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Preventing Red Eye Syndrome in Military Personnel Through a Multimodal Eye Hygiene Intervention: A Controlled Before-and-After Study

Sh.R. Abdullaev[1]*, A.K. Namazov[2], U.A. Radjabov[3], O.I. Oripov[4]

1*DSc, Associated Professor, Department of OphthalmOlogy, Center for the Development of Professional Qualifications of Medical Workers, Tashkent, Uzbekistan
oqilkhon.oripov@gmail.com
2Military Medical Institute, University of Military Security and Defense of the Republic of Uzbekistan, Tashkent, Uzbekistan
3Karshi State University, Karshi, Republic of Uzbekistan, 2Center for the Development of Professional Qualification of Medical Workers, Tashkent, Republic of Uzbekistan
4Tashkent State Medical University

ABSTRACT: Background. Red eye syndrome is an occupational health concern in military populations, where environmental exposures, communal living, and intensive training may contribute to ocular surface disorders and infectious conjunctivitis. This study evaluated the association between a multimodal eye hygiene intervention and the incidence and clinical burden of red eye syndrome among military personnel.

Materials and Methods. A controlled before-and-after study included 2,914 personnel from two military units: Unit A (n=1,438; intervention) and Unit B (n=1,476; control). Following a retrospective baseline assessment in 2024, a multimodal intervention combining isotonic saline cleansing, hyaluronic acid-containing eye drops, eyelid hygiene, and health education was implemented in Unit A during 2025, while Unit B continued routine practice. Outcomes included red eye syndrome incidence, clinical diagnosis distribution, and temporary work incapacity.

Results. Baseline incidence was comparable between Unit A and Unit B (199.5 vs. 196.5 cases per 1,000 personnel), with no significant difference in diagnostic distribution (P=0.954). During the intervention period, incidence decreased to 105.7 per 1,000 in Unit A, representing a 47.0% relative reduction, while remaining largely unchanged in Unit B (192.4 per 1,000). The proportion of bacterial conjunctivitis decreased in Unit A, and mean temporary work incapacity decreased descriptively for most diagnoses.

Conclusions. The multimodal eye hygiene intervention was associated with reduced red eye syndrome incidence and temporary work incapacity among military personnel. Larger multicenter and cluster-controlled studies are needed to confirm these findings.

INTRODUCTION

Red eye syndrome encompasses a heterogeneous group of ocular surface disorders, including infectious and allergic conjunctivitis and dry eye disease (DED). DED is a prevalent multifactorial condition characterized by loss of tear-film homeostasis and is increasingly recognized as a public and occupational health concern [1,2]. Environmental and behavioral exposures, including adverse climatic conditions, airborne pollutants, low humidity, and prolonged visual demands, may

contribute to ocular surface disturbance and exacerbate related symptoms [3].

Military personnel may be particularly vulnerable because environmental exposures are combined with communal living, intensive training, and the need to maintain continuous operational readiness. In this setting, ocular surface disorders may contribute not only to discomfort and medical consultations but also to temporary duty limitations and reduced personnel availability. Infectious conjunctivitis presents an additional public health concern because of its potential for transmission within organized communities; outbreaks and their impact on military readiness have previously been documented in military populations [4,5].

Preventive measures targeting modifiable ocular surface factors may therefore have practical value in military settings. Eyelid hygiene may improve tear-film and ocular surface parameters [6], while hyaluronic acid-containing lubricants can support ocular surface hydration and improve dry eye-related outcomes [7]. However, evidence on structured multimodal interventions combining ocular surface cleansing, lubrication, eyelid hygiene, and health education for routine preventive use in military populations remains limited. Therefore, this study aimed to evaluate the effectiveness of a multimodal eye hygiene intervention in reducing the incidence and clinical burden of red eye syndrome among military personnel.

MATERIALS AND METHODS

Study Design and Setting. A controlled before-and-after study was conducted in two military units (Unit A and Unit B) located in different regions of the Republic of Uzbekistan. The study comprised a one-year retrospective baseline period (2024) followed by a one-year prospective intervention period (2025). Unit A served as the intervention group, whereas Unit B served as the concurrent control group and continued routine practice. The total study population comprised 2,914 military personnel, including 1,438 in Unit A and 1,476 in Unit B. The units were selected to ensure comparability in climatic conditions, military service routines, and personnel strength. Because of institutional confidentiality requirements applicable to military facilities, their names, exact locations, and other identifying information are not disclosed.

Study Population and Eligibility Criteria. The source population comprised military personnel serving in the two participating military units during the respective study periods. All personnel registered in the units during the observation period and covered by the corresponding military medical services were eligible for inclusion. Personnel who were transferred, discharged from military service, or absent from the unit for a substantial part of the respective observation period were excluded if complete follow-up data were unavailable. Records with insufficient clinical information to ascertain the diagnosis of red eye syndrome or the study outcomes were also excluded. No exclusions were made on the basis of a previous history of conjunctivitis or dry eye disease, as these conditions constituted part of the outcomes of interest.

Sample Size. No formal sample size calculation was performed because the study used a population-based approach within the two participating military units and included the entire eligible population during the study periods. The final study population comprised 2,914 military personnel (1,438 in the intervention unit and 1,476 in the control unit).

Retrospective Baseline Assessment. Medical records from the medical services of both military units were retrospectively reviewed for the 2024 calendar year to establish baseline epidemiological and clinical characteristics of red eye syndrome. Extracted variables included the number of registered cases, clinical diagnosis (viral, bacterial, or allergic conjunctivitis and dry eye syndrome), duration of temporary work incapacity, recurrent episodes, seasonal patterns, and cases requiring isolation or hospitalization. These data were used to assess baseline comparability between the intervention and control units.

Prospective Intervention Phase. During 2025, a prospective controlled intervention was conducted. A dedicated eye hygiene station was implemented in Unit A, while Unit B continued routine practice without the intervention. The station provided isotonic saline for ocular surface cleansing, hyaluronic acid-containing lubricating eye drops, individual antiseptic wipes for eyelid hygiene, and visual and digital educational materials. A unit-level log was used to monitor station utilization without collecting personally identifiable information. Personnel in the intervention unit were also surveyed regarding frequency of use, perceived effectiveness, and subjective benefit.

Outcome Measures. The primary outcome was the incidence of registered red eye syndrome, expressed as the number of cases per 1,000 military personnel during each study period. Secondary outcomes included the distribution of red eye syndrome according to clinical diagnosis, mean duration of temporary work incapacity, frequency of recurrent episodes, seasonal distribution, and the proportions of cases requiring isolation or hospitalization. Outcomes during the prospective period were compared with the corresponding baseline values and between the intervention and control units.

Eye Hygiene Intervention. The eye hygiene intervention was implemented in Unit A through a dedicated eye hygiene station designed to provide standardized and readily accessible preventive ocular care. The intervention combined four components: ocular surface cleansing with sterile isotonic saline, lubrication with hyaluronic acid-containing eye drops, eyelid hygiene using individual antiseptic wipes, and health education on appropriate eye hygiene practices. Personnel were instructed on the correct use of each component and encouraged to use the station regularly, particularly after exposure to dust, wind, prolonged visual load, or other conditions associated with ocular discomfort.

The intervention was organized as a structured preventive pathway comprising personnel education, access to eye hygiene products, routine use of the station, and monitoring of its utilization. The overall organization and operational framework of the multimodal intervention are presented in Figure 1.

Ethical Considerations. The study protocol was approved by the Local Ethics Committee of the Military Medical Academy of the Armed Forces of the Republic of Uzbekistan (Protocol No.1, dated [05.01.2023]). The study was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from participants in the prospective phase. All data were anonymized, and the identities and locations of the participating military units were withheld in accordance with institutional confidentiality requirements.

Statistical analysis was performed using MedCalc Statistical Software (MedCalc Software Ltd., Ostend, Belgium). Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Incidence rates were calculated per 1,000 personnel. Differences in categorical variables between groups were assessed using the chi-square test. Changes in incidence between the baseline and intervention periods were expressed as absolute and relative changes. All statistical tests were two-sided, and a *P* value <0.05 was considered statistically significant.

RESULTS

During the 2024 baseline period, 577 cases of red eye syndrome were recorded across the two military units. The incidence was comparable between Unit A and Unit B (199.5 vs. 196.5 cases per 1,000 personnel, respectively; Table 1).

The clinical distribution of red eye conditions was also similar between the groups. Dry eye syndrome was the predominant diagnosis, accounting for 52.61% of cases in Unit A and 51.38% in Unit B, followed by bacterial conjunctivitis (30.66% and 32.07%, respectively). No significant difference in the overall distribution of diagnoses was observed between the units (χ^2 = 0.33, p = 0.954).

Despite being less frequent, viral conjunctivitis was associated with the longest period of temporary work incapacity (7.8 ± 1.4 days in Unit A and 7.9 ± 1.7 days in Unit B), whereas the shortest duration was observed for dry eye syndrome (Table 2). Recurrence, seasonal patterns, and the proportions of cases requiring isolation or hospitalization were likewise comparable between the two units at baseline.

Overall, these findings indicate broadly comparable epidemiological and clinical profiles in the two military units before implementation of the preventive intervention.

Following implementation of the preventive intervention, a marked reduction in red eye syndrome was observed in Unit A, with the number of registered cases decreasing from 287 in 2024 to 154 in 2025 and the incidence declining from 199.5 to 105.7 cases per 1,000 personnel. In contrast, Unit B showed only a minor change over the same period, from 290 to 284 cases and from 196.5 to 192.4 cases per 1,000 personnel (Figure 2). This divergence in temporal trends was observed following implementation of the eye hygiene intervention in Unit A.

In Unit A, the number of registered red eye syndrome cases decreased from 287 at baseline to 154 during the intervention period, corresponding to a 46.3% reduction. The incidence decreased from 199.5 to 105.7 cases per 1,000 personnel, representing a relative reduction of 47.0%.

The distribution of red eye syndrome diagnoses remained largely unchanged in Unit B between 2024 and 2025, whereas a distinct shift was observed in Unit A following implementation of the preventive intervention. In Unit A, the proportion of bacterial conjunctivitis decreased from 30.6% to 21%, while dry eye syndrome increased proportionally from 52% to 66% of all registered cases. Viral and allergic conjunctivitis accounted for relatively small proportions of cases throughout the study period.

The mean duration of temporary work incapacity decreased in Unit A during the intervention period for most clinical diagnoses, whereas no substantial changes were observed in Unit B. The most pronounced reductions in Unit A were observed

for viral conjunctivitis (from 7.8 to 6.5 days), bacterial conjunctivitis (from 5.2 to 4.1 days), and allergic conjunctivitis (from 4.3 to 3.5 days). The duration associated with dry eye syndrome changed only slightly (from 2.3 to 2.1 days). Overall, the reduction in disease-related work incapacity in Unit A paralleled the decline in red eye syndrome incidence observed during the intervention period.

DISCUSSION

The principal finding of this study was a substantial reduction in red eye syndrome following implementation of the multimodal eye hygiene intervention. Incidence decreased by approximately 47% in the intervention unit, while remaining largely unchanged in the control unit. Given the comparable baseline epidemiological profiles of the two units, this divergence suggests an association between the intervention and reduced red eye morbidity. This finding is particularly relevant in military settings, where communal living, close interpersonal contact, and intensive training may facilitate the transmission of infectious conjunctivitis. Previous reports of conjunctivitis outbreaks in military populations have demonstrated their potential impact on disease control and operational readiness [4,5].

The observed reduction may be related to the multimodal nature of the intervention, which integrated ocular surface cleansing, eyelid hygiene, lubrication with hyaluronic acid-containing eye drops, and health education. Previous studies have reported beneficial effects of eyelid hygiene on tear-film and ocular-surface parameters [6], while hyaluronic acid-containing lubricants are widely used to support ocular surface hydration and improve dry eye-related outcomes [7]. Evidence also suggests potential benefits of combined approaches incorporating eyelid cleansing and lubrication [8]. Integrating these measures into a single, readily accessible preventive station may facilitate their routine use; however, the present study design does not allow the contribution of individual intervention components to be determined.

The intervention was also associated with changes in the clinical and occupational burden of red eye syndrome. The proportion of bacterial conjunctivitis decreased in the intervention unit, whereas dry eye disease accounted for a greater proportion of the remaining cases. This relative increase should not be interpreted as an increase in the absolute incidence of dry eye disease, but may reflect a greater reduction in other red eye conditions. This interpretation is consistent with the multifactorial nature of dry eye disease and its association with environmental, behavioral, and individual factors [1–3]. From an occupational and public health perspective, the observed reduction in temporary work incapacity is also relevant, as even relatively minor ocular conditions may result in repeated medical consultations, duty limitations, and reduced personnel availability in organized military populations [4,5].

Several limitations should be considered. The non-randomized intervention was implemented at the unit level, and only one intervention and one control unit were included; therefore, unit-level effects cannot be fully separated from the effect of the intervention, and residual differences between units or temporal and environmental factors cannot be excluded. The multimodal design also precludes assessment of the independent contribution of individual components, while reliance on routinely collected medical records may have introduced measurement or classification bias. These limitations restrict causal inference and generalizability. Nevertheless, the large study population, contemporaneous control unit, and comparable baseline epidemiological profiles support the observed association and provide a rationale for further evaluation of this preventive approach in larger multicenter and cluster-controlled studies.

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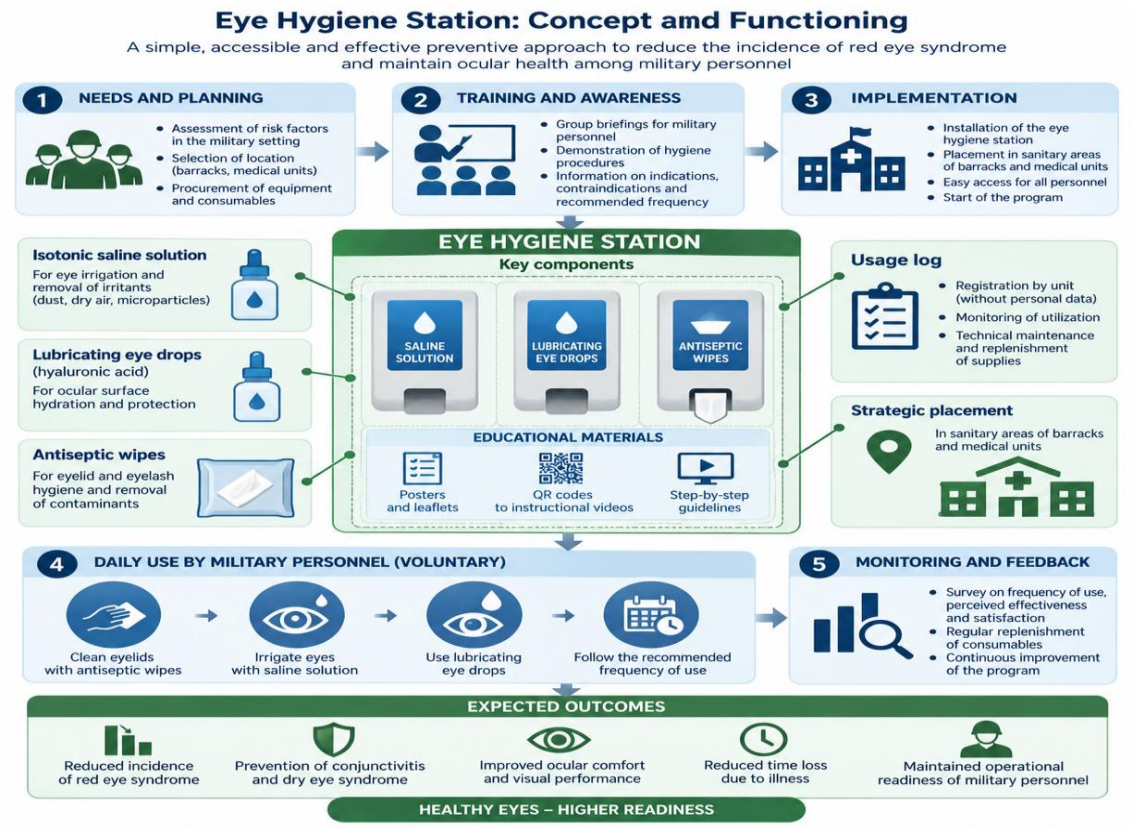


Figure 1. Conceptual framework and operational workflow of the multimodal eye hygiene intervention.

Table 1. Baseline epidemiological and clinical characteristics of red eye syndrome in the intervention and control units.

Military unit	Total personnel, n	Red eye syndrome cases, n	Incidence per 1,000 personnel
Unit A	1,438	287	199.5
Unit B	1,476	290	196.5
Clinical diagnosis		Unit A, n (%)	Unit B, n (%)
Viral conjunctivitis		14 (4.88)	16 (5.52)
Bacterial conjunctivitis		88 (30.66)	93 (32.07)
Allergic conjunctivitis		34 (11.85)	32 (11.03)
Dry eye syndrome		151 (52.61)	149 (51.38)
Total		287 (100)	290 (100)

Note: Incidence was calculated as the number of registered cases per 1,000 military personnel during the 2024 baseline period. Values are presented as n (%). The overall distribution of clinical diagnoses did not differ significantly between Unit A and Unit B ($\chi^2 = 0.33$, $p = 0.954$).

Table 2. Baseline clinical and occupational burden of red eye syndrome in the intervention and control units.

Clinical diagnosis	Unit A, days, mean ± SD	Unit B, days, mean ± SD
Viral conjunctivitis	7.8±1.4	7.9±1.7
Bacterial conjunctivitis	5.2±1.1	5.3±0.9
Allergic conjunctivitis	4.3±1.4	4.7±1.5
Dry eye syndrome	2.3±1.2	2.1±0.8
Outcome	Unit A, n (%)	Unit B, n (%)
Recurrent cases (>2 episodes/year)	54 (18.81)	58 (20.00)
Cases occurring during seasonal peaks (spring/autumn)	50 (17.42)	50 (17.24)
Cases requiring isolation	14 (4.88)	16 (5.52)
Cases requiring hospitalization	3 (1.05)	5 (1.72)

Note: Values are presented as n (%). Percentages were calculated relative to the total number of registered red eye syndrome cases in the respective military unit (Unit A, n = 287; Unit B, n = 290).

CONCLUSION

Implementation of a multimodal eye hygiene intervention was associated with a substantial reduction in red eye syndrome incidence and temporary work incapacity among military personnel. These findings suggest that a structured, accessible preventive approach combining ocular surface cleansing, eyelid hygiene, lubrication, and health education may have practical value in organized military settings. Larger multicenter and cluster-controlled studies are needed to confirm these findings and assess the generalizability of this preventive approach.

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Declaration of Generative AI and AI-Assisted Technologies

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for language editing, improvement of academic style, manuscript organization, and assistance in creating the schematic representation presented in Figure 1. All AI-assisted content was reviewed and edited by the authors, who take full responsibility for the final manuscript. Generative AI was not used for data generation, modification, statistical analysis, or scientific interpretation.

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Conflicts of Interest: There are no conflicts of interest.

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