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A Study of The Prevalence and Factors Associated with Computer Vision Syndrome (CVS)

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Abstract
Computer Vision Syndrome (CVS) is rising rapidly due to the increasing use of electronic devices. Symptoms of CVS are dry eyes, eye strain, blurred vision, double vision, headache, neck pain, back pain, and shoulder pain. Therefore, the purpose of this study is to analyze the relationship between the prevalence of Computer Vision Syndrome (CVS) and the usage of electronic devices among the undergraduate students of the Mathematical Department of the Faculty of Science in Universiti Teknologi Malaysia (UTM). A cross-sectional study was conducted using a questionnaire. Out of 85 respondents, 98% of them suffered from CVS based on their self-reported symptoms. The most common and severe symptom is neck pain, followed by shoulder pain, while double vision is the less common symptom based on the self-report. The probability of developing shoulder pain in the respondents is the highest, 1.000, while the probability of developing headache in the target students is the lowest, which is 0.0684 only. The prevalence of CVS is very high among the respondents. Thus, increasing the awareness of CVS, ergonomic practices, and the '20-20-20' rule are required to prevent CVS.

Keywords: Computer vision syndrome; electronic device; computer use; digital eye strain

1. Introduction

Prolonged use of computers can increase in the work-related risk of suffering "computer-related health syndromes" such as Occupational Overuse Syndrome (OOS), Computer Vision Syndrome (CVS), upper limb symptoms, back pain, and psychosocial stress [1]. In medical science, CVS refers to the condition of an individual who experiences one or more of the ocular complaints as a side effect of using a digital device [2]. CVS also refers to Digital Eye Strain (DES), digital asthenopia, occupational asthenopia, and video display terminal syndrome (VDTS) [3]. The American Optometric Association defines CVS as a group of eye and vision-related problems caused by prolonged usage of digital devices [4].

CVS is a type of visual and eye symptoms that some people experienced after continue using of electronic devices for a long time [5]. In medical science, CVS refers to the condition of an individual who experiences one or more of the ocular complaints as a side effect of using a digital device [2]. CVS is also known as digital eye strain (DES), digital asthenopia, occupational asthenopia, and video display terminal syndrome (VDTS) [3]. According to the American Optometric Association, CVS is a group of eye and vision-related disorders due to the continuous use of digital devices such as computers, laptops, tablets, e-book readers, and smartphones [4][6][7]. Computer vision syndrome is the most common occupational hazard in the twenty-first century, affecting 63%-89% of computer users based on the population studied. Around 60 million computer users worldwide have CVS, with almost one million new cases being identified every year [8].

Studied has reported that eye irritation, eye dryness, asthenopia, eye strain, watery eyes, double vision, blurred vision, light sensitivity, slowness of focus change, shoulder pain, back pain, and neck pain as CVS symptoms [9]. Studies have linked prolonged computer use, poor lighting conditions, improper eye level to the screen, slow refresh rates, and the wearing of vision eyewear to CVS symptoms such as back pain, tension headaches, eye strain, and others [10]. CVS is rising quickly due to the increasing use of electronic devices [10]. Visually related symptoms of CVS are dry eyes, eye strain, blurred vision, and double vision, and extraocular-related risks include headache, neck pain, back pain, and shoulder pain [11]. According to [2], the factors of CVS are the period of electronic devices usage and the duration of rest time. Furthermore, the room lighting condition, viewing distance to the device's screen, sitting posture, and screen brightness may increase the severity of CVS symptoms.

In 2019, the worldwide pandemic COVID-19 outbreak has spread and caused death in many people. Malaysia has chosen to implement Movement Control Order (MCO), which refers to the restriction of movement or lockdown as a protection and preventive measure for this disease, to control the spread of the COVID-19 pandemic. As a result, all education institutions in Malaysia have closed and then followed by the implementation of teaching and learning online. Furthermore, work-from-home has been implemented in business and industry sectors. Therefore, almost everyone owns at least one electronic device such as a smartphone, tablet, laptop, or desktop as digital devices have become vital nowadays. However, prolonged use of digital devices can cause uncomfortable and may cause CVS symptoms. This study intends to find out the risk factors of CVS and the association between the risk factors and the prevalence of CVS among undergraduate students of the Mathematical Department of the Faculty of Science in Univerisiti Teknologi Malaysia (UTM). The factors that affect the occurrence rate of CVS among the students were identified by employing multiple logistic regression analysis.

2. Multiple Logistic Regression

Previous studies have almost exclusively focused on using logistic regression analysis to determine the effect of the associated factors on the prevalence of CVS. There is another study on the visual sequelae of Computer Vision Syndrome: A cross-sectional case-control study, the researcher performed logistic regression analysis to determine the factors of developing CVS [3]. The result from this study claims that improper close eye-screen viewing distance, incorrect gaze angle, poor designation of screen and screen resolution, inappropriate seating posture, and texting with both thumbs, and associated refractive errors are the factors related to CVS development.

Another study reported that high development of CVS occurred among secretaries with the associated risk factors such as average monthly income, the habit of frequent voluntary blinking, regular breaks taking in between work, optical correction application, light sources at the workplace, antiglare filter use and knowledge related to CVS [12].

3. Materials and methods

Multiple Logistic Regression

Regression analysis refers to predictive modelling techniques that aim to determine the relationship between one (or more) independent variables, X, also known as covariates, or regressors and the dependent variables, Y, or response variables. The different types of regression models are usually characterized by the types the dependent and independent variables, which can be continuous, binary, categorical, or counts [13].

Logistic regression analysis is the regression technique that aims to determine the relationship of independent variables, $X_1, X_2, \dots, X_k$, to a dichotomous dependent variable, Y, which is binary and

coded as either 0 or 1. The primary objective of a binary regression analysis is to model and determine the effects of the covariates on the (conditional) probability.

$$\pi_i = P(y_i = 1) = E(y_i)$$

for the outcome $Y_i = 1$, with values of independent variables $X_{i1}, \dots, X_{ik}$. The response variables are presumed to be (conditionally) independent in this specification.

The linear probability model is:

$$\pi_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_k x_{ik}$$

The linear predictor

$$\eta_i = \beta_0 + \beta_1 x_{i1} + \cdots + \beta_k x_{ik} = x_i' \beta$$

All popular binary regression models use a relation of the form to combine the probability π_i with the linear predictor η_i:

$$\pi_i = h(\eta_i) = h(\beta_0 + \beta_1 x_{i1} + \cdots + \beta_k x_{ik}) \quad (1)$$

where h is known as the response function, where $h(\eta) \in [0,1]$ and the $equation\ (1)$ can be expressed in the form of

$$\eta_i = g(\pi_i)$$

with the inverse function $g = h^{-1}$, which is also called as the link function.

Logit model and Odds Ratios (ORs)
The logit model is expressed as below:

$$\pi_i = \frac{\exp(\eta_i)}{1 + \exp(\eta_i)}$$

or the logit link function

$$g(\pi) = \log\left(\frac{\pi}{1 - \pi}\right) = \eta = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k$$

This yields a linear model for the logarithmic odds (log-odds).

Transformation with the exponential function yields the odd ratio. The odd ratio in logistic regression is used to determine the effect of independent variables to the dependent variable.

The odds ratio, (OR)

$$(OR) = \frac{\pi_i}{1 - \pi_i} = \frac{P(y_i = 1)}{P(y_i = 0)} = \exp(\beta_0) \cdot \exp(\beta_1 x_{i1}) \cdot \ldots \cdot \exp(\beta_k x_{ik})$$

The logit form of the logistic regression model is given by:

$$logit[p(y = 1)] = \beta_0 + \sum_{j=1}^{k} \beta_j X_j$$

Data Source
By referring to [14], a questionnaire was modified and used as a tool for data collection in this study. The questionnaire was distributed to the target students, the undergraduate students from the Mathematical Department of the Faculty of Science in Universiti Teknologi Malaysia (UTM). The questionnaire contains several sections which include the demographic profile of the respondents,

electronic devices use and awareness, ergonomic practices, and posture during the use of electronic devices. The last section of the questionnaire is about the prevalence and severity of computer vision syndrome (CVS) symptoms.

4. Results and discussion

Descriptive Statistic Analysis

Table 1 shows the distribution of the demographic details (gender, race, age, and year of study) of 85 respondents who are undergraduate students of the Mathematical Department of the Faculty of Science in UTM. In this survey, 54 of the respondents are male and 31 of the respondents are female. From Table 1, it is clearly presented that the respondents' race is Chinese primarily (49.4%), followed by Malay (42.4%), while only one of each Bumiputera and Indonesian participated in this survey. 70.6% of the respondents are currently in their final year (Year 4), ages between 22 to 24.

Table 1: Demographic Characteristics of Respondents $(n = 85)$

Variables	*Categories*	*Frequency*	*Percent (%)*
Gender	Male	54	63.5
	Female	31	36.5
Race	Malay	36	42.4
	Chinese	42	49.4
	Indian	5	5.9
	Bumiputera	1	1.2
	Indonesian	1	1.2
Age	19-21	19	22.4
	22-24	66	77.6
Year of Study	1	6	7.1
	2	8	9.4
	3	11	12.9
	4	60	70.6

Figure 1 presents the types of electronic devices used by the respondents. According to the bar chart, 92.9% of the students use laptops for studying purposes, followed by smartphones (91.8%), while the application of desktop is the least, with only 8 students from 85 respondents.

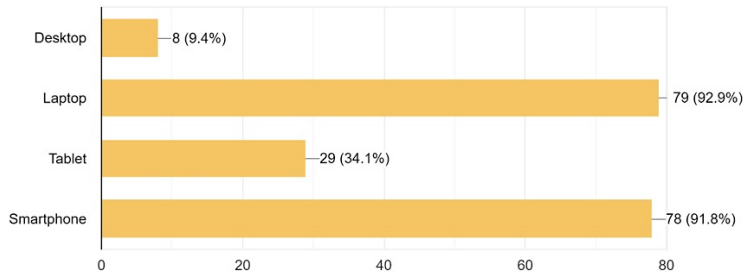

Figure 1 The Types of Electronic Devices Used by The Respondents.

Figure 2 displays the severity of each of the Computer Vision Syndrome (CVS) symptoms. Eight symptoms of CVS were tested in this study, which are headache, burning eyes, blurred vision, double vision, eye strain, dry eyes, neck pain, and shoulder pain. Most of the respondents have CVS symptoms no matter is mild, moderate, or severe. According to Figure 2, it is reported that double vision is the least symptom that the respondents experienced, while neck pain and shoulder pain are the most

common and severe symptoms suffered by the students. Overall, most of the students suffered from extraocular-related risks of CVS such as neck pain and shoulder pain, as these symptoms have the highest severity in comparison to no symptoms at all.

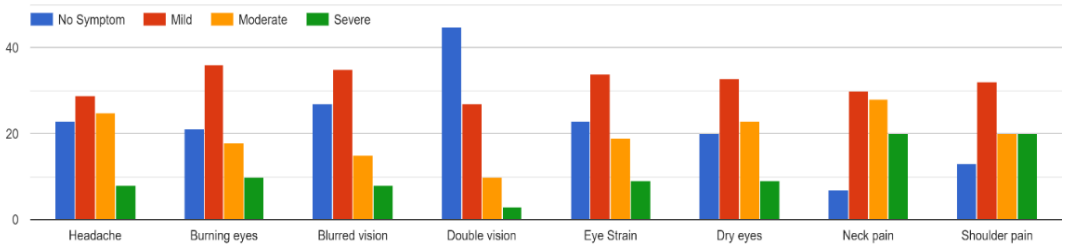

Figure 2 The Types of Electronic Devices Used by The Respondents.

Figure 3 displays the pie chart of the prevalence of CVS among the respondents. As shown in the pie chart in Figure 4.5, 98% of the respondents suffered from CVS based on their self-reported symptoms in this study. The students who have experienced one of the CVS symptoms were classified as suffering from CVS no matter is mild, moderate, or severe. The prevalence of CVS is very high among the undergraduate students of the Mathematical Department of the Faculty of Science in UTM.

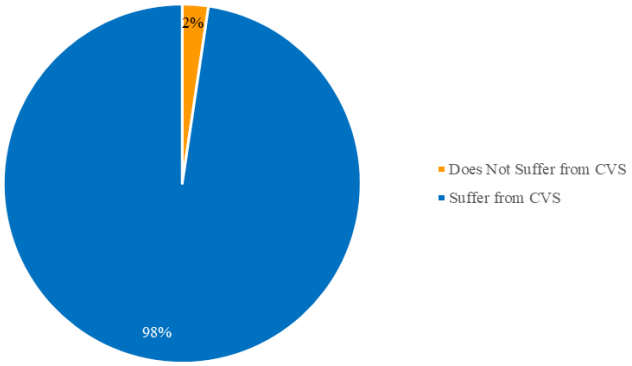

Figure 3 Prevalence of Computer Vision Syndrome (CVS)

This study involved 85 undergraduate students of the Mathematical Department of the Faculty of Science in Universiti Teknologi Malaysia (UTM). After the data cleaning process, the final analysis involved 76 respondents.

Multiple Logistic Regression

Multiple logistic regression was performed by using XLMiner Analysis Toolpak in Microsoft Excel and Minitab Statistical Software. The response variables, Y, are the symptoms of CVS, which are headache, burning eyes, blurred vision, double vision, eye strain, dry eyes, neck pain, and shoulder pain. The respondent is considered to have the symptom if he/she has experienced the symptoms during the use of electronic devices, no matter is mild, moderate, or severe. The independent variables, X, are the electronic devices used and awareness and the ergonomic practices and postures during the use of electronic devices.

This regression equation shows how the electronic devices used and awareness and the ergonomic practices and postures during the use of electronic devices relate to the headache. The regression coefficient explains the strength and direction of the correlation between the headache occurrence and the independent variables. In general, positive coefficients increase the likelihood of

the event, whereas negative coefficients decrease the likelihood of the event. The effect of the independent variable is likely to be minimal if the estimated coefficient is close to 0.

The regression equation for headache is:

$$Y' = -4.23 + 1.619\ Room\ illumination + 0.801\ Device\ holder - 1.807\ Back\ support + 1.575\ Thigh\ horizontal$$

The regression equation for burning eyes is:

$$Y' = 3.92 + 1.735\ Leg\ vertical$$

The regression equation for double vision is:

$$Y' = -1.61 + 1.081\ Screen\ brightness$$

The regression equation for eye strain is:

$$Y' = -1.01 + 1.287\ Antiglare\ screen$$

The regression equation for dry eyes is:

$$Y' = 3.31 + 1.526\ Screen\ brightness$$

The regression equation for shoulder pain is:

$$Y' = 1.37 + 5.16\ Room\ illumination + 4.26\ Device\ holder$$

The equation relates the event probability to the CVS development due to the logit link function is:

$$P(CVS) = \frac{\exp(Y')}{1 + \exp(Y')}$$

For example, the probability for headache development,

$$Y' = -4.23 + 1.619(1) + 0.801(1) - 1.807(1) + 1.575(1) = -2.611$$

$$P(headache) = \frac{\exp(Y')}{1+\exp(Y')}\frac{exp\ (-2.611)}{1+exp\ (-2.611)} = 0.0684$$

The probability of developing CVS for every symptom is tabulated in Table 4.2.

Table 2: Probability of Developing CVS

Symptoms	Probability
Headache	0.0684
Burning eyes	0.9965
Double vision	0.3708
Eye strain	0.5688
Dry eyes	0.9921
Shoulder pain	1.000

According to Table 4.2, in this study, the probability of developing shoulder pain in the respondents is the highest, 1.000, with its significance factors the room illumination when using the device and the application of device holder during the device used. The probability of developing burning eyes and dry eyes is also very high, with 0.9965 and 0.9921 respectively. The probability for headache development in the target students is the lowest, with 0.0684 only.

Conclusion

In this study, 98% of the respondents suffered from CVS. This result implies that the prevalence of CVS is very high among the respondents. The most common symptoms are extraocular-related symptoms such as neck pain and shoulder pain while the least common symptom experienced by the respondents is double vision. The most common factors contributing to all CVS symptoms are the screen brightness of the devices as the value of Odds Ratios is high for every symptom of CVS. The association is not statistically significant between the electronic devices used and awareness and the ergonomic practices and postures during the use of electronic devices with blurred vision and neck pain, as the p-value for both symptoms is greater than the significant level $\alpha=0.05$. In this study, the probability of developing shoulder pain in the respondents is the highest, 1.000, while the probability of developing headache in the target students is the lowest, with 0.0684 only. In future study, the size of the population should increase by involving more respondents, and not only limited to the undergraduate students from the Mathematical Department of the Faculty of Science in Universiti Teknologi Malaysia. Besides, apart from university students, the study on the prevalence of CVS can be carried out on different respondents such as bank officers, programmers, and lecturers.

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