

# Risk Factors Affecting Dry Eye Symptoms among Visual Display Terminal Users

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## ABSTRACT

**Introduction:** Dry eye symptoms are the common ocular complaints that are found at the ophthalmologic outpatient services. This research's main purposes were to study the risk factors associated with dry eye symptoms and to evaluate the severity of dry eye among Visual Display Terminal (VDT) users. **Methods:** This study was a descriptive observational study involving 104 VDT users in 3 branches of the Social Security Offices and the Bureau of Labor Protection and Welfare in Samutprakarn province, Thailand. The study instruments used were: (1) questionnaires associated with VDT use and dry eye symptoms that were evaluated by using the Ocular Surface Disease Index (OSDI) and (2) Lux meter for desk-brightness and the angle of gaze measurement during VDT use. Data were analyzed using a Chi-square test and multiple logistic regression. **Results:** The results found that VDT users had severe dry eye symptoms, accounting for 51.9%, and experienced moderate and mild dry eye symptoms in the same number, which was 24.0%. In addition, dry eye symptoms were related to VDT use for 5-7 hours/day with statistically significant value. Other VDT use factors, including the desk-brightness or the angle of gaze during VDT use, were related to severe dry eye symptoms with no statistically significant difference. **Conclusion:** Based on the findings, VDT users should use VDT no more than 5 hours/day in order to reduce VDT-related dry eye symptoms. these factors were not statistically significant for the occurrence of severe dry eye symptoms.

**Keywords:** desk-brightness, dry eye symptoms, risk factors, visual display terminal users

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## INTRODUCTION

Today, the digital era 4.0 is an era of technological advancement. Computers, therefore, play a very important role in the daily work in both public and private organizations. Computers help collect information and process storage quickly and efficiently (Office of the National Digital Economy and Society Commission, 2017). According to a survey in 2018, 99.7% of office workers used computers on a regular basis (National Statistical Office, 2018). Using a Visual Display Terminal (VDT) to work for more than 2 hours can cause eye symptoms including headaches, blurred near-sightedness, blurred far-sightedness, dry eye, burning sensation, red eye, watery eye, double vision, eyelid twitching or distorted vision (Ranasinghe *et al.*, 2016; Rungsirisangratana, Pinsuwannabud and Hirunphasert, 2020). The American Optometric Association (AOA) describes an eye syndrome associated with the use of digital devices in relation

to vision. Using a VDT for a long time can cause eye disorders and visual problems. The level of abnormality can increase when using a VDT for a long period. In average, Americans use a computer to work in the office 7 hours a day (Randolph, 2017).

Dry eye symptoms are the common ocular problems among VDT users. A study on employees working with a VDT in India found that the prevalence rate of dry eye among VDT users was 75.0% (Mallik *et al.*, 2017), while a study in Japan found 60% of the VDT workers had dry eye (Kawashima *et al.*, 2015). Furthermore, a study in Samutprakarn province, Thailand, revealed that industrial factory workers who used a VDT had the symptoms of burning/irritation and dry eye at 69.2% and 41.5%, respectively (Rungsirisangratana, Pinsuwannabud and Hirunphasert, 2020). Dry eye has been the most common symptom that leads patients to visit their ophthalmologists. Moreover, dry eye has contributed to health costs both directly and indirectly, affecting the overall quality of life and vision. In fact, most dry eye patients have normal vision. However, when assessing the quality of vision, it is often found that decreased visual

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acuity is caused by tear instability and corneal surface irregularity, so some patients have a higher-order aberration or have irregular astigmatism that cannot be corrected by wearing glasses (Lekhanont, 2018). Furthermore, the DREAM clinical trial at 27 clinical centers in United States found that worse symptoms of dry eye were associated with decreased work productivity and activity levels (Greco *et al.*, 2021).

From the statistical report of dry eye symptoms of those who came to receive services in the ophthalmology outpatient unit, Rajaprachasamasai Institute, Department of Disease Control, Samutprakarn province, Thailand in 2019, it was found that 32 out of 58 employees (57.11%) who worked with a VDT in Social Security Offices and Bureau of Labor Protection and Welfare in Samutprakarn province had dry eye (Rajprachasamasai Institute, 2019). This is considered a group of office workers who suffer from relatively high dry eye problems and may have an increasing rate of the disease. Nevertheless, data on the relationship between dry eye symptoms and computer screen workers in Thailand are still limited. Therefore, this study aims to study the risk factors for dry eye symptoms among VDT users in offices in Samutprakarn Province, Thailand. It is expected that the results of the study can be used as a guideline to reduce risk factors for dry eye symptoms including planning for surveillance, prevention, and control of occupational diseases as well as to further improve the quality of life of the working age group.

## METHODS

This study was a descriptive observational study. The study used the entire population working in front of a computer screen in 3 branches of the Social Security Offices and the Bureau of Labor Protection and Welfare in Samutprakarn Province, Thailand. All 104 employees who worked in front of a computer screen in all branches of the Social Security Offices and the Bureau of Labor Protection and Welfare in Samutprakarn province voluntarily participated in this study. The exclusion criteria included workers who only had one eye, wore an eye prosthesis or had glaucoma. The duration of the study was between February 2021 and April 2021. The study instruments consisted of (1) questionnaires and (2) an environmental assessment.

(1) Questionnaires were divided into 3 parts. Part 1 consisted of personal data of employees who worked with a VDT in the office, including age, gender, underlying diseases, history of ocular surgery, menopause (females only), alcohol drinking, smoking habits, a condition of wearing contact lens, and number of years working with a VDT. Part 2 consisted of information about working with VDT among employees in the office, including the number of hours of VDT use per day, overtime use of VDT, eye breaks during VDT use, and a light filter attached to a VDT. Part 3 consisted of a questionnaire related to dry eye symptoms, based on the Ocular Surface Disease Index (OSDI), with a total of 12 questions; this is the most popular questionnaire for dry eye symptoms evaluation since the diagnostic criteria and severity of dry eye symptoms are numerically indicated and uncomplicated for evaluation (Stapleton *et al.*, 2017; Wolffsohn *et al.*, 2017). The questionnaire consisted of 3 parts: 1) 5 questions about the ocular symptoms experienced by the patient, 2) 4 questions about the effects of dry eye symptoms on vision, and 3) 3 questions about environmental factors that exacerbate dry eye symptoms. The employees were asked to answer these questions based on what they felt during the past 1 week. Each question had five possible answers based on the frequency of symptoms, ranging from 0 meaning no symptoms to 4 meaning having symptoms all the time. Then, the scores for each item were added together. The scores for each part were 1) + 2) + 3), divided by the number of questions answered and multiplied by 25 (0-12 = no dry eye symptoms, 13-22 = mild dry eye symptoms, 23-32 = moderate dry eye symptoms, greater than 32 = severe dry eye symptoms) (Schiffman *et al.*, 2000).

The validity of the Part 1 and 2 questionnaires were verified by 3 qualified specialists, 2 ophthalmologists and 1 ophthalmic nurse who examined the accuracy and coverage of the questionnaire content. The verified questionnaires were used for reliability testing on 30 employees who worked in front of computer screen in government offices. The Cronbach's alpha formula was used for the questionnaire reliability with the Cronbach's alpha coefficient of 0.60. Meanwhile, the Part 3 questionnaire was one of the standard questionnaires for dry eye assessment with the Cronbach's alpha coefficient of 0.92 (Schiffman *et al.*, 2000).

(2) Assessment of environmental factors used scientific instruments. First, the brightness of the individual VDT desk was measured using a Lux meter, Extech®, Heavy Duty Light Meter model 407026. Brightness was measured by having employees sit at their VDT desks. Then, the Lux meter was placed at the midpoint of the distance between the center of the VDT screen and the employees' eyes. After that, the brightness value that the Lux meter showed as a number on its digital screen was read. The unit of that number was Lux. Secondly, the magnitude of the angle of gaze that VDT users looked at their VDT screen was measured by having the employees sit at their VDT desks. Then, the distance between the center of the VDT screen and the eyes, and the distance between the center of the VDT screen and the top edge of the VDT screen were measured. After that, the magnitude of the angle of gaze was calculated using the mathematical formula:  $\sin C = B/A$  where A (in centimeter) was the distance between the center of the VDT screen and the eyes, B (in centimeter) was the distance between the center of the VDT

screen and the top edge of the VDT screen, and C (in degrees) was the magnitude of the angle used to view the VDT screen.

This study has been reviewed and approved by the Human Research Ethics Committee of the Rajprachasamasai Institute, Department of Disease Control, Ministry of Public Health, Thailand, No. 63001, dated November 17, 2020.

The data were used to assess the severity of dry eye symptoms using descriptive statistics, analyze the relationship between the risk factors and the occurrence of dry eye symptoms with Chi-Square test and analyze risk factors for dry eye symptoms among employees working with a VDT using multiple logistic regression statistics with a Statistical SPSS Version 22.0.

## RESULTS

The study found that 104 employees who worked with a VDT were mostly females of 89 (85.6%). Furthermore, 61.5% of all employees were older than or equal to 40 years old, 76 employees

**Table 1.** Risk factors for Severe Dry Eye Symptoms among VDT users in Samutprakarn, Thailand between February 2021 and April 2021

Variables	VDT Users		Severe Dry Eye Symptoms		OR (95%CI)	p-value
	Person	percentage	person	percentage		
Gender						
Male	15	14.4	9	60	1	0.500
Female	89	85.6	45	50.6	1.47 (0.482-4.466)	
Age (years old)						
<40	43	41.3	24	55.8	1	0.505
>40	61	58.7	30	49.2	0.77 (0.350-1.678)	
Systemic diseases						
No	76	73.1	40	52.6	1	0.812
Yes	28	26.9	14	50	0.90 (0.378-2.142)	
History of ocular surgery						
No	98	94.2	50	51.0	1	0.463
Yes	6	5.8	4	66.7	1.92 (0.336-10.971)	
Alcohol drinking						
No	74	71.2	35	47.3	1	0.141
Yes	30	28.8	19	63.3	1.93 (0.805-4.601)	
Smoking						
No	101	97.1	53	52.3	1	0.523
Yes	3	2.9	1	33.3	0.45 (0.045-5.154)	
Menopause (females only)						
No	68	76.4	35	51.5	1	0.758
Yes	21	23.6	10	47.6	0.86 (0.322-2.283)	

**Advanced Table 1.** Risk factors for Severe Dry Eye Symptoms among VDT users in Samutprakarn, Thailand between February 2021 and April 2021

Variables	VDT Users		Severe Dry Eye Symptoms		OR (95%CI)	p-value
	Person	percentage	person	percentage		
VDT users who wore contact lens						
No	94	90.4	49	52.1	0.92 (0.249-3.383)	0.898
Yes	10	9.6	5	50.0		
Number of years working with VDTs (years)						
<10	31	29.8	15	48.4	1	0.638
>10	73	70.2	39	53.4	1.22 (0.528-2.838)	
Overtime Use of VDT						
No	23	22.1	10	43.5	1	0.360
Yes	81	77.9	44	54.3	1.55 (0.608-3.931)	
Take eye breaks every 2 hours						
Yes	73	70.2	39	53.4	1	0.638
No	31	29.8	15	48.4	1.22 (0.528-2.838)	
Use a VDT screen filter						
Unknown	18	17.3	7	38.9	1	0.228
No filter	86	82.7	47	54.7	1.90 (0.670-5.349)	
VDT desk brightness (Lux)						
400-500	7	6.7	5	71.4	1	0.344
<400	82	78.8	43	52.4	2.27 (0.416-12.364)	
>500	15	14.4	6	40.0	0.27 (0.038-1.852)	
VDT angle of gaze (Degrees)						
10-20	83	79.8	44	53.0	1	0.659
<10	21	20.2	10	47.6	0.81 (0.309-2.102)	

**Table 2.** Factors Associated with the Occurrence of Dry Eye Symptoms

Duration of VDT use while Working in Normal Business Time	Ocular Surface Disease Index (OSDI)			n	x <sup>2</sup>	Sig.
	Mild (person)	Moderate (person)	Severe (person)			
2-4 hours	2	4	0	6	8.34	0.01
5-7 hours	23	21	54	98		
<b>Total</b>	25	25	54	104		

(73.1%) had no systemic diseases, 98 employees (94.2%) had no history of ocular surgery, and 94 employees (90.4%) did not wear contact lens while working with a VDT as shown in Table 1.

The data of working with a VDT found that almost all employees (94.2%) worked in front of a VDT during their normal business hours for 5-7 hours. More than two-thirds (70.2%) had an eye break while working in front of a VDT every 2 hours. In addition, approximately three-quarters (77.9%) of all employees worked overtime with a VDT, as shown in Table 1.

The results of examination with scientific instruments to find environmental factors showed that the brightness of the employees' VDT desk at less than 400 Lux was found to be recorded at 78.8%. Meanwhile, the brightness of the employees' VDT desk at 400 -500 Lux and more than 500 Lux were found to be recorded at 6.7% and 14.4%, respectively. The study revealed that 79.8% of the employees who worked in front of a VDT screen had a viewing angle (angle of gaze) of 10-20 degrees, as shown in Table 1.

The questionnaire based on the Ocular Surface Disease Index (OSDI) for the assessment of the severity of dry eye symptoms demonstrated that 54 employees (51.9%) had severe dry eye symptoms. Both moderate and mild dry eye symptoms were found in the same number, accounting for 25 employees (24.0%). The study also showed that 54 employees who worked in front of a VDT screen for 5-7 hours per day during normal business hours had severe dry eye symptoms. Meanwhile, 21 employees had moderate dry eye symptoms and 23 employees had mild dry eye symptoms. Employees who worked in front of a VDT screen 2-4 hours per day did not experience severe dry eye symptoms. However, 4 employees experienced moderate dry eye symptoms and 2 employees experienced mild dry eye symptoms in the group of workers who worked in front of a VDT 2-4 hours per day. The relationships between the factors and the occurrence of dry eye symptoms were analyzed using a chi-square test, and it was found that the duration of 5-7 hours of VDT use during normal business hours was significantly associated with the occurrence of dry eye symptoms ( $p$ -value = 0.01), as shown in Table 2.

Analysis of risk factors for severe dry eye symptoms among VDT users found that females were 1.47 times more likely to develop severe dry eye symptoms than males. VDT users who worked in front of a computer screen for more than 10 years were 1.22 times more at risk of developing severe dry eye symptoms than those who worked less than 10 years. In addition, VDT users who worked in front of a computer screen overtime were 1.55 times more likely to develop severe dry eye symptoms than those who did not work overtime.

Employees who did not take an eye break while using a VDT every two hours was 1.22 times more likely to develop severe dry eye symptoms than those who took an eye break. Employees who used a VDT without a screen filter were 1.90 times more likely to develop severe dry eye symptoms. VDT desk-brightness less than 400 Lux was 2.27 times more likely to develop severe dry eye symptoms compared to the standard brightness range (400-500 Lux). However, these factors were not statistically significant for the occurrence of severe dry eye symptoms, as shown in Table 1.

## DISCUSSION

Dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of

the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage play etiological roles. The ocular surface inflammation and damage can increase tear film instability and tear evaporation, resulting in an increase in tear osmolarity (Craig *et al.*, 2017). The repeated cycles of destruction of the ocular surface cause eye irritation, tearing, burning eye, dry eye, a feeling of dust particles in the eyes, photophobia, blurred vision, discomfort with contact lens, red eye, sticky eye or eye strain. Dry eye symptoms among VDT users can be attributed to continuous focus on the monitor that can cause decreased blinking rates or incomplete reflex blink, resulting in increased tear evaporation and tear film instability (Argilés *et al.*, 2015; Craig *et al.*, 2017).

This study found that 54 VDT users (56.16%) who worked with a computer screen for 5-7 hours per day had severe dry eye symptoms. This result is consistent with the study by Sanchez-Valerio M. *et al.* examining office workers who worked in front of a computer screen for 4-7.9 hours per day. They evaluated dry eye symptoms by using the ocular surface disease index (OSDI) and ocular surface damage signs. The study found that the prevalence of dry eye was 45.4% (Sánchez-Valerio *et al.*, 2020). Another study of Kawashima M. *et al.* examined employees who worked in front of a computer screen for approximately 6 hours per day. The prevalence of dry eye was 60% (Kawashima *et al.*, 2015). The result is similar to what was been found in our study, although the prevalence of dry eye among VDT users was markedly heterogeneous with values ranging from 9.5% to 87.5% (Courtin *et al.*, 2016). This heterogeneity might result from the definitions given for the diagnostic criteria of dry eye that are still defined in many different definitions. From our literature review, we found that the diagnostic criteria of dry eye in many studies have three main components, namely dry eye symptoms, tear film abnormalities and ocular surface epithelial damage. Furthermore, the studies using a combination of all diagnostics criteria found a lower prevalence of dry eye than the studies using either one or both of the diagnostic criteria of dry eye (Fjærvoll *et al.*, 2021).

In this study, the use of a VDT within 5-7 hours per day was associated to dry eye symptoms with statistically significant value ( $p$ -value = 0.01). The result is in accordance with the study by Rossi G. *et al.* which found that the use of a VDT for more than 4 hours per day was a risk factor for dry eye ( $p$

value  $<0.001$ ) (Rossi *et al.*, 2019). Another study by Titiyal *et al.* (2018) found that VDT users who used a VDT for more than 4 hours per day had a risk factor for severe dry eye (OR 63.9, 95%CI 47.1-86.7;  $p$ -value  $<0.001$ ). Furthermore, the study by Cheng X found that VDT use for more than 11 hours per day had a risk factor for dry eye (OR 2.22, 95%CI 1.17-4.20;  $p$  value  $<0.05$ ) (Cheng *et al.*, 2019). Longer VDT time was associated with lower blink rates and increased tear evaporation. This relationship resulted in increased tear film instability and tear osmolarity. These led to damage to the eye surface and ultimately to dry eye (Craig *et al.*, 2017). However, some studies did not find a significant association between VDT usage time and dry eye symptoms in student population who had better compensatory mechanisms and intact protective tear films than working age group (Mowatt *et al.*, 2017; Altalhi *et al.*, 2020). The studies have not revealed any significant relationship of dry eye problems among other factors such as age, gender, systemic diseases, previous ocular surgery, alcohol drinking or smoking.

For environmental factors related to the brightness of the workplace, the Government Gazette of the Department of Labor Protection and Welfare, Ministry of Labor, Thailand announced "The standard of light intensity" on 27 November 2017. The announcement requires employers to arrange the workplace to have the intensity of light not lower than the specified standard in which the light intensity at the area where employees have to work in front of a computer screen in the manner of routine work in the office such as printing, data recording reading and/or processing should be designated at 400-500 Lux (Department of Labor Protection and Welfare, 2017). This study found that only 7 VDT users (6.7 %) had desks which were illuminated within the standards announced by the Department of Labor Protection and Welfare. However, severe dry eye symptoms were noted as high as 71.4 % among VDT users whose desks were within the standard range of brightness. This can be related to several other factors that may affect dry eye symptoms including 1) reflected glare, such as light coming from a window or door that strikes a computer screen and then is reflected back into the eye; 2) directed glare, such as direct light from a computer screen into the eyes; 3) low temperature and low humidity in the workplace that can cause increased tear evaporation. All of the above factors can also be contributing factors in the occurrence of dry eye symptoms (Lekhanont, 2018).

For work in less than standard light intensity, this study found that there were as many as 82 VDT users (78.8%) whose desks were illuminated less than 400 Lux. This result is consistent with the result of another study in Ubon Ratchathani province, Thailand which revealed that 72.9% of VDT users had desk-brightness less than 400 Lux (Tubtimhin and Puthaburi, 2019). Moreover, it was also found that 25 VDT users (24%) had desk-brightness which was less than 150 Lux, which is the minimum illumination of light intensity in the office room or computer room (Department of Labor Protection and Welfare, 2017). However, this study found severe dry eye symptoms, accounting for 52.4%, among VDT users whose desk-brightness was less than 400 Lux. In an insufficient light environment, the pupil diameter is dilated by the iris dilator muscle contraction (Bouffard, 2019). Meanwhile, during VDT use, VDT users stare at the computer screen, and the eyes perform an automatic process known as accommodation, which consists of three components that work simultaneously: 1) ciliary muscle contraction, 2) pupil constriction and 3) convergence binocular eye movement (McDougal and Gamlin, 2015). Thus, during VDT use in an insufficient light environment, the pupillary function occurs in two different actions at the same time. In an insufficient light environment, the pupil is dilated from the action of the iris dilator muscle, while in VDT use, the pupil is constricted from the action of the circumferential iris sphincter muscle (Bouffard, 2019). These simultaneous actions of both iris muscles result in more staring efforts to try and adjust the sharpness of the image and the light generated by the computer screen. These visual efforts cause a decrease in the blinking rates and an increase in eye strain (asthenopia), resulting in increased tear evaporation from the surface of the eyes leading to the occurrence of various dry eye symptoms (Craig *et al.*, 2017).

Our study has some limitations. The information for the assessment of dry eye symptoms was obtained from the responses given by VDT users in questionnaires. Therefore, there were no clinical examinations of dry eye. Clinical examinations may provide more precise specifications related to ocular surface abnormalities than questionnaires alone. The information about the estimated duration of working using a VDT was also obtained from the questionnaires, and thus the actual number of working hours with a VDT incurred at the time of study was not measured. Other data on the confounding factors such as time to wear contact

lens, time to wear reading glasses or use of air conditioning should also be collected for further analysis. In addition, VDT users may also use other electronic devices with screens such as smartphones or tablets. Dry eye might not be the result of solely working in front of a computer screen at the office. Thus, more prospective randomized studies with more complete follow-up should be done in the future to further clarify the association between VDT use and dry eye problems that can be implicated to the general public policy in dry eye prevention among VDT users.

## CONCLUSION

In summary, VDT use has been increasing in offices, and a large number of VDT users experience dry eye symptoms associated with VDT use. Based on the results of this study, it can be concluded that the amount of time that VDT users spent more than five hours a day in front of computer screen was associated with dry eye symptoms. Hence, there is a need for policy recommendations from occupational disease regulators such as limiting the use of VDTs as well as taking periodic eye breaks from VDT use. These actions can reduce the risk of dry eye symptoms from working with VDTs. In addition, the annual occupational health examination of VDT users who work in front of computer screen should include a dry eye screening test.

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