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Ocular health among industrial workers: a prevalence study of foreign body injury, refractive error, dry eye, pterygium and pingueculae

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Abstract

Background: *Workplaces play a critical role in developing ocular diseases, owing to the risk of accidents. This study aimed to evaluate the ocular health of industrial workers by determining the prevalence of foreign body injury, refractive error, dry eye, and pterygium/pingueculae, as well as the factors influencing these diseases.* **Methods:** *This study involved on-site examinations of workers from an industrial area hosting marble processing factories and metal sectors. Data such as refractive error, foreign body injury-related corneal nephelium, pterygium/pingueculae presence, and Schirmer test-assisted dry eye evaluation were all collected.* **Results:** *The average age of workers was 35.78±10.05 years, with a female-to-male ratio of 20:220. The majority of workers had completed primary school (56.3%), smoked >1 cigarette/day (57.6%), and did not use any assistive devices for bodily functions (88.3%). On average, working hours/week were 55.07±8.79, and working years were 5.99±7.00. Dry eyes were found in 31(22%), and 35(34%) marble and metal workers, respectively (p=0.042). 11(7.9%) marble workers and 29(28%) metal workers had foreign body ocular injury-related corneal nephelium (p=0.0001). Furthermore, pterygium/pingueculae were revealed in 17 marble workers (12.3%) and three metal workers (3%) (p=0.009).* **Conclusions:** *Ocular health is essential, and routine ocular health screening in industrial workers, as well as workplace safety measures, should be implemented to prevent potential occupational accidents.*

1. Introduction

Uncorrected refractive errors, cataract, age-related macular degeneration, glaucoma, and diabetic retinopathy are among the top five causes of visual impairment worldwide, according to the World Health Organization (WHO). Whatever the cause, the fact that nearly one billion people worldwide have a treatable but incurable visual impairment is astounding [1]. The prevalence of these diseases varies from country to country. While cataract causes more visual impairment in low- and middle-income countries, conditions such as diabetic retinopathy, glaucoma, and age-related macular degeneration are more prevalent in high-income countries [2].

Focusing on both the individual and social implications of disease outbreaks is critical. According to the WHO, visual impairments double the risk of

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falling, whereas depression, anxiety, and motor function loss triple the risk [1]. Visual impairments have an impact on employment and accidents [3]. Workplaces play a critical role in this context due to the possibility of developing accidents and potentially associated ocular diseases. It has been reported that ocular injuries account for 3-10% of all occupational injuries [4-8].

Aside from accidents, working conditions have been linked to an increase in the prevalence of diseases such as dry eye [9], pterygium [10], and cataract [11], emphasizing the importance of workers' ocular health protection and improvement. The value of occupational risk assessments in determining the necessary precautions cannot be overstated in this regard.

As a result, the current study was designed to assess the ocular health of industrial workers by determining the prevalence of foreign body injury, refractive error, dry eye, pterygia/pingueculae, and the associated influencing factors.

2. Methods

2.1. Study design and participants

This cross-sectional study enrolled 9,000 industrial workers from the Aegean region of Afyonkarahisar province in Turkey between April and May 2021. This province's industrial area has long been known for its internationally valuable marble and metal industries. While those in the marble sector worked on quarry marble, those in the metal sector worked on marble cutting machines. The sample size was calculated to be 215 based on the expected value of 40.4% for refractive errors [12], which is the highest expected value for ocular disease prevalence, using the Epi Info Program, with an 8% margin of error, 1.5 design effects, and five clusters planned to be selected. Five factories were randomly chosen from the industrial area to arrive at this figure, and two hundred and forty factory volunteers participated in the study.

2.2. Ocular assessment

A senior ophthalmologist (IEA) performed a comprehensive ocular examination on all participants between 09:00 AM and 12:00 AM to minimize any potential diurnal and climatic condition-related ocular physiological changes, particularly in the aspect of a possible dry eye condition. Also, personal protective equipment such as an N95 mask, visor, apron, gloves, and so on was used during the examination to prevent SARS-CoV-2 transmission. The other study authors gathered demographic information and distributed a workplace health questionnaire (MD, YŞ, AT).

A complete anamnesis was performed, including noting any other diseases or medications and visual acuity using the Snellen chart (6m) before measuring refractive error in glasses and contact lens users. An anterior segment examination was performed using a hand slit lamp (Reichert, NY, USA) to detect cataracts, pterygium, pingueculae, and dry eye. The Schirmer test was performed after instilling local anesthesia into the cornea. Participants with values less than 5 mm and a tear break-up time (TBUT) test of greater than 10 seconds were classified as having dry eyes. Dilated fundoscopy was performed using a 90D Volk in cases with visual acuity below 20/20, and any ocular pathology was recorded.

2.3. Statistical analysis

the statistical analysis was conducted using the Statistical Program in Social Sciences (SPSS) 23.0 package. Continuous variables were reported as mean and standard deviation, while categorical variables were reported as numbers and percentages. The χ^2 test was used to compare categorical variables and the possible relationship between workplace risk factors and ocular diseases such as dry eye, refractive error, foreign body injury status, pterygium, and pingueculae. Yates' correction or Fisher's exact test was used when necessary.

3. Results

The average age of workers was 35.78±10.05 years, with a female-to-male ratio of 20:220. Working hours per week averaged 55.07±8.79, and working years averaged 5.99±7.00. The majority of workers had finished primary school (56.3%), smoked more than one cigarette per day (57.6%),

Table 1. The socio-demographic characteristics of industrial workers.

Parameters	Marble sector, n. (%)	Metal sector n. (%)	Total n. (%)	χ^2	P value
Gender					
Female	9(6.5)	11(10.8)	20(8.3)	1.395	0.238
Male	129(93.5)	91(89.2)	220(91.7)		
Education level					
Illiterate and Literate	2(1.4)	6(5.9)	8(3.3)	16.616	<0.001*
Primary school graduates	35(25.4)	24(23.5)	59(24.6)		
High school graduates	56(40.6)	20(19.6)	76(31.7)		
University graduates	45(32.6)	52(51.0)	97(40.4)		
Smoking Status					
None	35(25.4)	36(35.3)	71(29.6)	2.975	0.226
More than one cigarette/day	83(60.1)	55(53.9)	138(57.5)		
Quit smoking	20(14.5)	11(10.8)	31(12.9)		
Chronic disease status					
Absent	122(88.4)	89(87.3)	211(87.9)	0.073	0.787
Present	16(11.6)	13(12.7)	29(12.1)		
Assistive devices for body functions					
None	119(86.2)	93(91.2)	212(88.3)	3.011	0.223
Glasses	15(10.9)	9(8.8)	24(10.0)		
Others	4(2.9)	0(0.0)	4(1.7)		
Total	138(100.0)	102(100.0)	240(100.0)		

**p<0.05, n=Number of participants, %=Percentage.*

and did not use any assistive devices for bodily functions (88.3%). Table 1 summarizes the socio-demographic characteristics of industrial workers.

Most industrial workers were employed in production (marble and metal sectors) units (68.3%). 24.6% of the employees were not directly involved in production but were working in management, marketing and technical units. Only 22.5% worked the night shift. 36.3% reported workplace exposure to flying, moving or falling objects. 14.6% had been exposed to corrosive-corrosive chemicals (e.g., silica, fluorine) at work. The remaining workplace units and associated risk factors are shown in Table 2.

Most factories in the industrial area had an occupational physician – 195(81.3%). Despite this, the vast majority of industrial workers, 231(96.2%), were not subjected to regular ocular examinations. Despite having an eye problem, 25(10.4%) workers could not be visited by an ophthalmologist for various reasons, including difficulties obtaining hospital rendezvous and permission to leave the workplace for outpatient clinics. Participants had an 18.3% refractive error, a 27.5% dry eye, a 16.7% pterygium/pingueculae, and a 8.3% corneal foreign body injury (Figure 1).

Most participants were emmetropes (81.7%), with no dry eye (72.5%), pterygium/pingueculae (83.3%), or history of corneal foreign body injury (91.7%) (Table 3 and Figure 1).

There were no statistically significant differences between refractive error and occupational sector (p=0.147). Dry eye was detected in 22% of the marble sector and 34% of the metal sector workers (p=0.042). Metal workers had a higher rate of foreign body injury-related corneal nephelium (28.4%) than marble workers (7.9%) (p=0.0001). However,

Table 2. Industrial workers' workplace units and risk factors.

Parameters	Marble sector n. (%)	Metal sector n. (%)	Total n. (%)	χ^2	P value
Units					
Administration, marketing and technical	40(29.0)	19(18.6)	59(24.6)	3.405	0.182
Welding	9(6.5)	8(7.8)	17(7.1)		
Production in marble and metal sectors	89(64.5)	75(73.5)	164(68.3)		
Nigh shift status					
Yes	96(69.6)	90(88.2)	186(77.5)	11.724	0.001*
No	42(30.4)	12(11.8)	54(22.5)		
Workplace exposure to flying, moving, or falling objects					
No	89(64.5)	64(62.7)	153(63.8)	0.078	0.781
Yes	49(35.5)	38(37.3)	87(36.3)		
Exposure to corrosive-corrosive chemicals in the workplace (e.g., silica, fluorine)					
No	125(90.6)	80(78.4)	205(85.4)	6.949	0.008*
Yes	13(9.4)	22(21.6)	35(14.6)		
Construction machinery use with a colored signal or warning lamp					
No	101(73.2)	69(67.6)	170(70.8)	0.872	0.35
Yes	37(26.8)	33(32.4)	70(29.2)		
Welding Machine Usage					
No	116(84.1)	71(69.6)	187(77.9)	7.117	0.008*
Yes	22(15.9)	31(30.4)	53(22.1)		
Wearing glasses with visors (Personal Protective Equipment)					
No	75(54.3)	49(48.0)	124(51.7)	0.935	0.334
Yes	63(45.7)	53(52.0)	116(48.3)		
Total	138(100.0)	102(100.0)	240(100.0)		

**p<0.05, n=Number of participants, %=Percentage.*

marble workers (12.3%) were more likely to have pterygium/pingueculae than metal workers (3%) (Table 3).

4. Discussion

The present study was conducted in occupational settings, and therefore it may be more effective than hospital-based studies in revealing eye accidents, injuries, and diseases. Indeed, occupational accidents are under-reported in developing countries, including Turkey. As a result, the current study findings take on greater significance. The presence of foreign body injury-related corneal nephelium could indicate unreported accidents.

Heinrich accident pyramid reported 29 accidents with minor injuries and 300 near-misses per accident, with one serious injury and death [13]. By accepting 40 foreign body injuries as minor accidents, this situation can be interpreted as indicating 1-2 serious injuries or fatal accidents and 413 near misses. Therefore, existing preventive measures are either insufficient or not correctly implemented. Indeed, primary eye protection reduces the risk of eye-related accidents by 90% [14]. Despite this precautionary measure, the main issue here is that employers and employees generally disregard this risk. It is worth noting that, of the sectors studied, those working in the metal sector had a higher rate of eye injuries caused by foreign objects than those

working in the marble sector. Based on the literature, the metal industrial sector appears to be the most hazardous for eye injuries, consistent with the current study findings [15].

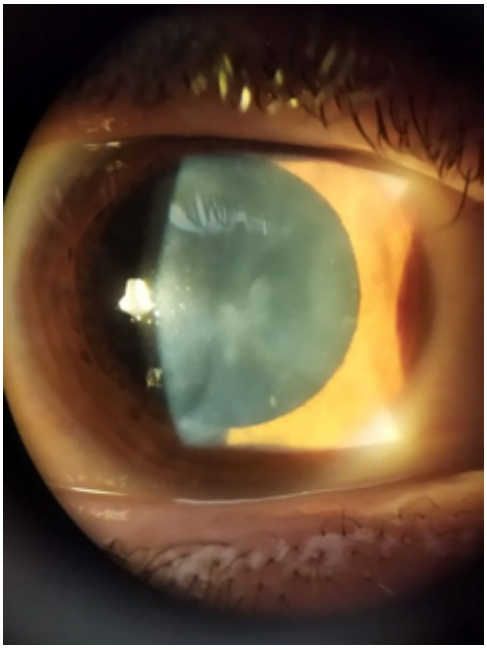

Figure 1. Corneal nephelium caused by multiple foreign body trauma in a 45-year-old male worker at a marble cutting machine factory.

Another significant finding in the current study was that 16.2% of the industrial workers did not know whether their workplace had an on-site physician: 2.5% of workers stated that they don't have an occupational physician. However, the workplaces where the study was conducted were classified as high-risk and served by a responsible physician. As a result, the occupational medical unit is underutilized in a sector with severe ocular problems. The workplace physician's list of ocular diseases should be screened, and it should be determined whether workers take necessary precautions. The current study, on the other hand, revealed that the occupational physician did not perform ocular screening procedures regularly and that an ophthalmologist had not examined 62% of workers in more than a year. The employer and the employees appeared to place too little emphasis on ocular health, and the occupational physician did not plan periodic examinations based on job requirements. Given the nature of the job, it is presumed that ocular diseases should be included in workplace screening, and training interventions should be planned to raise the awareness of workers in hazardous jobs.

Pterygium and pingueculae are two other diseases that the workplace may influence. Their development has been linked to UV rays, age, high

Table 3. The relationship between industrial workers' occupational sector and ocular health conditions.

	Occupational sector				
Parameters	**Marble Sector n. (%)**	**Metal Sector n. (%)**	**Total n. (%)**	**χ^2**	**P value**
Refractive error					
Present	21(47.7)	23(52.3)	44(100.0)	2.106	0.147
Absent	117(59.7)	79(40.3)	196(100.0)		
Dry eye					
Present	31(47.0)	35(53.0)	66(100.0)	4.131	0.042*
Absent	107(61.5)	67(38.5)	174(100.0)		
Corneal foreign body injury					
Absent	127(63.5)	73(36.5)	200(100.0)	17.678	<0.001*
Present	11(27.5)	29(72.5)	40(100.0)		
Pterygium/Pingueculae					
Absent	121(55.0)	99(45.0)	220(100.0)	6.752	0.009*
Present	17(85.0)	3(15.0)	20(100.0)		

**p<0,05, n=Number of participants, %=Percentage.*

cholesterol metabolism, dust exposure, elastotic degeneration, alcohol, and dry eyes [16]. A 52% prevalence of pingueculae has been reported [16], much higher than the rate of 8.3% found in the current study. However, the population was also older, with a mean age of 63.4±14.5 years, compared to 35.78±10.05 of our study subjects, which could account for a low rate of pterygium and pingueculae detection.

The prevalence of pterygium/pingueculae was around 25% in a study of quarry workers in Ghana [17]. One of the most important risk factors for the pterygium/pingueculae is UV radiation [18]. Our study was carried out in factories in the industrial zone. Both marble workers and metal workers were working indoor. Therefore, UV radiation was not considered the main risk for either group. The lower frequency found in our study might be due to younger age and low UV exposure. The marble sector workers had a higher frequency of pterygium and pingueculae than those from the metal sector. This increase could be attributed to dust generated during the manufacturing process of the marble industry, which influences the formation of pterygium and pingueculae. Given this disparity, interventions to reduce ambient dust are only partially effective. Environmental measures, for example, could effectively reduce the dust effect and the formation of pterygium and pingueculae.

Refractive errors, including astigmatism, myopia, and hyperopia, are the most common vision problem worldwide [1]. In the refractive error meta-analysis [12], the estimated pool prevalence for myopia was 26.5%, 30.9% for hyperopia, and 40.4% for astigmatism, with significant differences across countries. Genetic and environmental factors may have contributed to the development of this difference. A substantial proportion of working-age adults have an undiagnosed refractive error, according to a cohort study conducted in England [3]. Consistently, we found that 18.3% of workers had refractive errors. While 10% of those with refractive errors wore glasses, 8.3% did not seek corrective measures for their visual defect. Age and educational level could be critical variables in refractive errors [19]. The younger age group, as well as the concentration of education at the primary and secondary levels, are thought to contribute to the lower incidence of refractive errors.

Dry eye is linked to decreased eye comfort, poor quality of life [20], and poor work performance [21]. Dry eyes affect between 5% and 35% of the population [22]. A meta-analysis of studies on workers who used screens found that the prevalence was 39.1% in studies investigating symptom-based dry eye and 25.4% in studies investigating tear film anomalies [23]. The method used in these studies could have played a significant role in the prevalence discovered [24, 25]. The current study employed the Schirmer and TBUT tests, and the prevalence of dry eye in employees was 27.5%. It backs up previous research on the tear film. Dry eye can be caused by various factors, including age, gender, particle exposure, environmental conditions such as climatic conditions, work conditions [visual-demanding work], and medications such as antihistamines and steroids [21]. Khorshed et al. [24] study with 250 workers in the marble quarry found that 51.2% had dry eyes. Compared to Khorshed et al., the current study found a lower rate of dry eye. The present study evaluated the occupational sectors associated with marble processing in the industry may have revealed this difference. Khorshed et al. evaluated the workers directly involved in marble extraction in a marble quarry.

Overall, dry eye was more prevalent in metal than in marble workers. A study in the Netherlands [9] to investigate the relationship between population-based dry eye and occupation types discovered that the metal sector was the most dangerous business group for dry eye. It is worth noting that exposure to dust, chemicals, toxins, and the overall hazardous working environment are prevalent in these industries.

The current study has a significant limitation: it only included workers from the marble and metal industries. Specific ocular health concerns may exist for automotive, biomedical, and other automotive workers. In this context, multi-centred field studies with a larger workforce and other business lines related to this issue would be clinically and occupationally valuable. Furthermore, workers were presumed to have always worked the same job throughout their professional lives. Workers with

extensive work experience may have previously worked in different business lines and suffered eye injuries. However, the risk of eye injury based on the workers' working years was not considered. It is unknown whether new workers value safety precautions more than experienced workers. Inexperienced workers may sustain more eye injuries. Nonetheless, because it is a direct field study conducted by an ophthalmologist under the supervision of public health experts, our study adds to the literature in an unprecedented way. More research on this topic, however, is needed.

5. Conclusions

The majority of workers had completed primary school, smoked more than one cigarette per day, and did not use any bodily function assistive devices. The metal sector had a higher rate of eye injuries caused by foreign objects than the marble sector, indicating its high potential for visual injuries. The same industry had a higher prevalence of dry eye. The fact that occupational physicians did not regularly perform ocular screening procedures and that an ophthalmologist had not examined more than 60% of workers in more than a year demonstrates how little attention was paid to ocular health conditions. Further large-scale multi-center research involving different industrial sectors, in addition to marble and metal, could provide clinically and occupationally relevant outcomes in the long term, providing a complete picture of ocular health status.

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