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The impact of eyeliner usage on dry eye symptoms

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The objective of this study was to investigate whether eyeliner use is associated with an increase in dry eye symptoms. A survey was conducted to collect data on cosmetic usage and Ocular Surface Disease Index (OSDI) scores from a diverse public sample. Additionally, eyecare professionals were queried regarding their practice of inquiring about cosmetic use during patient consultations. The survey included specific questions about eyeliner application and the calculation of OSDI scores, with a score of 13 or higher indicating the presence of dry eye symptoms. Individuals who reported using eyeliner had a significantly higher rate of OSDI scores above 13 compared to non-users (42.93% vs. 33.38%, $p < 0.001$). Notably, subjects who applied eyeliner to the lid margins exhibited an even more pronounced increase in high OSDI scores (48.17%, $p < 0.001$). Furthermore, a significant proportion of patients (23.37%) expressed reluctance to discontinue cosmetic use when advised in medical contexts, while only 48.19% of healthcare providers routinely inquired about cosmetic use during patient consultations. The usage of eyeliner is associated with higher OSDI scores, underscoring the need for both eyecare practitioners and eyeliner users to be more cognizant of the potential impact of eyeliner on the ocular surface.

Keywords Dry eye disease (DED), Ocular surface disease index (OSDI), Eyeliner, Cosmetics

The Tear Film & Ocular Surface Society recently published a report emphasizing the influence of cosmetics on ocular surface diseases, and that several eye cosmetic products may have the potential to damage the ocular surface and adnexa¹⁻³. Eyeliner is one of the most-used eye cosmetics, which can be either permanent or rinsed off⁴⁻⁶. The most common purpose for using eyeliner is to enhance the definition of the eye, and its history can be traced back thousands of years⁷⁻⁹. A recent report demonstrated the impact of eyeliner tattoos on ocular surface homeostasis, but it remains unclear whether rinse-off eyeliners also impact the ocular surface¹⁰⁻¹³.

We hypothesize that the use of rinse-off eyeliner is a risk factor for increased dry eye symptoms¹⁴⁻¹⁶. To test this hypothesis, we conducted a survey that included questions about cosmetic use and the Ocular Surface Disease Index (OSDI) questionnaire. The OSDI questionnaire consisted of 12 questions, and the total score was positively correlated with the severity of dry eye and its impact on daily activities¹⁷. The combination of clinical signs of dry eye and OSDI scores provided a comprehensive evaluation of ocular surface disease^{18,19}. As many individuals with mild dry eye symptoms do not typically seek medical consultation, we conducted our survey among the general population rather than in clinical settings.

Methods

Questionnaire collection

This study strictly adheres to the principles outlined in the Declaration of Helsinki. The study protocol was approved by the Medical Ethics Committee of Zhongnan Hospital, Wuhan University, China (2022130). Electronic informed consent was obtained in the questionnaires from all subjects and/or their legal guardian(s). A total of two questionnaires were collected. The first questionnaire aimed to assess the general cosmetic usage patterns among both healthcare and non-healthcare professionals. The questionnaire detailed the types and frequencies of skincare and cosmetic products used (Table 1). Non-healthcare participants were queried about their willingness to temporarily discontinue cosmetic use based on medical recommendations. In contrast, healthcare professionals were surveyed on their practices regarding the inquiry of cosmetic use among their patients during the diagnostic and treatment processes.

The second part of the study was a survey of the general population regarding eyeliner usage and the Ocular Surface Disease Index (OSDI). This survey included basic information about the population, such as age, gender, occupation, general health conditions, etc., as well as information about eyeliner use, including the brand, frequency, location, etc. We asked about other factors that may cause dry eye symptoms, such as contact lens

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The question	The answer
Your gender	
Your age	
Your nationality	
Are you a doctor or a nurse	
Your professional title	
Do you use cosmetics?	
Which of the cosmetics do you use?	Eyeliner/ mascara cream/ eye shadow/ eyebrow pencil/ colored contact/ foundation/ concealer / sunblock / others
The frequency of the use of cosmetics	
Do you use skin care products?	
The frequency of using skin care products	
Do you ask the patient if they use cosmetics or skin care products?	
If your doctor advises you to stop using cosmetics, what is your opinion?	

Table 1. The use of cosmetics by medical personnel and the general public.

wear, previous ocular surface disease, refractive surgery, topical ocular medications, prolonged screen use, air-conditioned use and other conditions that may affect the ocular surface. These factors were used as exclusion criteria in the questionnaire. We did not specifically ask about screen time, as the age and occupational types of the eyeliner and non-eyeliner groups in the questionnaire were matched, and we assumed their screen time would be similar. The OSDI scale was incorporated into the questionnaire (Table 2). Participants who had used eyeliner for over 1 year with a usage frequency of at least 3 times per week were categorized as the eyeliner group, while those who did not meet this criterion were placed in the non-eyeliner user group. An OSDI score of 13 or higher was defined as an indicator of the presence of dry eye symptoms²⁰.

Statistical analysis

The data analysis was conducted using SPSS 23.0 (IBM, Armonk, New York, United States). The OSDI scores were presented as mean \pm standard deviation (SD). The Kolmogorov-Smirnov test was used to test for normality, with a P-value > 0.05 indicating a normal distribution. For non-normally distributed data, the nonparametric Mann-Whitney U test was used for two independent samples, while the nonparametric Kruskal-Wallis test was used for more than two independent samples. To explore the association between the presence of dry eye symptoms in the population and potential predictive factors such as gender, age distribution, the use of eyeliner, and the presence of eyeliner tattoos, odds ratios (OR) and univariate, unadjusted logistic regression models were applied (Table 3). Furthermore, binary logistic regression analysis was conducted to pinpoint potential predictive factors for the population exhibiting symptoms of dry eye disease, focusing on eyeliner use, eyeliner tattoos, and gender (Table 4). The Chi-square tests were employed to assess the impact of various risk factors on the prevalence of the disease in the statistical analysis.

Results

A total of 654 questionnaires were gathered for the initial survey, with 354 from non-healthcare practitioners and 300 from healthcare practitioners (<https://www.wjx.cn/wjx/activitystat/verifyreportpassword.aspx?viewtype=1&activity=172487561&type=1>). The respondents included 158 males and 496 females aged 16–73 years old from various countries, with a mean age of 33.9 ± 8.1 .

In the follow-up survey focusing on eyeliner usage behaviors and OSDI scores, 1344 samples from 28 different countries were collected, including 169 males and 1175 females aged 16–60 years old, with a mean age of 19.4 ± 10.8 (<https://www.wjx.cn/wjx/activitystat/verifyreportpassword.aspx?viewtype=1&activity=158522950&type=1>). The results showed that the general public and healthcare practitioners reported cosmetics usage frequencies of 75.42% and 63.67% ($p < 0.01$), respectively (Fig. 1A and B). Additionally, 23.37% of patients were unwilling or hesitant to comply if advised to discontinue using cosmetics in medical situations (Fig. 1C), and only 48.19% of healthcare practitioners asked their patients about their cosmetic usage behavior during consultations (Fig. 1D).

There were 722 individuals in the control group (non-eyeliner users) with an average age of 23.86 ± 5.21 , and 622 individuals in the eyeliner group with an average age of 21.25 ± 4.89 . When using analysis of variance to compare the percentage of populations with an OSDI score higher than 13 between the eyeliner group and the control group, it was found to be 42.93% in the eyeliner group and 33.38% in the control group ($p = 0.0004$, $p < 0.001$, Fig. 2A and Supp Fig. 1A). After adjusting for confounding factors such as eyeliner tattooing, the

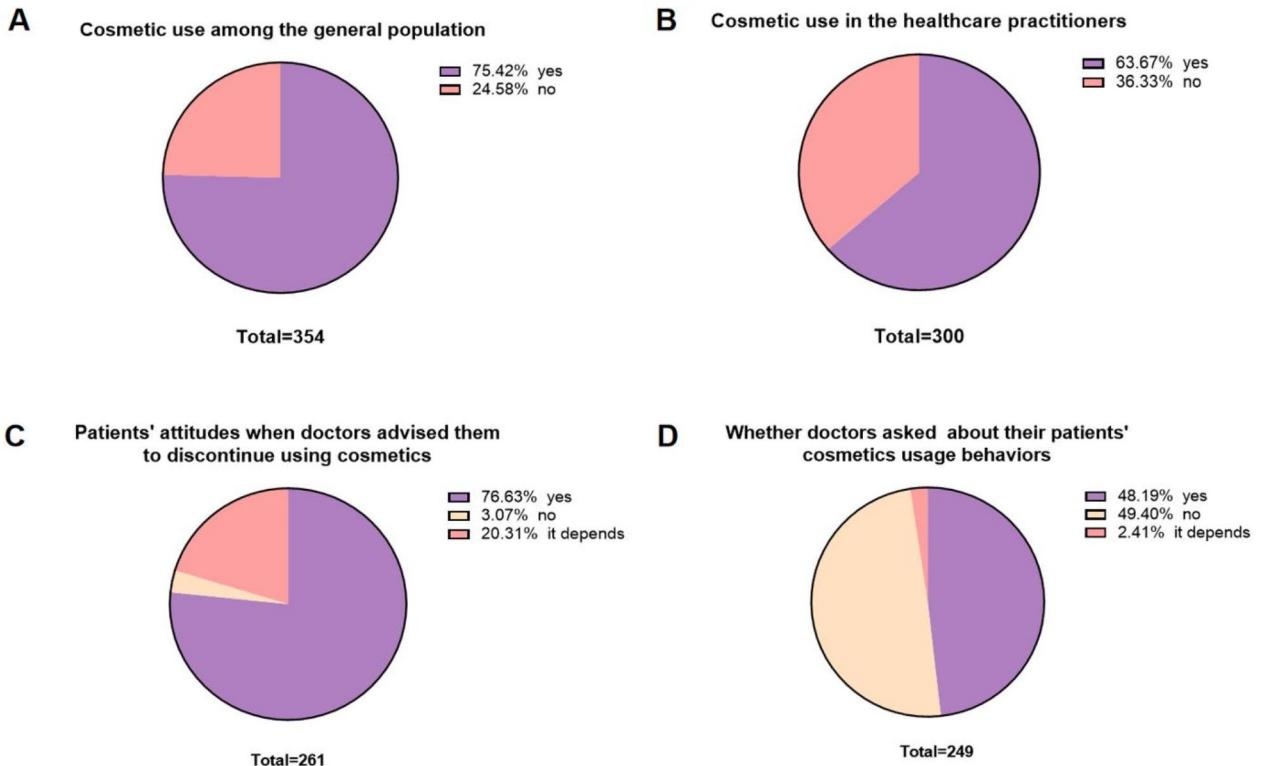
The question	The answer
Your age	
Your gender	
Your profession	
Do you wear eyeliner?	
The position of your eyeliner	Upper eyelid/ inside upper eyelid/ lower eyelid/ inside lower eyelid/ both
The location of your eyeliner	In front of the lash line/ on the lash line
The type of your eyeliner	Gel/ liquid/ pencil/ other
Do you have any systemic diseases	
Have you had any history of eye surgery, wearing contact lenses or scleral lenses, or using eye medication	
How long is your daily screen usage time?	
Do you often stay in an air-conditioned room? If it is yes, please specify the time.	
The brand of your eyeliner	
The frequency of eyeliner application (day/week)	
How long have you been using eyeliner ?	
Do you wear contact lenses or have any ocular surface disease?	
Eyeliner tattoo	
Eyes that are sensitive to light?	
Eyes that feel gritty?	
Painful or sore eyes?	
Blurred vision?	
Poor vision?	
Have problem with your eyes limited when reading?	
Have problem with your eyes limited when driving at night?	
Have problem with your eyes limited when working with a computer?	
Have problem with your eyes limited when watching TV?	
Have your eyes feel uncomfortable in windy conditions?	
Have your eyes feel uncomfortable in place with low humidity?	
Have your eyes feel uncomfortable in areas that are air conditioned?	

Table 2. Survey on the use of cosmetics and OSDI in the population.

	Total number of patients	With DED symptoms	Without DED symptoms	Crude		Adjusted	
				OR(95%CI)	P	OR(95%CI)	P
Total	1344	508	836				
Gender							
Male	169	55	114	1.000		1.000	
Female	1175	453	722	1.643(1.123–1.832)	0.003	1.357(0.979–1.530)	0.089
Age distribution							
≤ 40	1201	447	754	1.000		1.000	
> 40	143	61	82	1.255(0.833–1.783)	0.206	1.095(0.944–1.269)	0.158
Eyeliner							
Yes	622	267	355	1.467(1.174–1.826)	0.001	1.158(1.063–1.261)	0.001
No	722	241	481	1.000			
Eyeliner tattoo							
Yes	115	106	9	23.507(11.698–47.235)	0.001	8.513(4.537–15.973)	0.001
No	722	241	481	1.000			

Table 3. Univariate and multivariate logistic regression of potential predictive factors of population with DED symptoms. OR Odds ratios.

	B	S.E.	Wals	df	Sig.	Exp(B)
Variables in the equation						
Eyeliner	0.460	0.120	14.645	1	0.000	1.585
Eyeliner tattoo	3.728	0.593	39.454	1	0.000	41.585
Gender	0.306	0.180	2.888	1	0.089	1.357
Constant	-1.066	0.172	38.614	1	0.000	0.344

Table 4. Binary logistic regression of potential predictive factors of population with DED symptoms.**Fig. 1.** Survey of the cosmetics usage behaviors. (A) Cosmetic use among the general population. (B) Cosmetic use in the healthcare practitioners. (C) Patients' attitudes when doctors advised them to discontinue using cosmetics. (D) Whether doctors asked about their patients' cosmetics usage behaviors.

percentage of individuals with an OSDI score higher than 13 was significantly higher in the eyeliner users ($p=0.0086$, Fig. 2B and Supp Fig. 1B), but there was no significant difference between whether the participants applied eyeliner on the inner side of the lash line or the outer side ($p=0.14$, Fig. 2C and Supp Fig. 1C). The proportions of individuals with an OSDI score higher than 13 were significantly higher in those who applied eyeliner on the inner side of the lash line compared to the non-eyeliner users ($p=0.0006$, $p<0.001$, Fig. 2D and Supp Fig. 1D), and significantly higher in those with eyeliner tattoos compared with the control group ($p<0.0001$) (Fig. 3 and Supp Fig. 1E). In Supplementary Fig. 1, we plot the results mentioned above as a stacked bar chart to show the differences between groups more intuitively. It is important to note that the small sample size of the eyeliner tattoo population may impact the statistical significance. As the frequency of eyeliner increases, dry eye symptoms appear to increase (Fig. 4A). In addition, the longer the eyeliner was applied, the easier dry eye symptoms increase (Fig. 4B), which may be related to the inability to clean thoroughly and the residue of eyeliner ingredients.

Univariate logistic regression revealed that the following factors were significantly correlated with a population having a higher OSDI score (Table 3): gender (reference: male; female, crude OR=1.643 (1.123–1.832), $p=0.003$), eyeliner use (reference yes, crude OR=1.467 (1.174–1.826), $p=0.001$), and eyeliner tattoo (reference yes, crude OR=23.507 (11.698–47.235), $p=0.001$). And age (reference: ≤ 40 ; > 40 years old, crude OR=1.255 (0.833–1.783), $p=0.206$) was not significantly correlated which maybe because of only 143

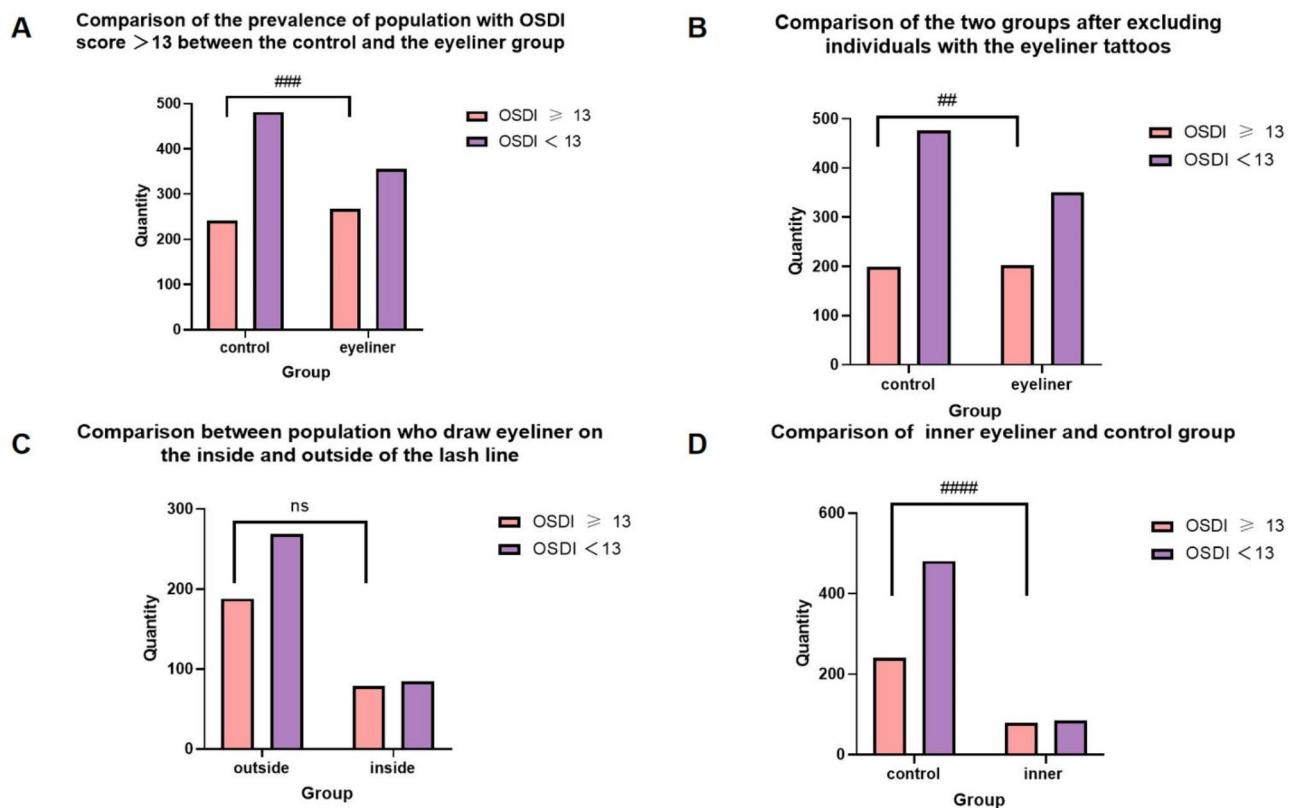


Fig. 2. Survey of eyeliner usage behaviors and OSDI scores. (A) Comparison of the prevalence of population with OSDI score >13 between the control and the eyeliner group. (B) Comparison of the two groups after excluding individuals with the eyeliner tattoos. (C) Comparison between population who draw eyeliner on the inside and outside of the lash line. (D) Comparison of inner eyeliner and control group. Chi-square test $\#p<0.05$, $\#\#p<0.01$, $\#\#\#p<0.005$, $\#\#\#\#p<0.0001$.

participants older. A final multivariate model was performed including gender, eyeliner use, and eyeliner tattoo as predictors which were statistically significant in the univariate analysis (Table 3). To further explore the contribution of different potential influential factors, binary logistic regression was used (Table 4). In binary logistic regression, the regression coefficient for the use of eyeliner was 0.46, which indicated that the use of eyeliner was positively correlated with dry eye symptoms, and the $p<0.0001$ was statistically different which further validates our suspicions. Eyeliner tattoo was found to significantly impact populations that have higher OSDI scores ($B = 3.728$, $p<0.0001$).

Discussion

In this questionnaire survey, it was observed that individuals who regularly use eyeliner tend to exhibit higher OSDI scores, suggesting a potential link between the use of this cosmetic product and the health of the ocular surface. This finding underscores the importance of considering cosmetics use as a potentially impactful factor on ocular health, which is often overlooked in routine assessments and discussions.

Eye makeup use is an omnipresent lifestyle choice and exerts a considerable influence on ocular health. Our research revealed a notable increase in the prevalence of dry eye symptoms among individuals who use eyeliner whether it's pencil or liquid, as opposed to those who do not. Specifically, we found that 42.93% of eyeliner users reported experiencing dry eye symptoms, which is significantly higher than the 33.38% observed among non-eyeliner users.

The analyses conducted in our study, including univariate and multivariate logistic regression as well as binary logistic regression (Tables 3 and 4), consistently demonstrated that the use of eyeliner is a significant predictor of dry eye symptoms²¹. These findings underscore the importance of considering cosmetic use, particularly eyeliner, as a contributing factor when assessing and managing dry eye conditions. This is consistent with the risk factors for dry eye mentioned in previous articles including gender, age, cosmetic use, etc^{1,22–24}. It is essential for both healthcare providers and the general public to be aware of the potential ocular health implications associated with the regular use of eye makeup products.



Comparison of the population with OSDI score >13 between the eyeliner tattoo group and the control group

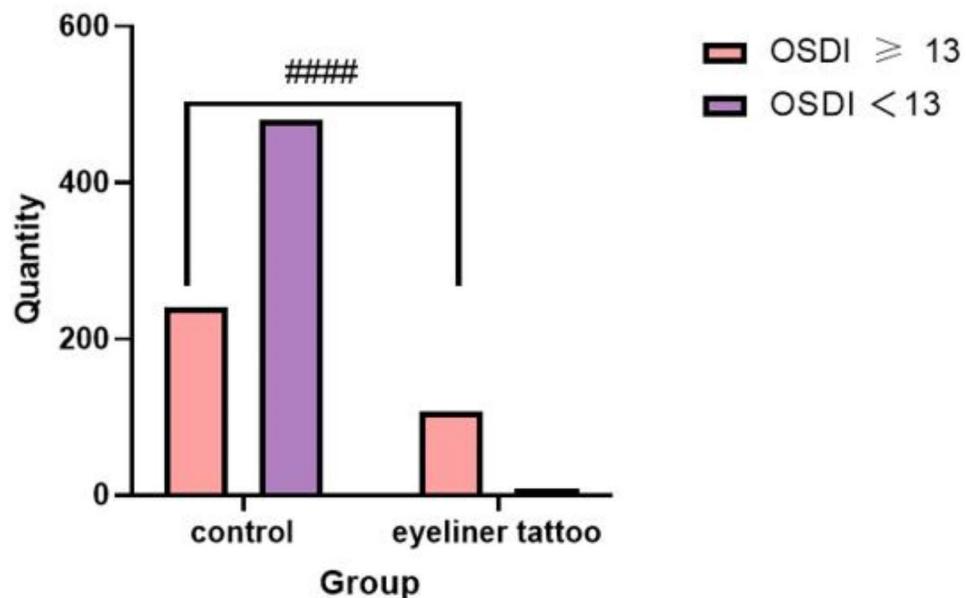


Fig. 3. Comparison of the population with OSDI score >13 between the eyeliner tattoo group and the control group. Chi-square test, #### $p < 0.001$.

Individuals who apply eyeliner, especially on the inner side of the lash line, have been found to exhibit a significantly higher rate of elevated OSDI scores when compared to the general population ($p < 0.001$). The inner side of the eyelash line is closer to the eye surface, and the application of eyeliner in this area increases the likelihood of the cosmetic's particles interacting with the ocular surface and tear films with each blink. Such contact can potentially lead to irritation and compromise the integrity and function of the ocular surface and the meibomian glands^{25–27}. Using eyeliner on the inner side of the eyelashes is more likely to cause dry eye symptoms compared to the outer side. Although our questionnaire also showed this result, there was no statistical difference, possibly because only 164 participants who used eyeliner on the inner side of the eyelashes were included, and the sample size was small or unevenly distributed. Moreover, our study found that individuals with eyeliner tattoos exhibited significantly higher OSDI scores compared to the control group. This result is consistent with a previous report on the impact of eyeliner tattoos on mice, which showed reduced tear secretion, ocular surface damage, and increased inflammation levels in both the meibomian gland and lacrimal gland^{10,28}. While our survey mainly focused on rinse-off eyeliner, we found that approximately 4.91% of participants who use eyeliner also have eyeliner tattoos. The presence of both temporary eyeliner applications and permanent eyeliner tattoos may exert a synergistic effect, potentially exacerbating the adverse impact on the ocular surface.

Interestingly, we observed 75.42% of the general public and 63.67% of healthcare practitioners reported daily cosmetic use, respectively ($p < 0.01$). And approximately half of the healthcare practitioners did not inquire about their patients' cosmetic usage habits during medical consultations. The proportion of women among healthcare practitioners is 74.33%, which is slightly lower than that in the general participant population (77.12%). Additionally, the average age of healthcare practitioners is 35.7 ± 6.9 years, compared to 32.1 ± 7.4 years in the general population. Given that the proportion of men who wear makeup is relatively low and some are reluctant to admit to it and complete the questionnaire, the differences in gender and age distribution may partially explain the variations in cosmetic usage observed between the two groups. However, these findings indicate that the use of makeup is an aspect that is often overlooked in clinical consultations. It is possible that

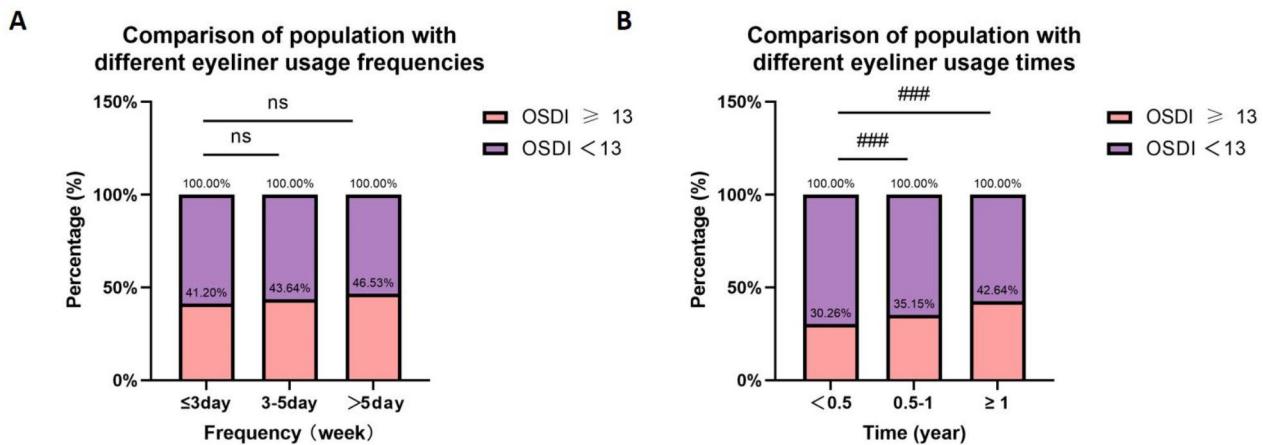


Fig. 4. Survey of eyeliner usage behaviors and OSDI scores. (A) Comparison of population with different eyeliner usage frequencies. (B) Comparison of population with different eyeliner usage times. Chi-square test $^{\#}p<0.05$, $^{##}p<0.01$, $^{###}p<0.005$, $^{####}p<0.001$.

healthcare professionals who use fewer cosmetics themselves may not fully recognize the prevalence of makeup use as a prominent lifestyle choice among their patients and its potential impact on eye health. Furthermore, our findings revealed that approximately 23.37% of patients were hesitant or unwilling to cease cosmetic use even when medically advised. This reluctance underscores the importance of patient education regarding the potential impact of cosmetics on the health of the ocular surface^{29,30}.

To be noted, this study primarily focused on the questionnaire, and we did not assess the objective signs of ocular surface disease. The reason for this is that the questionnaire was designed for the general population rather than patients visiting the hospital for consultation. Our goal was to include as many participants as possible, particularly healthy individuals or those with mild symptoms, as most hospital visitors tend to have more severe symptoms or other medical conditions. And it was impractical for us to collect objective data from 1,344 participants across various countries. It is worth noting that several studies have shown that the associations between signs and symptoms of dry eye are often low and inconsistent³¹⁻³³. Given that the primary objective of our study is to investigate the impact of eyeliner usage on dry eye symptoms, we chose to focus solely on questionnaire data. However, a small subset of participants underwent tests such as fluorescein tear film break-up time, tear meniscus height, ocular surface fluorescein staining, Schirmer I test, meibomian gland function assessment, and Demodex infection screening (Data not shown). The results from these tests were consistent with previous studies, which have shown that individuals who use eyeliner for extended periods are more likely to exhibit objective signs of dry eye compared to those who do not use eyeliner^{21,25,34}.

One limitation of our study is its primary focus on younger women, which may introduce bias. It's important to note that the use of cosmetics is not exclusive to females³⁵, but some of male cosmetic users are reluctant to admit and complete the questionnaire. Beside this limitation, the basic characteristics of the collected population were matched. Although our study lacked sufficient male participants, there is a growing number of males incorporating cosmetics into their routines. Clinicians are encouraged to take note of this trend and inquire about cosmetic use during consultations with male patients as well. Furthermore, our study did not analyze the ingredients in different eyeliner brands, nor consider the various levels of impact on the homeostasis of the ocular surface. In our future study, we will conduct further research on the mechanism by which eyeliners impact the ocular surface, as well as analyze the differences between eyeliner brands and their chemical composition.

To support eyeliner users in maintaining ocular health and to assist healthcare professionals in providing informed guidance, we propose the following guidelines:

1. Outer lash line application: We recommend applying eyeliner primarily on the outer side of the lash line during daily use. This technique reduces the risk of irritation and dry eye symptoms compared to applying eyeliner on the inner lash line or waterline.
2. Avoid inner lash line: Refrain from applying eyeliner on the inner lash line or waterline, as this can obstruct meibomian gland orifices and exacerbate dry eye conditions.
3. Timely cleaning: Ensure thorough and regular cleaning of the eyelids and lashes to remove residual makeup. Use gentle, non-irritating makeup removers or wipes specifically designed for the eye area.
4. Avoid sharing: Do not share eyeliner products with others to prevent the transmission of infections and contaminants.
5. Replace regularly: Replace eyeliner products regularly (i.e. every 3 months) to minimize the risk of bacterial growth and contamination.

6. Product selection: Choose eyeliners that are specifically formulated to be less irritating to the skin. Look for products labeled as hypoallergenic, fragrance-free, and ideally preservative-free. Individuals with a history of dry eye or sensitive skin should consult with an ophthalmologist or dermatologist for personalized recommendations.

In conclusion, our study highlights that the widespread use of eye cosmetics is associated with higher OSDI scores. It is imperative that both clinicians and patients be more cognizant of this common lifestyle practice and its implications for eye health. Healthcare providers should consider cosmetic use as a factor in their patient assessments and engage in patient education about the potential risks associated with their cosmetic routines.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Author contributions

Y.L. and M.K. proposed experimental design and ideas. Y.R.S. and A.G.S. collected of questionnaire data. Y.L. and Y.R.S. wrote the main manuscript text and prepared Tables 1, 2, 3 and 4; Figs. 1, 2, 3, 4 and 5 and supplementary figure 1. T.Z. revised the manuscript. All authors reviewed the manuscript.

Declarations

Competing interests

Yang Liu – ESSIRI Labs (Personal financial interests), Amy Gallant Sullivan – ESSIRI Labs (Personal financial interests), Lübris BioPharma (Personal financial interests). Other authors declare no conflict of interests.

Additional information

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