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Ocular and Visual Activities-related Complaints among Healthy Smokers: A cross-sectional study

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Abstract
Smoking and the harmful compound in smoke has been associated with many deleterious effects on the eye. Yet, the ocular and visual-related complaints that may arise due to physiological changes are inadequately explored. This study aimed to investigate the effect of smoking behaviour on ocular symptoms. A self-administered questionnaire describing the ocular surface discomfort and visual-related activities was distributed to healthy smokers. Majority of smokers reported severe dry eye symptoms and often complained of glare disability. A comparison of reported symptoms between groups showed older-aged, dual smokers, longer duration of smoking, and current-daily smokers obtained significantly higher scores ($p<0.005$).

Keywords: smoking; ocular complaint; ocular discomfort; dry eye

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1.0 Introduction

Tobacco consumption has been shown to decrease substantially in many countries, with the recent smoking prevalence among people above 15 years old standing at 17.5% in 2019 (Burki, 2021; World Health Organisation, 2018). Nevertheless, smoking prevalence among Malaysian male adults is still comparably higher (22.8%) than in developed countries like Singapore (16%) and there was an increase of 2.3% in the proportion of smokers among young adults in 2015 (Lim et al., 2018). Smoking tobacco is burning a substance or plant material, and the resulting smoke is typically inhaled and exhaled to be tasted and absorbed into the bloodstream. Tobacco cigarette smoking is the conventional way of smoking, consisting of a harmful complex mixture mainly nicotine, tars, carbon monoxide, and formaldehyde. While electronic cigarettes use a liquid solution typically containing nicotine, various chemical substances (such as propylene glycol or glycerol), and often flavouring that is heated by the battery and inhaled by the user. More than 70% of current e-cigarette users were also found to be conventional cigarette smokers (Ab Rahman et al., 2019).

Smoking has been linked to various types of ophthalmological disorders including dry eye disease, age-related macular degeneration (AMD), cataract, ocular inflammation, Graves ophthalmopathy, glaucoma, retinal ischemia, anterior ischemic optic neuropathy, and offspring strabismus from the smoking mothers (Galor & Lee, 2011; Hum et al., 2016; Makrynioti et al., 2020). The mainstream smoke, inhaled by smokers from the burning tobacco and side stream smoke emitted by the surrounding during puffs, contains the most

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hazardous chemicals during the vapour and particulate phase (Talhout et al., 2011). The mixture in tobacco smoke is toxic and potentially carcinogenic, with more than 5,000 chemicals. Though fewer toxins are reported in electronic cigarettes than in traditional cigarettes, the long-term effects of electronic cigarettes are still under investigation (Martheswaran et al., 2021). Electronic cigarettes might be used in combination with a tobacco product and may re-initiate nicotine addiction (Makrynioti et al., 2020). On that account, the physiological changes of the ocular structures due to the interaction of the toxic's cigarette ingredients with the sensitive organ including the eyes may arise visual and ocular-related complaints.

2.0 Literature Review

2.1 Smoking in association with ocular changes

A decrement in tear quality and quantity is observed among cigarette smokers. Cigarette smoke has been associated with ocular irritation and dry eye symptoms due to the lipid peroxidation process that leads to damage of the pre-corneal film lipid layer and changes of the conjunctiva and tears histological structures (Sayin et al., 2014). Also, meibomian gland dysfunction, chronic ocular surface inflammation, and a decrease in the sensitivity of the cornea and conjunctiva have been linked to smoking (Makrynioti et al., 2020). While in electronic cigarettes, the release toxicants in electronic cigarette vapours are known to be strong irritants for the eye, nose, and throat and to induce oxidative stress (Md Isa et al., 2019). Smokers exposed to dry eye syndrome, commonly complain of irritation, burning sensation, itchiness, lacrimation, and dryness, which can easily be screened with the Ocular Surface Disorder Index (OSDI) questionnaire.

Nicotine in the cigarette through the vasoconstriction mechanism results in reduced ocular blood flow and a significant decrease in choroidal thickness following oral intake (Zengin et al., 2014), which may induce an ischemic and hypoxic environment of the tissues. Nicotine also caused a significant decrease in macular microcirculation in a study investigating the acute effect of chewing nicotine gum on retinal microcirculation (Cınar et al., 2019). Besides, nicotine in e-cigarettes has been demonstrated to modify retinal response characteristics via interactions with nicotinic acetylcholine receptors (nAChRs). NAChRs have been discovered in the inner plexiform layer of humans and on amacrine cells in many animals. Furthermore, it has been demonstrated that applying nicotine, a nicotinic agonist, to amacrine cells indirectly promotes the release of dopamine, which may interfere with the ability of the retina to appropriately respond to the normal circadian cycle in a human (Martheswaran et al., 2021; Varghese et al., 2011). There were also changes in the crystalline lens through the direct oxidative damage mechanism; associated with the prevalence of nuclear and cortical opacities among smokers (Beltrán-Zambrano et al., 2019). Smokers also exhibit higher concentrations of cadmium in blood and lens, which alters the level of antioxidants.

2.2 Smoking behaviour and ocular-related problems

Previous studies have described the smoking behavior separately in terms of duration of smoking, number of cigarettes smoked, smokers status (active, passive, current, ever, or former), and also in forms of a type of smoking. The heavy smoker, classified as having 15 years or more cigarette pack-years, showed a significantly higher prevalence of nuclear cataracts and cortical cataracts than light smokers and never-smokers from the population-based cross-sectional Andhra Pradesh Eye Disease Study (Krishnaiah, Vilas, et al., 2005). Similarly, smokers with a history of heavy cigar smoking showed a significantly higher prevalence of AMD compared with never smokers, attributed to 14% of the avoidable risk of AMD in the study population (Krishnaiah, Das, et al., 2005). Cumulative smoking dose of cigarettes plays a significant role in accounting for the higher prevalence of ocular problems in the population. Also, the chronic and acute effects of smoking with regard to ocular circulation and ocular surface have been demonstrated in many studies (Ayhan et al., 2017; Bardak et al., 2017; Md Isa et al., 2019; Ortiz-Peregrina et al., 2021). Even in the acute period, smoking only one cigarette significantly decreased the retinal and optic disc vessel density parameters among non-smoking cases (Kaymaz et al., 2020).

Many studies demonstrated the effects of smoking at the microscopic and macroscopic levels. Yet, the visual and ocular-related complaints that may arise due to physiological changes of the ocular due to smoking is inadequately explored. Of importance, few studies document visual and ocular complaints specifically on types of smoking behaviour and few of the studies deliberately pick healthy smokers. Hence, this study aimed to determine the ocular discomfort and visual-related disabilities among healthy smokers with determined types of smoking behaviour.

3.0 Methodology

3.1 Study design

This cross-sectional study used a purposive-convenient sampling among healthy cigarette smokers in Selangor. The sample was calculated using the prevalence of current cigarette smokers in Selangor, estimated at 896 337 (IPH et al., 2019). Using Raosoft software, the total sample size for this study was 384 to 95% of the confidence interval, 5% margin error, and 50% of the response distribution.

This study was approved by the university's Research Ethics Committee (FERC/FSK/MR/2022/0077). The online platforms (Whatsapp, Facebook and Instagram) were used to advertise and spread the self-administered questionnaire. Malaysian citizens who smoke and live in Selangor were invited to participate in the study. The participants must be above 18 years old, healthy, and smoke whether tobacco cigarettes (conventional), electronic cigarettes (e-cigarettes), or both conventional and e-cigarettes. Contact lens

wearers, or those with systemic diseases such as Diabetes Mellitus and Hypertension were excluded from the study. The exclusion criteria also include those who have ophthalmological disorders such as dry eye diseases (DED), anterior ischemic optic neuropathy, age-related macular degeneration (AMD), cataract, thyroid-associated ophthalmopathy (TAO), open-angle glaucoma, and diabetic retinopathy. Written informed consent was obtained from all the participants after being explained the purpose and possible consequences of the study through the Google Forms platform.

3.2 Study instrument

The questions were adapted from The Ocular Surface Disease Index (OSDI), which aims to identify symptoms related to the anterior segment surface (Rahman et al., 2017), and the Visual Activities Questionnaire (VAQ), which aims to identify the visual function status of respondents (Sloane, M.E., Ball, K., Owsley, C., Bruni, J.R., Roenker, 1992). A pilot study was conducted with ten voluntary participants to identify any misleading mistakes in the questionnaire that could lead to unreliable responses.

The questionnaire included in this study was divided into four sections:

i) Section A: Social demographic information includes age, gender, race, living areas in Selangor, history of systemic or ophthalmic disease, eye surgery, and contact lens wear.

ii) Section B: Smoking behaviour consists of six questions: the type of cigarette that the respondents use (conventional cigarettes or e-cigarettes, or both), their current smoking statuses such as current-daily or current-occasional smokers (current smokers are defined as smokers who smoke at least one cigarette per day in the last 30 days), the number of cigarettes they smoke (in a day), duration (years of smoking) and voltage used for electronic cigarette.

iii) Section C: This section aims to identify symptoms related to the anterior segment surface. The questions are adopted from The Ocular Surface Disease Index (OSDI) (Rahman et al., 2017). Twelve items in the OSDI questionnaire were scored on a scale of 0 to 4 and not applicable, with 0 indicating none of the time, 1 indicating some of the time, 2 indicating half of the time, 3 indicating most of the time, and 4 indicating all the time. The total OSDI score was then computed using the formula: OSDI= [(sum of scores for all questions answered) 25] / [(total number of questions answered)]. As a result, the OSDI is graded on a scale of 0 to 100, with higher scores indicating greater disability. Subscale scores are generated the same way, with only the questions from each subscale being utilized to build its score.

iv) Section D: This section aims to identify the visual function status through grating disabilities in performing visual activities among respondents. It consists of 14 questions adapted from the Visual Activities Questionnaire, VAQ (Sloane, M.E., Ball, K., Owsley, C., Bruni, J.R., Roenker, 1992). The items that are selected from this questionnaire are; a) Color Discrimination (three items); b) Glare Disability (four items); c) Light/Dark Adaptation (four items); and d) Acuity/spatial Vision (four items). The goal of the VAQ is to construct a composite score for each visual function area that summarizes the subject's responses to the items addressing that visual function. The following scales are used to score an individual item on the VAQ: Never=1, rarely=2, sometimes=3, often=4, always=5. The mean response for the elements provided for a visual function is used to calculate the composite score for that visual function. Higher scores indicate worse visual function.

3.3 Data analysis

Data analysis was done using 'Statistical Package for Social Sciences' (SPSS) version 28.0. According to the data analysis, the Kolmogorov-Smirnov, Skewness/Kurtosis, histogram, and Q-Q Plot showed non-normal distribution. Therefore, the non-parametric Kruskal-Wallis and Man-Whitney test were used to determine the difference between smoking behaviours with OSDI and VAQ scores amongst smokers. Meanwhile, Kendall's tau-b correlation was run to determine the relationship between age and smoking behaviour factors towards OSDI and VAQ scores amongst smokers ($p<0.05$, CI=95% of the confidence interval).

4.0 Findings

4.1 Demographic distribution

Of 569 participants who returned the survey, only 518 samples qualified following inclusion and exclusion criteria. Demographic distribution showed the mean age of smokers was 31.27 (±9.16) years old, ranging from 18 to 67 years old, with a majority of them being males (93.8%) and from Malay ethnicities (76.8%). Tobacco cigarette smokers are the largest group among smokers (44%), and current-daily smokers are higher (78.6%) than current-occasionally smokers in this study. The demographic data of the participants are summarized in Table 1.

The ocular and visual-related complaints among dual smokers were assessed using OSDI and VAQ. This study found moderate OSDI scores among smokers, with a mean of 28.62 ±20.34. Figure 1 describes the distribution of OSDI scores based on the severity of the dry eye syndrome group. As for VAQ, the highest median score for visual-related complaints was glare disability (3.39 ±0.84). The response of VAQ on each selected visual function is summarized in Figure 2.

Table 1. Demographic data of smokers

Variables (n=518)	Categories	Frequency (%)
Age	18-27	223 (43.1)
	28-37	181 (36.9)
	38-47	72 (13.9)

	48-57	21 (4.1)
	58-67	11 (2.1)
Gender	Male	486 (93.8)
	Female	32 (6.2)
Race	Malay	398 (76.8)
	Chinese	87 (16.8)
	Indian	33 (6.4)
Types of cigarettes	Tobacco cigarette	228 (44)
	Electronic cigarette	187 (36.1)
	Dual smokers	103 (19.9)
Smokers' status	Current-daily	407 (78.6)
	Current-occasionally	111 (21.4)
Frequency of smoking	<10 sticks per day	139 (26.8)
	10-25 sticks per day	105 (20.3)
	>25 sticks per day	45 (8.7)
Voltage level for e-cigarette	Low (below 3.9V)	52(10)
	Moderate (4.0-4.9V)	147 (28.4)
	High (more than 5.0V)	16 (3.1)
	Not sure	74 (14.3)
Duration	<5 years	283 (54.6)
	6-10 years	141 (27.2)
	>10 years	94 (18.1)

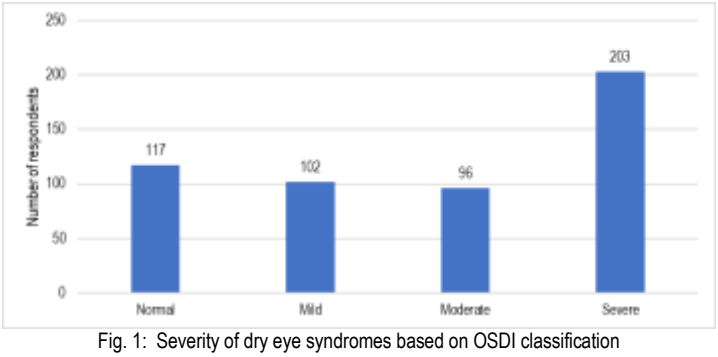
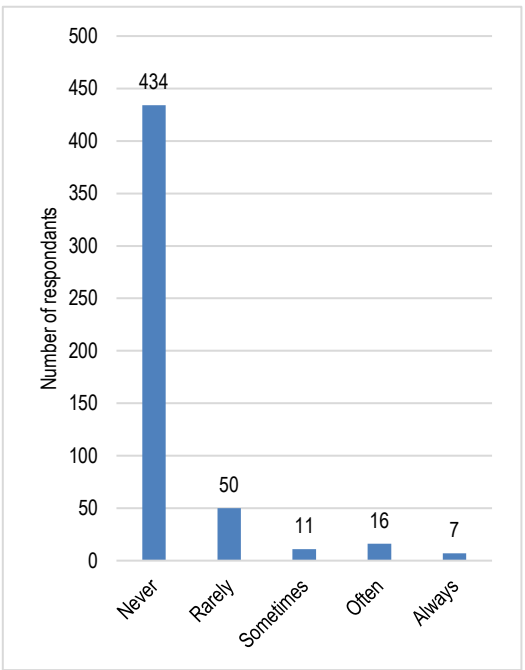
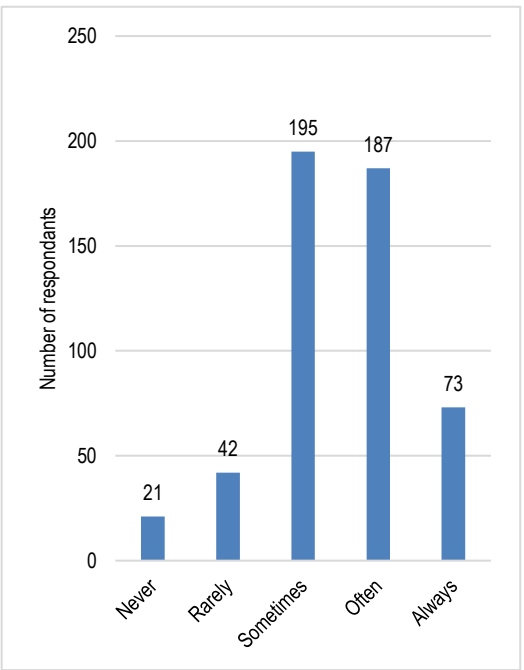


Fig. 1: Severity of dry eye syndromes based on OSDI classification



(a) Color discrimination



(b) Glare disability

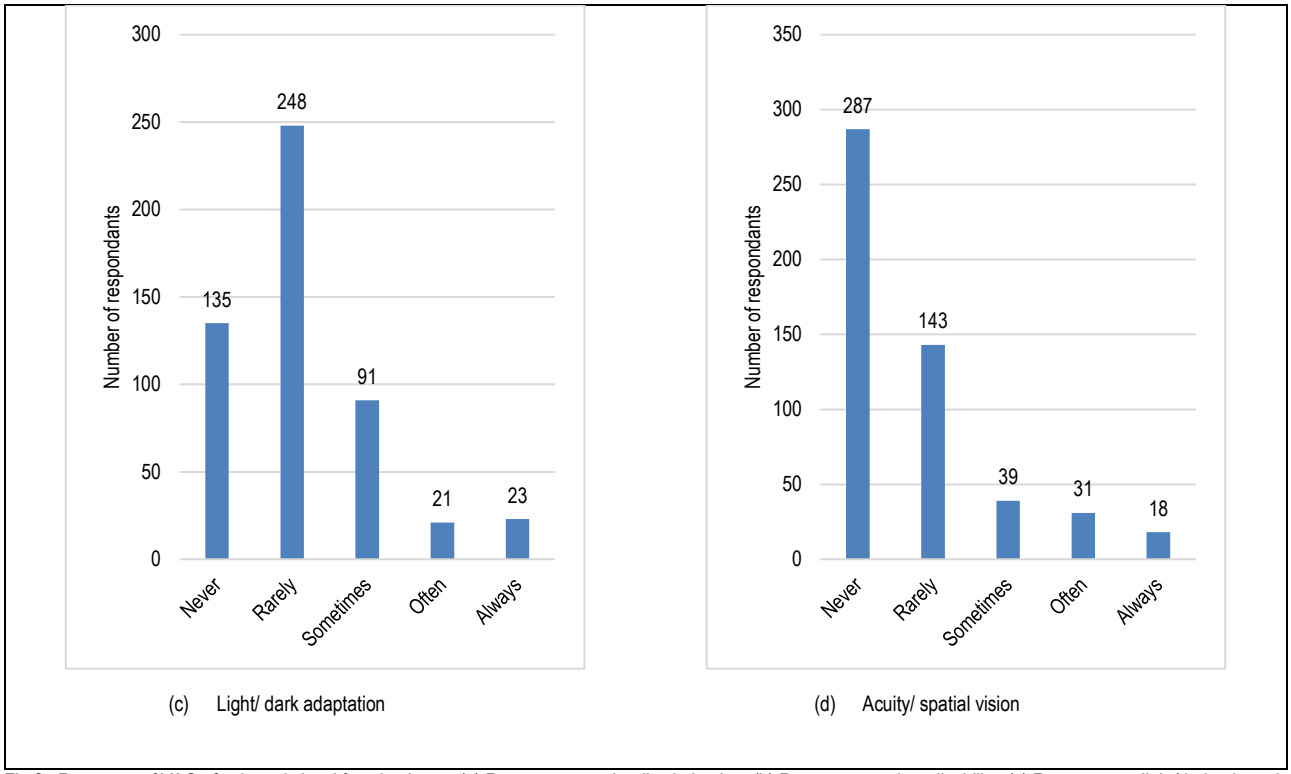


Fig 2: Response of VAQ of selected visual function items, (a) Response on color discrimination; (b) Response on glare disability; (c) Response on light/dark adaptation; and (d) Response on acuity/spatial vision

4.2 Smoking Behaviour and ocular discomfort

The comparison of OSDI scores between each category of smoking behaviour was identified using Kruskal-Wallis or Mann-Whitney test, as appropriate. Types of smoking, duration of smoking, the common voltage used for vaping, and smoking status significantly differ within each category ($p<0.001$) (Table 2). Kruskal-Wallis post hoc analysis revealed dual smokers and more than ten years duration of smoking obtained significantly higher OSDI scores ($p<0.001$). For the common voltage used for e-cigarettes, the pairwise comparison showed unsure voltage used obtained a higher OSDI scores rank (Mdn=33.71) than the moderate voltage (Mdn= 18.75); ($\chi2(3)=13.25$, $p<0.004$). Meanwhile, a Mann-Whitney test between the status of smokers' categories indicated current-daily smokers had higher OSDI scores rank (Mdn=29.55) than current-occasionally smokers (Mdn=16.67); ($U=15283.00$, $p<0.001$).

Table 2. Comparison of OSDI scores between groups

Variables	Categories	n	Median (IQR)	Mean rank	Kruskal Wallis (df) / Mann-Whitney U	P=value
Type of smoking	Tobacco	228	29.17 (26.94)	279.98	79.35 (df=2)*	<0.001
	E-cigarette	187	16.67 (17.70)	188.17		
	Dual	103	41.67 (25.00)	343.66		
Duration of smoking	<5 years	283	20.83 (25)	223.23	49.26 (df=2)*	<0.001
	6-10 years	141	29.55 (26.52)	274.87		
	>10 years	94	41.67 (25.40)	345.63		
TC sticks per day	<10 sticks per day	139	36.36 (22.92)	146.81	4.312 (df=2)*	0.116
	10-25 sticks per day	105	39.58 (32.58)	152.46		
	>25 sticks per day	45	27.08 (20.83)	122.00		
EC voltage	Low (3.9V)	52	27.5 (35.12)	161.63	13.25 (df=3)*	0.004
	Moderate (4-4.9V)	147	18.75 (22.92)	127.48		
	High (>5V)	16	21.87 (50.52)	159.66		
	Not sure	74	33.71 (37.60)	164.96		
Smoking status	Current, daily	407	29.55 (30.00)	277.45	15283.00^	<0.001
	Current, occasionally	111	16.67 (19.17)	193.68		

* Kruskal-Wallis test. ^Mann-Whitney test. TC: Tobacco cigarette; EC: Electronic cigarette.

4.3 Smoking behaviour and visual-related complaints

Types of smoking, duration of smoking, the common voltage used for vaping, and smoking status significantly differ within each category ($p<0.001$) (Table 3). Kruskal-Wallis post hoc analysis revealed dual smokers with more than ten years duration of smoking and current daily smokers significantly obtained higher mean rank for colour discrimination, glare disability, light/dark adaptation, and acuity/spatial vision indicating the more frequent vision-related activities disability experienced by the respondents ($p<0.001$). The number of tobacco cigarette sticks per day and electronic cigarette voltage used insignificantly differed across vision-related activities ($p>0.05$), except for acuity/spatial vision ($p<0.001$).

Table 3. Comparison of VAQ scores between groups

	Categories	n	Color discrimination		Glare disability		Light/ dark adapatation		Acuity/ spatial vision	
			Mean rank	X^2, df /U (p-value)	Mean rank	X^2 / U (p-value)	Mean rank	X^2 /U (p-value)	Mean rank	X^2 /U (p-value)
Type of smoking	Tobacco	228	264.50	8.490, df=2	280.52	50.43, df=2	251.28	18.22, df=2	300.51	18.22, df=2
	E-cigarette	187	240.43	(p=0.014)	201.26	(p<0.001)	239.78	(p<0.001)	181.03	(p<0.001)
	Dual	103	282.88		318.69		313.50		311.18	
Duration of smoking	<5 years	283	241.16	22.21, df=2	239.53	21.41, df=2	245.02	9.74 (p<0.001)	238.35	51.61 (p<0.001)
	6-10 years	141	262.33	(p<0.001)	258.76	(p<0.001)	262.15		236.22	
	>10 years	94	310.48		320.72		299.11		358.09	
TC sticks per day	<10 sticks per day	139	148.09	8.85, df=2	145.68	1.82, df=2	137.59	2.70, df=2	125.25	15.37, df=2
	10-25 sticks per day	105	153.70	(p=0.12)	150.27	(p=0.40)	154.86	(p=0.26)	161.44	(p<0.001)
	>25 sticks per day	45	115.13		130.61		144.88		167.66	
EC Voltage	< 3.9 V	52	162.87	6.65, df=2 (p=0.084)	163.92	4.68, df=2 (p=0.197)	150.92	0.810, df=2 (p=0.847)	168.63	23.04, df=2 (p<0.001)
	4.0 - 4.9 V	147	135.82		136.74		142.28		126.55	
	>5.0 V	16	153.19		158.84		157.25		211.31	
	Nor sure	74	148.91		145.11		143.60		150.72	
Smoking status	Current-daily	407	269.74	18422.50^ (p<0.001)	273.29	16976.50^ (p<0.001)	275.45	16095.50^ (p<0.001)	266.11	19899.00^ (p<0.001)
	Current-occasionally	111	221.97		208.94		201.00		235.27	

X^2:Kruskal-Wallis; U/^: Mann-Whitney. TC: Tobacco cigarette; EC: Electronic cigarette.

4.4 Association of smoking behaviour factors and OSDI and VAQ scores

A Kendall's tau-b correlation was run to determine the relationship between age and smoking behaviour factors towards OSDI and VAQ scores amongst smokers (Table 4). There was a weak, positive correlation between age and duration of smoking, with OSDI and VAQ scores amongst smokers, which was statistically significant (p<0.001). The number of tobacco cigarette sticks per day and the status of smokers obtained a weak, negative correlation with OSDI and VAQ scores among smokers, which was statistically significant (p<0.001).

Table 4. Association of smoking behaviour factors and OSDI and VAQ scores

	OSDI	Color discrimination	Glare disability	Light/ dark adaptation	Acuity/spatial vision
	τb, (p-value)	τb, (p-value)	τb, (p-value)	τb, (p-value)	τb, (p-value)
Age	0.155, (p<0.001)	0.612, (p=0.002)	0.141, (p<0.001)	0.122, (p<0.001)	0.143, (p<0.001)
Types of cigarette	0.596, (p<0.18)	0.012, (p=0.760)	-0.013, (p=0.717)	0.094, (p=0.010)	-0.093, (p=0.011)
Duration of smoking	0.244, (p<0.001)	0.162, (p<0.001)	0.152, (p<0.001)	0.125, (p<0.001)	0.176, (p<0.001)
TC sticks per day	-0.336, p<0.001)	-0.240, (p<0.001)	-0.279, (p<0.001)	-0.148, (p<0.001)	-0.199, (p<0.001)
EC voltage	0.051 (p=0.266)	-0.028, (p=0.596)	-0.037, (p=0.447)	-0.012, (p=0.797)	0.008, (p=0.869)
Smokers status	-0.190, (p<0.001)	-0.149, (p=0.001)	-0.156, (p<0.001)	-0.184, (p<0.001)	-0.075, (p<0.050)

τb: Kendall's tau-b coefficient; TC: Tobacco cigarette; EC: Electronic cigarette.

5.0 Discussion

This study attempts to determine possible ocular discomfort and disability in performing visual-related activities among healthy smokers by scoring of the Ocular Surface Disease Index (OSDI) and Visual Activities Questionnaire (VAQ).

The mean OSDI scores recorded in this study was 28.62 ±20.34, indicating a moderate category of dry eye syndrome based on OSDI severity classification. These findings corroborate many studies that suggest the pronounced dry eye syndrome among smokers (Makrynioti et al., 2020; Martheswaran et al., 2021; Najmee et al., 2022; Sayin et al., 2014). A previous study found higher OSDI scores and increased lissamine green staining in chronic smokers than in control subjects. Oxidative and ischemic damage and smoked-direct exposure to the ocular surface and cornea increased the subjective complaints (Ağın et al., 2020). According to the Blue Mountains Eye Study, smoking cigarettes may be a substantial risk factor for dry eyes (Chia et al., 2003). Additionally, smoking was found to have

statistically significant adverse effects on the precorneal tear film and ocular surface, lower Schirmer's scores and tear break-up time, meibomian gland dysfunction, and alteration of microscopy characteristic of the cornea (Ağın et al., 2020; Makrynioti et al., 2020; Sayin et al., 2014). Several causes of dry eye have been proposed, including persistent ocular surface inflammation, decreased sensitivity of the cornea and conjunctiva, decreased tear production and stability, and epithelium damage (Mantelli et al., 2013).

As a result of this study, aging is associated with a higher OSDI score ($p<0.05$). In one study, individuals' age has been a risk factor for higher OSDI scores (Hashmani et al., 2020). When the age group graphed the OSDI score, it showed a significant increment in OSDI score from the third to fourth decade of life, followed by a constant increase. Furthermore, older people have been reported to have lower goblet cell densities on the ocular surface (Wei et al., 2011). It has been demonstrated that each of the mentioned changes affects how the aging tear film behaves and functions, affecting the dry eye condition. Hence, it can be hypothesized that the increasing age might exacerbate the dry eye symptoms among dual smokers in this study.

In a study of the prevalence of e-cigarette use among adults in Malaysia, among current e-cigarette users, 74% (95% CI = 64-82) also smoked tobacco cigarettes (Ab Rahman et al., 2019). In this study, a comparison between groups showed dual smokers obtained higher OSDI scores compared to tobacco cigarette smokers and electronic cigarette smokers ($p<0.005$). Though no tobacco and no combustion in electronic cigarettes are used, the harmful levels of toxic chemicals in heated electronic cigarettes require long-term effect investigation (Makrynioti et al., 2020). Previous studies have also documented higher OSDI scores among vapers compared to non-smokers (Md Isa et al., 2019). The release of toxicants in electronic cigarettes vapours, particularly formaldehyde, acetaldehyde, acrolein, and free radicals, are known to be strong irritants to the eyes and to induce oxidative stress (Md Isa et al., 2019). The symptoms might be exacerbated with the combination of tobacco cigarettes among dual smokers.

Duration of smoking, number of tobacco cigarette sticks per day and electronic cigarette voltage may illustrate the cumulative smoking dose. Based on one study entitled Effect of Smoking on Ocular Surface and Tear Film Resulting from smoking frequency, the OSDI score was significantly higher in heavy (>20 cigarettes) smokers than in light (<10 cigarettes) and moderate (11 – 20 cigarettes) smokers. However, the difference was insignificant (Agrawal et al., 2018). Satici et al. (2003) stated that a study conducted by Kjaegard showed tobacco employees exposed to high concentrations of the chemical experienced a greater level of eye discomfort (Satici et al., 2003). High concentrations of the chemical were believed in longer duration of smoking, number of cigarettes smoked, and the usage of both tobacco and electronic cigarette per smoker.

The most frequent visual-related activities complaint recorded was glare disability with most respondents answering 'sometimes' (37.6%) to 'often' (36.1%) experiencing the symptoms. One study said that dry eye patients' tear film changes could cause corneal surface abnormalities, resulting in glare impairment (Huang et al., 2002). In addition, light beam aberrations and scattering inaccuracies may be related to surface structural irregularities, which then cause the cornea scatters light and reduce vision quality, leading to glare (Spadea et al., 2016).

There were several limitations in conducting this study. Firstly, we used self-reports of ocular complaints with no objective testing; thus, we could not clinically diagnose our participants as having mild dry eye disease. The next limitation that we encountered was the presence of external factors that could contribute to our findings among smokers. Smoking might not be the sole contributing factor to the mild dry eye disease that smokers in our study were found to have. Although healthy smokers who had undergone refractive surgery and wore contact lenses had been excluded from the test to avoid any participants having pre-existing dry eye disease, dry eye is also influenced by environmental factors, including wind, high temperature, low humidity, high altitude, and air pollution.

6.0 Conclusion and Recommendation

Based on this study, healthy smokers manifest moderate dry eye symptoms and glare disability as their ocular and visual activities-related complaints. This study provides insight into how ocular comfort and disability in visual-related activities are represented through smoking behaviours. Future research can be done in conjunction with experimental procedures to assess tear film and ocular surface integrity as well as other visual function tests such as non-invasive tear break-up time, fluorescein break-up time, and tear meniscus, 100 hues, functional acuity contrast sensitivity, and functional vision analyzer tests to support the hypothesis. Another suggestion that could be made is to identify the correct voltage and nicotine concentration of each e-cigarette to allow the correct level of power output and nicotine to be determined. Also, a study on the effect of smoking on ocular and visual activities-related complaints among secondary or passive smokers should be further investigated, thus helping spread awareness of the adverse impact of smoking on ocular health not only to an individual but to the people around them.

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Paper Contribution to Related Field of Study

This study provides insight into how ocular comfort and disability in visual-related activities are represented through smoking behaviours.

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