high heat and dryness, such as the Red Sea islands.[4] The keratopathy in Labrador and Northern Newfoundland resembles the Dahlak Islands in the Red Sea, Somalia, Eritrea, and Saudi Arabia.[6]

The presence of an unusual corneal disease in Italian Somaliland and the Dahlak Islands was reported. Coinciding with observations linking the Eritrean cases with those in Saudi Arabia, we carried out an intensive study of the condition.[7]

From clinical reports and observational point of view, solar keratopathy and pterygium seems very common in the Dahlak Islands mainly due to the reason that people are exposed to some risk factors that can contribute to the development of the disease process. It is not uncommon to find many old people who lost their sight in the Dahlak Islands which may be due to this problem and other causes. However, there is no updated scientific evidence that defines the cause, burden, and magnitude of this disease. The aim of this study was to determine the prevalence of solar keratopathy, pterygium, and cataract in the Dahlak and nearby Islands of Eritrea. And also to measure the association between solar keratopathy, pterygium, and cataract and selected variables (age, sex, occupation, use of sunglasses, hat use).

The evidence obtained from this study will fill the knowledge gap and will provide recommendations to the programs that targeted the preventive and curative approaches against the disease. Also, the result will assist and guide the development and advocacy of sustained behavioral changes that can promote good eye health practices.

Methods

Study Design

It was a community-based cross-sectional study. All residents of the islands aged above 40 years were enrolled in this study as the number of inhabitants was not too large. Visual acuity was tested with a standard chart, usually an illiterate E chart. Each patient was examined with a loupe, light torch, and ophthalmoscope for signs of solar keratopathy, and cataract. Besides, the extent of pterygium, pinguecula, and other ocular problems was recorded.

Study Setting and Population Size

The study was conducted in the Dahlak and nearby islands of Northern Red Sea zone of Eritrea. This includes five administrative areas of the Dahlak subzone: Nora, Jemhile, Dhul, Derbushet, and Dessie. Naval officers who had close contact with the sea, living in the islands of Nakura, and Harat and, peninsula of Marsa Fatna and Marsa Gulbub were also included in the study.

The study area had a population of about 3456 and there were estimated to be about 1150 of those aged above 40 years. (Source: Dahlak subzone administration; December 2018). These who were available during the screening and data collection time were the study population for this research. In this area, there is one health center, two health stations and naval force health center. There is no vision center or other eye care centers in these areas and people are referred to the zonal eye clinic which is located in Massawa Hospital.

Study Population

All people aged 40 years and above were eligible for this study. Individuals who were younger than 40 years were excluded from the survey as they had less exposure to the possible risk factors for the disease processes.

Data Collection

Study participants were examined and screened for the presence of solar keratopathy and other ocular diseases by an experienced ophthalmic officers and ophthalmologists. Examination results were recorded using a purposely designed clinical check list. Besides the sociodemographic characteristics of the respondents were also collected using a similar tool during the screening time. Data were gathered from March 20 to April 20, 2021.

Data Analysis and Interpretation

Data were entered into an Excel spreadsheet and transported to SPSS version 21. Prior to analysis; data were cleaned, checked, and rechecked in order to remove errors. To identify any detecting errors and discrepancies; frequency tables were applied for all questions section by section. Missed information was also retrieved by looking at the original filled questionnaire. Results were presented with frequency, tables, and percentages. Furthermore; chi-squared test was used to assess the association between keratopathy and selected demographic variables. *P*-values less than 0.05 were considered significant.

Definition of Variables

Respondents were grouped as blind, normal, and poor vision with visual acuity of no light perception, 6/6–6/12, and >6/18, respectively. Study participants who had one eye pathology were considered as having the disease process.

Ethical Consideration

Ethical approval was obtained from Ministry of Health Research Review and Ethical Approval Committee of Eritrea, and Zonal Ministry of Health office and sub-zonal administration. Autonomy of study participants was respected through informed and continuing consent; and identifying and valuing an individual's right to anonymity, confidentiality, and privacy. All participants were informed about the nature and purpose of the study clearly. Participants' consent was obtained in written form and the study was conducted in accordance with the Declaration of Helsinki. Respecting of cultural values and norms including gender issues was one of the mandated tasks of this research. Respondents had the right to withdraw from the study at any time and that this did not affect their care in any way. Moreover, in order to keep their emotional and mental well-being, they were left free to not answer any question that made them uncomfortable.

Results

A total of 787 participants were enrolled in the study with 51% of them aged 40 to 49 years. Most of them had above 14 years work experience and the use of sunglasses and hat was minimal. Over half of the respondents had self-reported vision problems and one tenth of them had history of previous eye operation. The prevalence of solar keratopathy and cataract was 19.6% and 15.8% respectively. Pterygium and pinguecula were also commonly found with 40% and 32.1%, respectively. A very few participants had corneal staphyloma and corneal opacity due to trauma (Table 1).

Association of Background of Respondents with Their Visual Acuity

Study participants aged above 70 years and females had higher rate of blindness compared with their counterparts ($P<0.001$). Fishermen and housewives had the highest rate of poor vision and blindness and their level of blindness had increased with work experience ($P<0.001$). Respondents who used sunglasses and hat were having a lower rate of blindness compared to these who did not use them. About half of those who self-reported vision problems were blind (22.2%) and with impaired vision (36.0%) ($P<0.001$). Furthermore, about half of the respondents who had prior history of eye operation were blind (48.4%), and had poor vision (44.1%) ($P<0.001$) (Table 2).

Association of Background of Study Participants with Solar Keratopathy and Cataract

The prevalence of solar keratopathy and cataract had showed increments with age ($P<0.001$). Fishermen had a higher rate of solar keratopathy (44.6%) whereas cataract was more prevalent among housewives (30.2%), $P<0.001$. The prevalence of solar keratopathy showed increase with increased work experience, and 28.4% of the respondents with self-reported vision problems had solar keratopathy ($P<0.001$). Of the respondents who had priornhistory of eye operation, 46.2% and 36.6% had solar keratopathy and cataract, respectively (Table 3).

Association of Respondent's Background with Pterygium and Pinguecula

The prevalence of pterygium and pinguecula was 40% and 32.1% respectively. Respondents aged 40 to 49 years had the highest prevalence of pterygium (44.1%) and pinguecula (39.1%) ($P<0.001$). Study participants from the naval force had a higher rate of pterygium (44.7%, $P<0.001$) and pinguecula (38.1%, $P<0.004$) compared to the fishermen and housewives. Respondents with work experience between 15 and 24 years and 6 and 14 years had the highest prevalence of pterygium (46.1%) and pinguecula (49.1%), respectively, $P<0.001$. About half of these who

Table 1 Distribution of Respondents by Selected Characteristics

Variables	Frequency (N)	Percent (%)
Age of respondents (years)		
40–49	399	50.7
50–59	202	25.7
60–69	101	12.8
70 and above	85	10.8
Sex		
Female	205	26.0
Male	582	74.0
Occupation		
Housewife	205	26.0
Fisherman	251	31.9
Navy	331	42.1
Duration of work (years)		
6–14	55	7.0
15–24	232	29.5
25–34	151	19.2
35–44	103	13.1
45 and above	41	5.2
Use of sunglass		
Yes	128	16.3
No	659	83.7
Regular use of hat		
No	767	97.5
Yes	20	2.5
Do you have vision problems?		
No	332	42.2
Yes	455	57.8
History of eye operation		
Yes	93	11.8
No	694	88.2
History of eye trauma		
No	767	97.5
Yes	20	2.5
Visual acuity right eye		
Blind	111	14.1
Normal	458	58.2
Poor	218	27.7
Visual acuity left eye		
Blind	110	14.0
Normal	444	56.4
Poor	233	29.6
Solar keratopathy		
No	633	80.4
Yes	154	19.6
Corneal opacity due to trauma		
No	775	98.5
Yes	12	1.5
Corneal stadphyloma		
No	777	98.7
Yes	10	1.3
Corneal opacity due to surgery		
No	783	99.5
Yes	4	0.5
Cataract		
No	663	84.2
Yes	124	15.8
Pterygium		
No	472	60.0
Yes	315	40.0
Pseudo pterygium		
No	735	93.4
Yes	52	6.6
Pinguecula		
No	534	67.9
Yes	253	32.1
Total	787	100.0

did not complain of vision problems had pterygium (47.6%) and pinguecula (41.6%), respectively (P<0.001). Besides; study participants who had no previous history of eye operation had pterygium (41.6%, P<0.011) and pinguecula (35.0%, P<0.001), respectively (Table 4).

Discussion

Protecting the sight of the community is fundamental and indispensable. Light is at a maximum in the Red Sea territory, and the prevalence of climatic droplet keratopathy, conjunctival spheroids, and pinguecula are high at the Red Sea. This anim of this study was to determine the prevalence of solar keratopathy, pterygium and other causes of blindness in the inhabitants of the islands of Northern Red Sea zone.

The general prevalence of solar keratopathy was 19.6% and it had increased with increased age and work experience. Excluding the naval force participants, about 33.8% of the community in the Dahlak islands had solar keratopathy, and

Table 2 Association of Background of Respondents with Their Visual Acuity

Variables	Visual Acuity Left Eye			*P*-value
	Blind N (%)	Normal N (%)	Poor N (%)	
Age of respondents (years)				
40–49	9 (2.3)	322 (80.7)	68 (17.0)	<0.001
50–59	20 (9.9)	102 (50.5)	80 (39.6)	
60–69	28 (27.7)	18 (17.8)	55 (54.5)	
70 and above	53 (62.4)	2 (2.4)	30 (35.3)	
Sex				
Female	52 (25.4)	69 (33.7)	84 (41.0)	<0.001
Male	58 (10.0)	375 (64.4)	149 (25.6)	
Occupation				
Housewife	52 (25.4)	69 (33.7)	84 (41.0)	<0.001
Fisherman	57 (22.7)	93 (37.1)	101 (40.2)	
Navy	1 (0.3)	282 (85.2)	48 (14.5)	
Duration of work (years)				
6–14	1 (1.8)	49 (89.1)	5 (9.1)	<0.001
15–24	1 (0.4)	194 (83.6)	37 (15.9)	
25–34	7 (4.6)	98 (64.9)	46 (30.5)	
35–44	28 (27.2)	31 (30.1)	44 (42.7)	
45 and above	21 (51.2)	3 (7.3)	17 (41.5)	
Use of sunglasses				
Yes	7 (5.5)	85 (66.4)	36 (28.1)	0.005
No	103 (15.6)	359 (54.5)	197 (29.9)	
Regular use of hat				
No	110 (14.3)	427 (55.7)	230 (30.0)	0.026
Yes	0 (0.0)	17 (85.0)	3 (15.0)	
Do you have vision problems?				
No	9 (2.7)	254 (76.5)	69 (20.8)	<0.001
Yes	101 (22.2)	190 (41.8)	164 (36.0)	
History of eye operation				
Yes	45 (48.4)	7 (7.5)	41 (44.1)	<0.001
No	65 (9.4)	437 (63.0)	192 (27.7)	
History of eye trauma				
No	108 (14.1)	431 (56.2)	228 (29.7)	0.724
Yes	2 (10.0)	13 (65.0)	5 (25.0)	
Total	110 (14.0)	444 (56.4)	233 (29.6)	

48.1% and 81.2% of them were blind and with impaired vision, respectively. Previously conducted research showed a very high prevalence of Bietti's corneal degeneration (solar keratopathy) in 45.7% of the males examined and in 42% of the females was reported in the Dahlak islands.[7] Another study in the Japanese series reported that conjunctival spheroid degeneration was noticed in 31%[8] and was common in the Red Sea region.[9]

This was lower than the previously conducted research in the same area, but the prevalence in the community of Dahlak was almost similar. As there were no cases with solar keratopathy from the naval force, the number

Table 3 Association of Background of Study Participants with Solar Keratopathy and Cataract

Variables	Solar Keratopathy		*P*-value	Cataract		*P*-value
	No N (%)	Yes N (%)		No N (%)	Yes N (%)	
Age (years)						
40–49	383 (96.0)	16 (4.0)	<0.001	378 (94.7)	21 (5.3)	<0.001
50–59	168 (83.2)	34 (16.8)		166 (82.2)	36 (17.8)	
60–69	55 (54.5)	46 (45.5)		60 (59.4)	41 (40.6)	
70 and above	27 (31.8)	58 (68.2)		59 (69.4)	26 (30.6)	
Sex						
Female	164 (80.0)	41 (20.0)	0.856	143 (69.8)	62 (30.2)	<0.001
Male	469 (80.6)	113 (19.4)		520 (89.3)	62 (10.7)	
Occupation						
Housewife	164 (80.0)	41 (20.0)	<0.001	143 (69.8)	62 (30.2)	<0.001
Fisherman	139 (55.4)	112 (44.6)		204 (81.3)	47 (18.7)	
Navy	331 (100.)	0 (0.0)		316 (95.5)	15 (4.5)	
Duration of work (years)						
6–14	55 (100.0)	0 (0.0)	<0.001	52 (94.5)	3 (5.5)	<0.001
15–24	226 (97.4)	6 (2.6)		222 (95.7)	10 (4.3)	
25–34	129 (85.4)	22 (14.6)		141 (93.4)	10 (6.6)	
35–44	53 (51.5)	50 (48.5)		75 (72.8)	28 (27.2)	
45 and above	6 (14.6)	35 (85.4)		30 (73.2)	11 (26.8)	
Use of sunglasses						
Yes	107 (83.6)	21 (16.4)	0.324	115 (89.8)	13 (10.2)	0.057
No	526 (79.8)	133 (20.2)		548 (83.2)	111 (16.8)	
Regular use of hat						
No	613 (79.9)	154 (20.1)	0.025	646 (84.2)	121 (15.8)	0.925
Yes	20 (100.0)	0 (0.0)		17 (85.0)	3 (15.0)	
Do you have vision problems?						
No	307 (92.5)	25 (7.5)	<0.001	306 (92.2)	26 (7.8)	<0.001
Yes	326 (71.6)	129 (28.4)		357 (78.5)	98 (21.5)	
History of eye operation						
Yes	50 (53.8)	43 (46.2)	<0.001	59 (63.4)	34 (36.6)	<0.001
No	583 (84.0)	111 (16.0)		604 (87.0)	90 (13.0)	
History of eye trauma						
No	614 (80.1)	153 (19.9)	0.096	644 (84.0)	123 (16.0)	0.181
Yes	19 (95.0)	1 (5.0)		19 (95.0)	1 (5.0)	
Total	633 (80.4)	154 (19.6)		663 (84.2)	124 (15.8)	

decreased the higher rate of this disease in the community of the Dahlak subzone. This showed that if urgent interventions on the preventive measures cannot be done to save the sight of the community of the Dahlak subzone in particular, this higher rate of blindness could increase and many people will lose their sight.

The prevalence of pterygium was 40% and was higher in respondents aged 40 to 49 years and those who had

Table 4 Association of Respondent's Background with Pterygium and Pinguecula

Variables	Pterygium		*P*-value	Pinguecula		*P*-value
	No N (%)	Yes N (%)		No N (%)	Yes N (%)	
Age (years)						
40–49	223 (55.9)	176 (44.1)	<0.001	243 (60.9)	156 (39.1)	<0.001
50–59	121 (59.9)	81 (40.1)		132 (65.3)	70 (34.7)	
60–69	60 (59.4)	41 (40.6)		84 (83.2)	17 (16.8)	
70 and above	68 (80.0)	17 (20.0)		75 (88.2)	10 (11.8)	
Sex						
Female	123 (60.0)	82 (40.0)	0.993	155 (75.6)	50 (24.4)	0.006
Male	349 (60.0)	233 (40.0)		379 (65.1)	203 (34.9)	
Occupation						
Housewife	123 (60.0)	82 (40.0)	<0.001	155 (75.6)	50 (24.4)	0.004
Fisherman	166 (66.1)	85 (33.9)		174 (69.3)	77 (30.7)	
Navy	183 (55.3)	148 (44.7)		205 (61.9)	126 (38.1)	
Duration of work (years)						
6–14	35 (63.6)	20 (36.4)	<0.001	28 (50.9)	27 (49.1)	<0.001
15–24	125 (53.9)	107 (46.1)		145 (62.5)	87 (37.5)	
25–34	86 (57.0)	65 (43.0)		98 (64.9)	53 (35.1)	
35–44	66 (64.1)	37 (35.9)		71 (68.9)	32 (31.1)	
45 and above	37 (90.2)	4 (9.8)		37 (90.2)	4 (9.8)	
Use of sunglasses						
Yes	77 (60.2)	51 (39.8)	0.963	85 (66.4)	43 (33.6)	0.702
No	395 (59.9)	264 (40.1)		449 (68.1)	210 (31.9)	
Regular use of hat						
No	463 (60.4)	304 (39.6)	0.166	520 (67.8)	247 (32.2)	0.835
Yes	9 (45.0)	11 (55.0)		14 (70.0)	6 (30.0)	
Do you have vision problems?						
No	174 (52.4)	158 (47.6)	<0.001	194 (58.4)	138 (41.6)	<0.001
Yes	298 (65.5)	157 (34.5)		340 (74.7)	115 (25.3)	
History of eye operation						
Yes	67 (72.0)	26 (28.0)	0.011	83 (89.2)	10 (10.8)	<0.001
No	405 (58.4)	289 (41.6)		451 (65.0)	243 (35.0)	
History of eye trauma						
No	460 (60.0)	307 (40.0)	0.998	523 (68.2)	244 (31.8)	0.213
Yes	12 (60.0)	8 (40.0)		11 (55.0)	9 (45.0)	
Total	472 (60.0)	315 (40.0)		534 (67.9)	253 (32.1)	

work experience between 15 and 24 years. This was higher than another study that found the prevalence of pterygium was 19.2%.[6] This showed that if preventive measures are not appropriately implemented, this group of population will have serious consequences and may have some kind of blindness in the coming years.

This study showed that pinguecula was common on these who had work experience of 6 to 14 years. Currently

most of these who had pinguecula do not complain self-reported vision problems, but due to the disease process, they could have chronic complications of blindness if interventions are not taken. This result was lower than other studies conducted in the Japanese series that the prevalence of pinguecula was 60%[8] and in the Red Sea region in which pinguecula was 90%.[9]

Even though it was not anticipated and was lower in previous studies, house wives and females were having higher rates of solar keratopathy (20%) and pterygium (40.0%). This could be mainly due to that participation in some outdoor activities on the sea shore where there were sea cucumbers, snail nail, and artisanal fissures. They can also be exposed during transportation and fishing. Furthermore, their practice of not using sunglasses and their age could contribute to the increased risk of solar keratopathy and pterygium. Further research detailing to such issues is recommended.

This study revealed that the prevalence of cataracts was 15.8% and showed increment with increased age and work experience. This showed that cataract also contributes to the community as a cause of blindness and needs an operation to prevent additional burden of preventable blindness.

A higher rate of blindness was seen in respondents aged 70 years and above, fishermen, housewives and females. Even though the causes for the blindness could vary, solar keratopathy, cataract, pterygium, and age were among the common causes of blindness. This study also showed that the level of blindness and solar keratopathy had increased with age and increased work experience. Previous studies in the same area showed that most severe clinical manifestations of Bietti's corneal degeneration generally occurred in the elderly.[7] Age, sex and occupation had showed very significant association with solar keratopathy.[6] This showed that the effect of age and the association of chronic exposure to the sun and sea for the development and pathogenesis of solar keratopathy.

Even though the practice of using sunglasses and hat was low, respondents who used sunglasses and hat had a lower rate of blindness compared to these who did not. The community should be educated to practice wearing of protective materials like sunglasses and hat during the sunny time and while working in the sea. Besides, their availability and sustainability should be secured.

About half of the study participants who self-reported vision problems were blind (22.2%) and had poor vision (36.0%) and those who had prior history of eye operations were blind (48.4%) or had poor vision (44.1%). This showed that the contribution of operable eye diseases like cataract in addition to the other causes of blindness in the community.

Conclusion

The prevalence of solar keratopathy, cataract, pterygium, and pinguecula was high in the community. The fishermen with increased work experience had the highest prevalence of blindness and solar keratopathy. Age, occupation, work experience, sex, vision problems and history of eye operation showed significant association with visual acuity, solar keratopathy, cataract, pterygium, and pinguecula.

Recommendations

Community awareness on the preventive aspects such as regular use of sunglasses and hat, and limiting activities during the hot periods are crucial to protect the sight of the people. Ensuring the availability and sustainable supply of the sunglasses are also necessary. Scheduling operations for the cataract cases can also prevent further loss of sight in the community.

Acknowledgments

The authors acknowledge the naval force for coordinating the sea transportation for the data collectors between the islands.

Funding

The research had no any source of fund, except for the data collectors; the per diem was covered by the Ministry of Health Northern Red Sea region.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Izadi M, Jonaidi-Jafari N, Pourazizi M, Alemzadeh-Ansari MH, Hoseinpourfard MJ. Photokeratitis induced by ultraviolet radiation in travelers: a major health problem. *J Postgrad Med*. 2018;64(1):40–46. doi:10.4103/jpgm.JPGM_52_17
2. Sliney DH. Exposure geometry and spectral environment determine photobiological effects on the human eye. *Photochem Photobiol*. 2005;81(3):483–489. doi:10.1562/2005-02-14-RA-439.1
3. Sasaki H, Sakamoto Y, Schnider C, et al. UV-B exposure to the eye depending on solar altitude. *Eye Contact Lens*. 2011;37(4):191–195. doi:10.1097/ICL.0b013e31821fbf29
4. Serra HM, Holopainen JM, Beuerman R, Kaarniranta K, Suárez MF, Urrets-Zavalía JA. Climatic droplet keratopathy: an old disease in new clothes. *Acta Ophthalmol*. 2015;93(6):496–504. doi:10.1111/aos.12628
5. Schurr TG, Dulik MC, Cafaro TA, Suarez MF, Urrets-Zavalia JA, Serra HM. Genetic background and climatic droplet keratopathy incidence in a mapuche population from Argentina. *PLoS One*. 2013;8(9):e74593. doi:10.1371/journal.pone.0074593

6. Taylor HR. Aetiology of climatic droplet keratopathy and pterygium. *Br J Ophthalmol*. 1980;64(3):154–163. doi:10.1136/bjo.64.3.154
7. Rodger FC. Clinical findings, course, and progress of Bietti's corneal degeneration in the Dahlak Islands. *Br J Ophthalmol*. 1973;57:657. doi:10.1136/bjo.57.9.657
8. Norn M. Spheroid degeneration, keratopathy, pinguecula, and pterygium in Japan (Kyoto). *Acta Ophthalmol*. 2009;62(1):54–60. doi:10.1111/j.1755-3768.1984.tb06756.x
9. Norn M. Spheroid degeneration, pinguecula, and pterygium among Arabs in the Red Sea territory, Jordan. *Acta Ophthalmol*. 1982;60 (6):949–954. doi:10.1111/j.1755-3768.1982.tb00626.x