ELUCIDATING THE ASSOCIATION BETWEEN DRY EYE SYMPTOMS, SELF-ESTEEM AND NIGHT DRIVING DIFFICULTY IN ADULT DRIVERS

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WAN MUHAMMAD HIRZI BIN WAN DIN

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PERKAITAN ANTARA GEJALA MATA KERING, HARGA DIRI DAN KESUKARAN PEMANDUAN WAKTU MALAM DALAM KALANGAN PEMANDU DEWASA

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I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRAK

Penyakit Mata Kering (DED) merupakan keadaan pelbagai faktor yang dicirikan oleh kehilangan homeostasis lapisan air mata, lantas menyebabkan ketidakselesaan, gangguan penglihatan, dan ketidakstabilan air mata, yang boleh menjejaskan tugasan harian seperti memandu waktu malam. Kajian ini mengkaji hubungan antara gejala mata kering dan kesukaran pemanduan pada waktu malam yang dilaporkan sendiri dalam kalangan dewasa Malaysia, dengan mengambil kira potensi pengaruh harga diri terhadap prestasi pemanduan. Pendekatan berasaskan tinjauan digunakan dengan memanfaatkan versi Bahasa Melayu bagi Soal Selidik Penglihatan dan Kesukaran Memandu Waktu Malam (VND-Q-M), Indeks Penyakit Permukaan Ocular (OSDI), dan Skala Harga Diri Rosenberg (RSES). VND-Q-M telah diterjemahkan dan disesuaikan secara budaya melalui kaedah ke hadapan-belakang, dan telah disahkan oleh enam pakar optometri, menunjukkan kesahan kandungan yang tinggi (CVI=1.0 untuk relevansi, CVI=0.98 untuk kejelasan, CVI=1.0 untuk kefahaman). Nilai Kaisen-Meyer-Olkin (KMO) 0.79 menunjukkan kecukupan sampel yang baik, dan analisis faktor eksploratori mengenal pasti dua faktor—keterlihatan dan penilaian jarak—dengan konsistensi dalaman yang tinggi (Alpha Cronbach=0.84). Tinjauan utama, yang diedarkan kepada 373 pemandu dewasa aktif berumur 18 hingga 40 tahun, mendedahkan variasi signifikan dalam skor VND-Q-M merentas empat kategori OSDI ($p < 0.001$), dengan tiada perbezaan signifikan antara kumpulan normal dan ringan, atau kumpulan sederhana dan teruk selepas pembetulan Bonferroni. Korelasi positif ditemui antara skor VND-Q-M dan OSDI ($p < 0.001$), mencadangkan bahawa peningkatan gejala mata kering yang lebih teruk membawa kepada tahap kesukaran pemanduan waktu malam. Analisis regresi berganda mengesahkan OSDI sebagai peramal utama bagi skor VND-Q-M, dengan tiada pengaruh signifikan daripada RSES atau jantina. Penemuan ini menunjukkan bahawa gejala mata kering yang teruk terutamanya sensitiviti terhadap silau dan penurunan sensitiviti kontras adalah berkaitan dengan peningkatan kesukaran memandu waktu malam. Menguruskan mata kering boleh meningkatkan keselamatan pemanduan, terutamanya bagi wanita dan dalam keadaan cahaya malap. VND-Q-M telah dibuktikan sebagai alat yang sah dan boleh dipercayai, memberikan gambaran awal kepada profesional penjagaan kesihatan untuk menguruskan kesukaran pemanduan waktu malam. Kajian lanjut diperlukan untuk meneroka penggunaannya sebagai alat saringan klinikal untuk mengenal pasti individu yang memerlukan penilaian penglihatan atau intervensi lanjut. Cadangan termasuklah pemeriksaan mata berkala, saringan penglihatan untuk gejala mata kering, dan intervensi di tempat kerja untuk meningkatkan keselamatan pemanduan waktu malam.

ABSTRACT

Dry Eye Disease (DED) is a multifactorial condition characterized by a loss of homeostasis of the tear film, causing discomfort, visual disturbances, and tear film instability, which can impair daily tasks such as night driving. This study investigated the relationship between dry eye symptoms and self-reported night driving difficulties among Malaysian adults, considering the role of self-esteem in driving performance. A survey-based approach was used with the Malay versions of the Vision and Night Driving Questionnaire (VND-Q-M), Ocular Surface Disease Index (OSDI), and Rosenberg Self-Esteem Scale (RSES). The VND-Q-M was culturally adapted through a forward-backward translation and validated by six optometry experts, demonstrating high content validity (CVI=1.0 for relevance, CVI=0.98 for clarity, CVI=1.0 for understandability). The Kaisen-Meyer-Olkin (KMO) value of 0.79 indicated good sampling adequacy, and exploratory factor analysis identified two factors—visibility and distance judgment—with high internal consistency (Cronbach's alpha=0.84). The main survey, distributed to 373 active adult drivers aged 18 to 40 years, revealed significant variations in VND-Q-M scores across four OSDI categories ($p < .001$), with no significant difference between the normal and mild groups or the moderate and severe groups after Bonferroni adjustment. A positive correlation was found between VND-Q-M and OSDI scores ($p < .001$), suggesting that more severe dry eye symptoms lead to greater night driving difficulties. Multiple regression analysis confirmed OSDI as the primary predictor of VND-Q-M scores, with no significant influence from RSES or gender. These findings indicate that severe dry eye symptoms—particularly glare sensitivity and reduced contrast sensitivity—are linked to greater night driving difficulties. Managing dry eye could improve driving safety, especially for women and in low-light conditions. The VND-Q-M proved a valid and reliable tool, offering healthcare professionals quick insights for managing night driving difficulties. Future research should explore its use as a clinical screening tool to identify individuals needing further vision assessments or interventions. Recommendations include regular eye check-ups, vision screening for dry eye symptoms, and workplace interventions to enhance night driving safety.

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LIST OF ABBREVIATIONS

ADDE	Aqueous Deficient Dry Eye
ADES	Asia Dry Eye Society
BUT	Break Up Time
CSF	Contrast Sensitivity Function
CVI	Content Validity Index
DED	Dry Eye Disease
DES	Dry Eye Syndrome
EDE	Evaporative Dry Eye
EFA	Exploratory Factor Analysis
FARS	Fatality Analysis Reporting System
HOAs	Higher-Order Aberrations
KMO	Kaiser-Meyer-Olkin
LFU	Lacrimal Functional Unit
MGD	Meibomian Gland Dysfunction
MLR	Multiple Linear Regression
NEI	National Eye Institute
OSDI	Ocular Surface Disease Index
OSI	Objective Scatter Index
PAF	Principal Axis Factoring
RSES	Rosenberg Self-Esteem Scale
SPSS	Statistical Package for the Social Sciences
SSDE	Sjögren's Syndrome Dry Eye
TFOS	Tear Film & Ocular Surface Society
UFOV	Useful Field of View
UKM	Universiti Kebangsaan Malaysia
UMMC	University Malaya Medical Centre
VA	Visual Acuity

VDT	Visual Display Terminal
VIF	Variance Inflation Factor
VND-Q	Vision and Night Driving Questionnaire
VND-Q-M	Vision and Night Driving Questionnaire-Malay
WHO	World Health Organization

CHAPTER I

INTRODUCTION

1.1 RESEARCH BACKGROUND

Dry eye disease (DED) is a multifactorial, symptomatic disease characterized by a loss of homeostasis of the tear film and/or ocular surface, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities are etiological factors (Wolffsohn et al. 2025). Patients with DED frequently report difficulty performing vision-related daily tasks like driving (Deschamps et al. 2013; Tong et al. 2010). Driving is a necessary part of modern life, and night driving is no exception. Furthermore, the tear film instability associated with DED degrades optical quality by reducing contrast sensitivity and increasing higher-order aberrations (HOAs) (Koh 2016; Koh et al. 2017). These visual impairments are more noticeable at night when the pupil is dilated, exacerbating visual disturbances during activities such as night driving (Artal 2014; Wood 2020).

Patients with moderate to severe dry eye symptoms are common even in the absence of abnormal ocular surface signs (Deschamps et al. 2013). These symptoms can lead to visual impairment, which has an impact on the quality of night driving. For road safety, night driving necessitates excellent visual performance. Dry eye symptoms can be one of the factors that predict the night driving difficulty score, which can serve as important cues for clinicians to recognise the need for proper DED management. Therefore, this study investigates the impact of dry eye symptoms on vision-related quality of life while driving at night, emphasising the importance of targeted DED management.

The goal of this study is to examine the association between dry eye symptoms and self-reported night driving difficulty in Malaysian adults. To achieve this, the dry eye symptoms and self-reported night driving difficulty scores of Malaysian adult drivers were assessed using the Ocular Surface Disease Index (OSDI) and the Vision and Night Driving Questionnaire (VND-Q). The relationship and predictive factors between dry eye symptoms and night driving difficulty were then evaluated through statistical analysis. Beyond visual factors, psychological elements such as self-esteem also play a role in driving behaviour.

According to a report from Khan et al. (2020), driving and self-esteem are related, as drivers who believe driving is important for their self-esteem are more likely to accept risks when driving. This study emphasises the connection between self-esteem and driving, especially night driving. Self-esteem, which might influence the driving task, was measured using the Malay version of the Rosenberg Self-Esteem Scale (RSES) (Jamil 2006). The RSES was chosen for this study due to its brevity, simplicity, ease of administration, and long history of validation (Li et al. 2019). Consequently, this study also assessed whether self-esteem levels, alongside OSDI scores, serve as predictors for the VND-Q-M scores.

1.2 PROBLEM STATEMENT

DED is one of the most common eye conditions, and it is becoming more common in this technological age (Al-Mohtaseb et al. 2021; Stapleton et al. 2017). DED has been linked to visual impairments while driving in previous studies (Barber et al. 2018; Owsley & McGwin 2010). Under dim lighting conditions, such as night driving, DED may have a greater impact on vision-related daily activities. Although there is limited research exploring the relationship between DED and objective visual performance while driving at night, this study aims to examine the association between dry eye symptoms and self-reported difficulties with night driving. The lack of validated tests to assess night vision that are linked to night driving safety in most countries means that licensed drivers are allowed to drive in both day and night conditions, with authorities relying on drivers to self-regulate their own night driving. Drivers are known to underestimate their visual limitations at night and have limited insight into their own driving abilities, so this lack of vision awareness for night driving is problematic.

The precorneal tear film, the eye's most anterior refractive surface, plays an important role in ocular optical quality (Koh et al. 2002). The majority of patients with DED have normal visual acuity as measured by standard methods, but tear film instability causes wavefront higher-order aberration (HOA) changes, which always result in a reduction in vision quality (Liu et al. 2010). HOAs are a type of refractive error that is more subtle and complex than myopia, hyperopia, and astigmatism. These aberrations cannot be corrected with regular spectacles or contact lenses due to their complexity (Koh 2016). A study by Koh et al. (2008) defined "short break up time (BUT) dry eye" as having a decreased tear film BUT and DED but no ocular surface damage or tear deficiency. Furthermore, serial measurements demonstrated that HOAs increased in these eyes after blinking and continued to rise during the 10-second measurement period when the subject did not blink. These studies suggest that DED without ocular surface damage may have higher HOAs, lowering vision quality (Koh et al. 2008). As these higher-order aberrations are primarily associated with tear film instability, improving tear film stability may help reduce optical aberrations. However, such visual quality changes are not detected by standard visual acuity assessments, particularly under low-light conditions.

Patients with DED frequently report difficulty performing vision-related daily activities, as reported in previous quality-of-life surveys (Tong et al. 2010). For many people all over the world, driving is an essential part of their daily routine. Despite the fact that visual acuity is the most commonly used screening test when applying for a driver's licence, many other aspects of visual function are undoubtedly important in supporting effective vehicle control (Owsley & McGwin 2010). According to a study conducted in China, drivers with DED have a significantly higher frequency of unsafe driving habits and performance, potentially increasing the risk of dangerous driving (Wang et al. 2017). Another study found that, when compared to drivers without DED, drivers with DED were more likely to miss targets at crossroad entrances than targets that appeared straight ahead (Deschamps et al. 2013).

Driving plays a crucial role in modern life, and for many individuals, night driving presents unique challenges. The nighttime driving environment presents issues such as poor street lighting, intense oncoming headlight glare, and the need to adapt to a wide range of lighting conditions that are not currently examined in a standard clinical examination. When the pupil is dilated and objects are seen against a dark background at night, HOAs cause visual impairment, which leads to the perception of disturbances around bright light sources (Artal 2014). It is reasonable to assume that DED, which has been shown to increase HOAs, will cause night vision to deteriorate. This visual impairment could make nighttime driving more dangerous, as reports indicate that fatality rates from road crashes are up to three times higher during night driving activity than for daytime driving (Varghese & Shankar 2007).

As measured by contrast sensitivity, DED has been linked to significant deterioration of visual function and optical quality (Koh et al. 2017). Under low lighting conditions, a higher level of glare has a significantly greater impact on contrast sensitivity (Maniglia et al. 2018). During night driving, glare from vehicle headlights can affect the driver's contrast sensitivity. If the driver has DED, which reduces contrast sensitivity even more, the visual disturbance during night driving may become even worse.

Patients with moderate to severe dry eye symptoms are common in the absence of abnormal ocular surface signs. These patients may experience discomfort while driving on a regular basis, which may explain feelings of insecurity and lack of confidence (Deschamps et al. 2013). Ultimately, the core problem is that while physiological optical degradations (like HOAs and reduced contrast sensitivity) are known consequences of DED, standard daytime visual acuity tests fail to capture these deficits. Furthermore, there is a significant gap in the literature regarding how these specific symptoms translate into self-reported night driving difficulties among adult drivers in Malaysia. Therefore, it is critical to investigate the association between dry eye symptoms and vision-related night driving difficulties to guide proper DED assessment and management, which can ultimately improve driving safety.

1.3 OBJECTIVE OF RESEARCH AND SCOPE OF WORKS

The goal of this study is to evaluate the association between dry eye symptoms and self-reported night driving difficulty in Malaysian adults. To fulfil this, participants' dry eye symptoms and night driving difficulty were assessed using the OSDI and VND-Q instruments, respectively. The resulting data was then statistically analysed to investigate the relationship between these two factors.

1.3.1 General Objective

The aim of this study is to investigate the relationship between dry eye symptoms and night driving difficulty in Malaysian adults.

1.3.2 Specific Objective

1. To translate and validate the Vision and Night Driving Questionnaire (VND-Q) in Malay version.

2. To compare the self-reported night driving difficulty scores with normal, mild, moderate and severe dry eye symptoms in adult drivers.

3. To determine the association of dry eye symptoms and self-reported night driving difficulty scores in adult drivers.

4. To determine the predictors of self-reported night driving difficulty, including dry eye symptoms, self-esteem level, age, gender and average time of night driving.

1.4 RESEARCH QUESTIONS AND HYPOTHESES

To address the issues identified in the problem statement and achieve the study's objectives, the following research questions and hypotheses were formulated to systematically investigate the impact of dry eye symptoms on night driving difficulties among Malaysian adult drivers.

1.4.1 Research Questions

Based on the problem statement and research objectives, this study aims to answer the following research questions:

1. Is the Malay version of the Vision and Night Driving Questionnaire (VND-Q-M) a valid and reliable instrument for assessing night driving difficulty?

2. Are there significant differences in self-reported night driving difficulty scores among adult drivers with normal, mild, moderate, and severe dry eye symptoms?

3. Is there a significant association between the severity of dry eye symptoms and self-reported night driving difficulty scores in adult drivers?

4. Do dry eye symptoms, self-esteem level, age, gender, and average time of night driving significantly predict self-reported night driving difficulty scores?

1.4.2 Hypotheses

The following alternative hypotheses (H_a) were formulated for this study:

- H_a1: There is a significant difference in self-reported night driving difficulty scores among adult drivers across different severity levels of dry eye symptoms (normal, mild, moderate, and severe).

- H_a2: There is a significant positive association between the severity of dry eye symptoms and self-reported night driving difficulty scores.

- H_a3: Dry eye symptoms, along with self-esteem level, age, gender, and average time of night driving, are significant predictors of self-reported night driving difficulty scores in adult drivers.

1.5 RESEARCH SIGNIFICANCE

There is currently very little data on the link between DED and self-reported vision-related night driving difficulties. The effect of DED on self-reported night driving difficulty in Malaysian adults has been explored for the first time in this study. Furthermore, by successfully translating and validating the Malay version of the Vision and Night Driving Questionnaire (VND-Q-M), this research provides a vital, localized tool for future clinical assessments. Self-reported visual difficulties may reflect a person's daily visual demands (high or low), rather than actual visual ability. This study has highlighted the challenges clinicians face in balancing objective clinical findings with patients' subjective complaints across different levels of dry eye severity, which is crucial for optimizing therapeutic strategies in DED management. To achieve well-being in today's lifestyle, which includes intensive daily visual activities such as driving, excellent visual performance is required. Some patients may complain of DED even if no abnormal ocular surface signs are present. Ultimately, by establishing that self-reported DED alongside psychological factors like self-esteem and demographic variables acts as a predictor of night driving difficulty scores, this study provides important multidimensional cues for clinicians to recognize the need for DED management.

CHAPTER II

LITERATURE REVIEW

2.1 DEFINITION OF DRY EYE

“Dry eye” was first described as a symptom in 1925 by French dermatologist Henri Gougerot, who noted it as part of a systemic disorder characterized by dryness of the eyes, mouth, throat, nose, and vulva. Later, in 1933, Swedish ophthalmologist Henrik S.C. Sjögren introduced the term "dry eye" and was the first to describe the classic triad of dry eye, dry mouth, and joint pain, now recognized as Sjögren’s syndrome (Yazdani et al. 2019).

Over the years, the definition and understanding of dry eye have evolved significantly. In 1995, the Japan Dry Eye Society introduced one of the earliest formal definitions, considering dry eye a disease of tear deficiency that leads to damage of the ocular surface (Shimazaki 2018). Since then, global organizations such as the Asia Dry Eye Society (ADES) and the Tear Film & Ocular Surface Society (TFOS) have expanded the scope of dry eye definitions to reflect its multifactorial nature. The current gold standard, established by the TFOS DEWS III report (2025), now explicitly defines dry eye as a symptomatic disease. This latest update emphasizes that the loss of tear film or ocular surface homeostasis, driven by instability and hyperosmolarity, remains the core etiological factor (Wolffsohn et al. 2025).

Dry eye is typically diagnosed through a combination of subjective assessments and objective clinical indicators. Common symptoms include ocular discomfort, visual disturbances, and tear film instability. A summary of the evolution of dry eye definitions is provided in Table 2.1.

Table 2.1 History of the dry eye disease (DED) definition

Year	"Definition"	Defined by	Author
1933	"A general disease which attacks chiefly the eyes as well as the lacrimal and salivary glands"	Henrik S.C. Sjögren (The Swedish Ophthalmologist)	Yazdani et al. (2019)
1950	"Dry eye" exists only when there is a low flow of tears found with the Schirmer test, but without signs of keratoconjunctivitis sicca"	Andrew De Roetth (Dacryologist)	Murube (2004)
1995	"Dry eye is a disorder of the tear film due to tear deficiency or excessive evaporation, which causes damage to the interpalpebral ocular surface and is associated with symptoms of ocular discomfort"	National Eye Institute (NEI)/Industry Dry Eye Workshop	Lemp (2008)
2007	"Dry eye is a multifactorial disease of the tears and ocular surface that results in symptoms of discomfort, visual disturbance, and tear film instability with potential damage to the ocular surface. It is accompanied by increased osmolality of the tear film and inflammation of the ocular surface"	National Eye Institute (NEI)/Industry Dry Eye Workshop (TFOS DEWS I)	Lemp (2008)
2017	"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, and neurosensory abnormalities play etiologic roles"	Tear Film & Ocular Surface Society Dry Eye Workshop II (TFOS DEWS II)	Craig et al. (2017)
2025	"Dry eye is a multifactorial, symptomatic disease characterized by a loss of homeostasis of the tear film and/or ocular surface, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities are etiological factors."	Tear Film & Ocular Surface Society Dry Eye Workshop III (TFOS DEWS III)	Wolffsohn et al. (2025)

2.2 CLASSIFICATION OF DRY EYE DISEASE (DED)

The first thorough categorization of dry eye was released in 1995 as a result of the National Eye Institute (NEI)/Industry working group on Clinical Trials in Dry Eye's agreement. According to the report in 1995, dry eye was divided in two categories: tear-deficient and evaporative as indicated in Figure 2.1. These two groupings were further divided based on a variety of intrinsic and extrinsic etiological characteristics to contribute to dry eye development within these categories (Lemp 1995; Tsubota et al. 2020). Furthermore, in 2007 the classification scheme presented by TFOS DEWS report retained the two primary categories, aqueous deficient and evaporative, although tear deficient was redefined more specifically as aqueous deficient (Figure 2.2).

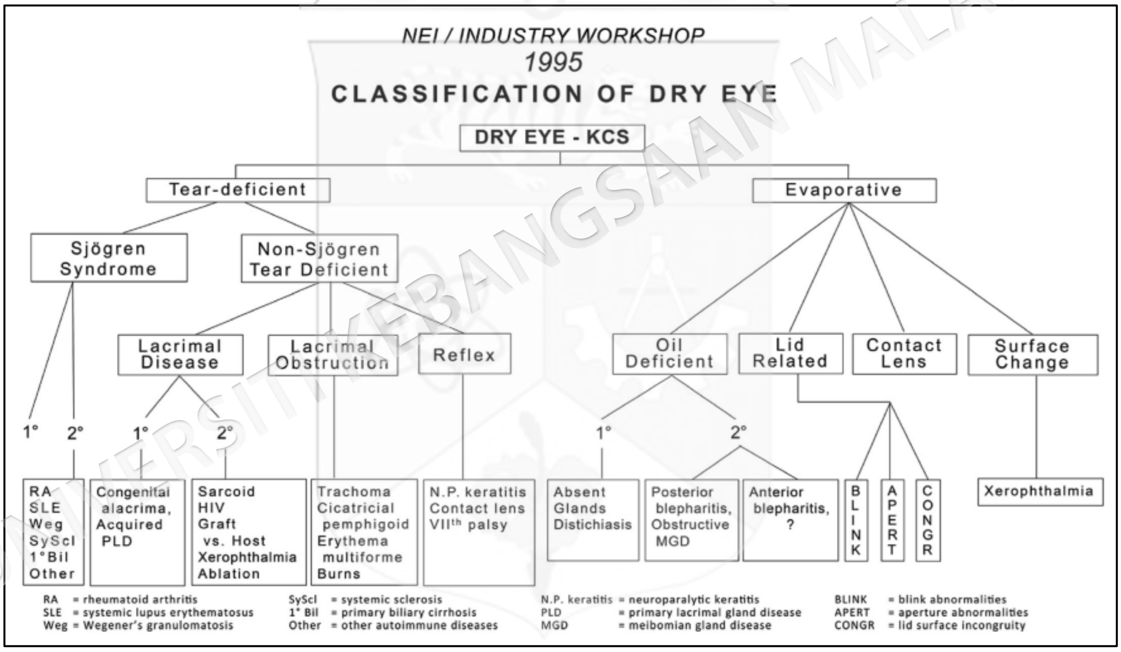

Figure 2.1 Dry eye classification from The NEI/Industry Report in 1995

Source: Lemp 1995

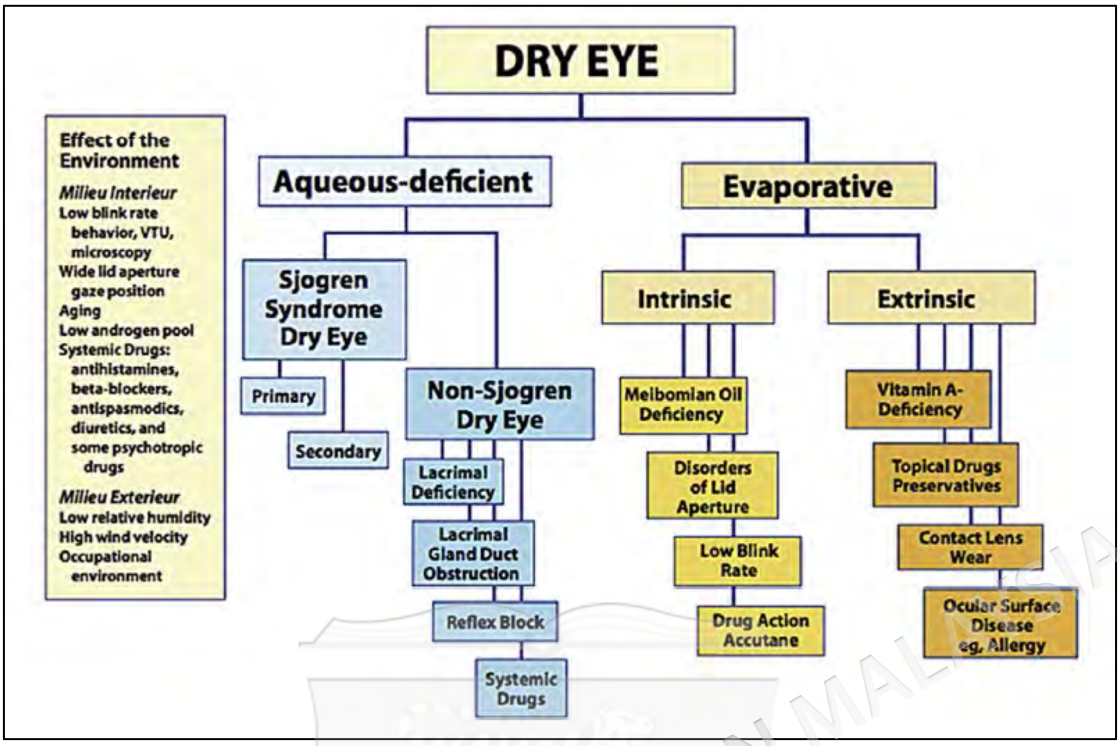

Figure 2.2 Dry eye classification from the 2007 DEWS Report

Source: Lemp & Foulks 2008

To address the complexities of the disease, the TFOS DEWS II report (2017) updated this framework by establishing a continuum model (Craig et al. 2017). It recognized that aqueous deficient dry eye (ADDE) and evaporative dry eye (EDE) are not mutually exclusive, and that patients frequently present with a mixed combination of both conditions. Tear deficiency or ADDE includes conditions such as Sjögren's syndrome and non-Sjögren's tear deficiency (Kaštelan et al. 2013). Sjögren's syndrome is an autoimmune disorder characterized by lymphocytic infiltration of exocrine glands, including the lacrimal glands, leading to decreased tear production (Castro et al. 2018). Aqueous tear deficit and decreased tear production are symptoms of Sjögren's syndrome dry eye (SSDE), which is caused by activated T-cells attacking the lacrimal glands (Zhao et al. 2022). As a consequence, there are less tears produced, which might hasten the onset of dry eye symptoms. Non-Sjögren's tear deficiency refers to tear deficiency that is not associated with Sjögren's syndrome (Kaštelan et al. 2013). According to Kurtul et al. (2015), these instances may have a variety of underlying reasons, including lacrimal gland malfunction, decreased tear production, reflex blockade, or medication action.

EDE is characterized by increased evaporation of tears from the ocular surface (Kaštelan et al. 2013). ADDE is less prevalent than EDE, which is commonly linked to meibomian gland dysfunction (MGD) (Daniel et al. 2020). The treatment of EDE due to MGD often involves addressing the underlying cause and managing the symptoms. Most recently, the TFOS DEWS III report (2025) fundamentally advanced this classification to optimize clinical management. Recognizing that essentially all DED cases involve an evaporative component, DEWS III shifts away from broadly categorizing patients into ADDE or EDE. Instead, the latest framework introduces a more precise subclassification based on specific etiological drivers. These are divided into tear film deficiencies (lipid, aqueous, and mucin/glycocalyx), eyelid anomalies (blink/lid closure and lid margin issues), and ocular surface abnormalities (such as anatomical misalignment, neural dysfunction, and primary inflammation/oxidative stress). This current paradigm ensures that clinicians can target the exact underlying anatomical mechanisms of the disease rather than relying on overlapping categories (Wolffsohn et al. 2025).

2.3 MECHANISM OF DRY EYE DISEASE (DED)

Dry eyes are often brought on by the lacrimal function unit (LFU), an integrated system that includes the lacrimal glands, ocular surface, and eyelids, as well as the sensory and motor neurons that connect them. The general purpose of the LFU is to maintain the tear film's integrity, the cornea's transparency, and the quality of the image that is projected onto the retina. Although any part of the LFU might become ill or be damaged, leading to tear film instability and tear hyperosmolarity, which are the main causes of dry eye (Mantelli et al. 2013).

The tear hyperosmolarity is regarded to be the main cause of ocular surface inflammation, damage, symptoms, and the beginning of compensatory responses in dry eye. Figure 2.3 shows how water evaporates from the exposed ocular surface when there is a low aqueous tear flow or excessive evaporation, leading tears to become hyperosmolar. Through the induction of a series of inflammatory processes and the release of inflammatory mediators into the tears, hyperosmolarity damages the surface epithelium (Lemp & Foulks 2007).

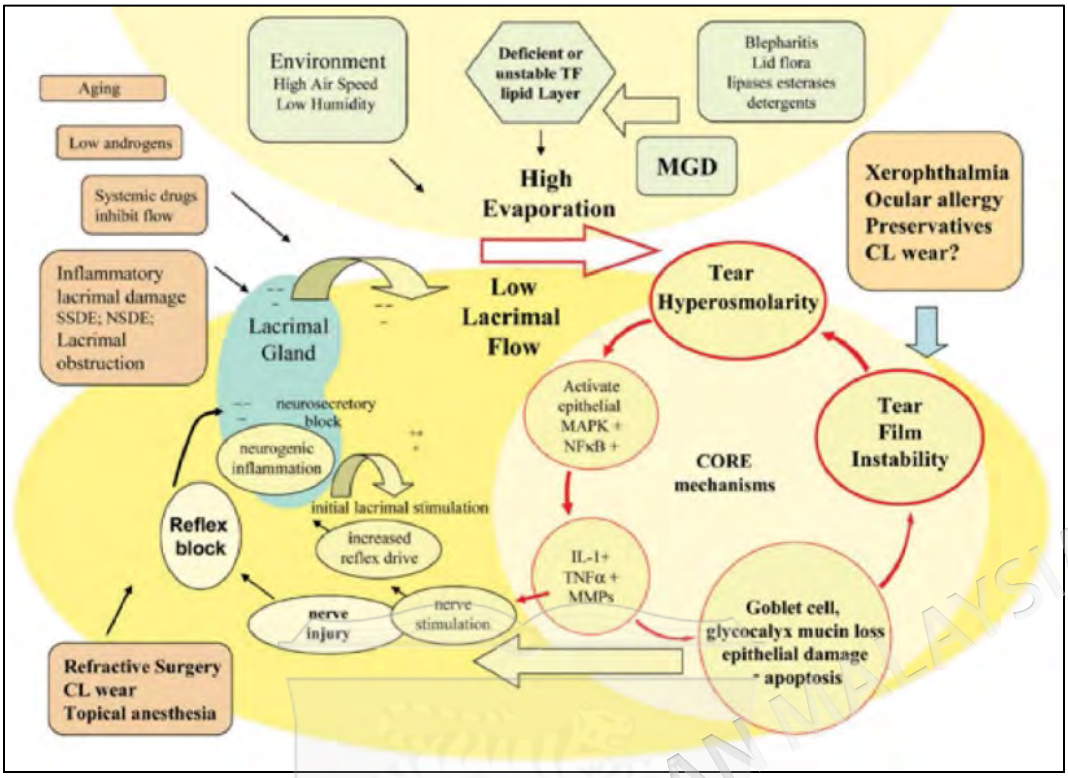

Figure 2.3 Mechanisms of dry eye

Source: Lemp 2008

Over the last two decades, experts have been more interested in the concept that inflammation is the primary cause of DED. A review focused on tissue culture, animal models, and DED patients, points out that the inflammation is the primary mechanism and major factor in the pathogenesis of DED (Wei & Asbell 2014). The protracted nature of the disease raises the possibility that immune system dysregulation results in a loop of ongoing inflammation and changes to both innate and adaptive immune responses.

2.4 RISK FACTORS OF DRY EYE DISEASE (DED)

DED is influenced by multiple risk factors. Key sociodemographic variables include gender (specifically female) and age, while behavioural factors such as contact lens use and prolonged digital device use also play a significant role (Kaštelan et al. 2013; Uchino et al. 2011; Wolffsohn et al. 2021). Thyroid disorders and hypertension have also been identified as systemic risk factors associated with an increased risk of DED (Hasan 2021). Many drugs used to treat chronic illnesses also contribute to DED.

Antidepressants and antihistamines are two examples of medications that are known to raise the risk of developing DED (Wong et al. 2011). In addition, it was determined how different vocations and exposure factors, such as sunlight, strong winds, smoking, drugs, and air pollution, affected the chance of developing dry eye (Ranjan et al. 2016). An increased risk of DED is also linked to tropical countries' outdoor settings, sunlight, and air pollution (Ahn et al. 2021; Courtin et al. 2016).

The usage of visual display terminals (VDT) was found to be an occupational risk factor for the development of DED. The vicious circle of DED is fuelled by the pathophysiology of VDT, which was linked to DED and increased evaporation by making blinks less frequent and increasing the amount of incomplete blinks as showed in Figure 2.4 (Argilés et al. 2015; Tsubota 1998). Tear film instability, ocular surface injury, hyperosmolarity, and dry eye symptoms might arise from the subsequent loss of tear fluid (Stapleton et al. 2017).

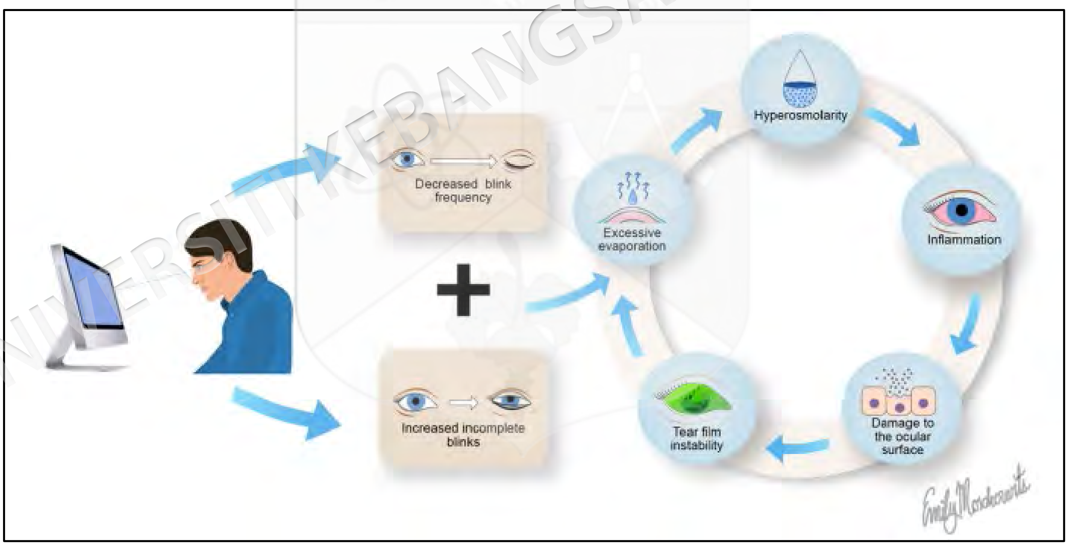

Figure 2.4 DED caused by VDT. VDT use reduces blink frequency and increases incomplete blinks, driving the vicious spiral of DED

Source: Craig et al. 2017

Growing older is a well-known risk factor for DED (Ahn et al. 2017). In fact, certain epidemiologic research has revealed that ageing is a key risk factor for DED (Sharma & Hindman 2014). With advancing age, decreased tear production due to lacrimal gland dysfunction, along with increased tear evaporation rate, might cause more DED. Additionally, older individuals frequently undergo eye surgery and take a variety of medicines that can cause DED (such as diuretics, antidepressants, antimetabolites and dopaminergic drugs). Men and women have different risk factors for DED, which may be related to how men and women's hormonal profiles vary as they age or even to changes in how each gender experiences the world (Uchino et al. 2011).

The risk factors of DED have been thoroughly researched, providing insight on the numerous elements that contribute to the disorder. It is critical to assess the study's quality, the magnitude of the effect, and the possibility of bias and confounding variables. The relationship between risk variables and disease prevalence is frequently complicated and multifaceted, necessitating careful data interpretation.

2.5 PREVALENCE OF DRY EYE DISEASE (DED)

DED affects millions of individuals worldwide, with a recent systematic review and meta-analysis estimating a global pooled prevalence of 34.6% (Xiao et al. 2025). Furthermore, broader prevalence estimates ranging from 5 to 50% globally (Stapleton et al. 2017), and reaching up to 73.5% in some specific areas (Alshamrani et al. 2017; Farrand et al. 2017). According to surveys conducted over the past 20 years, the prevalence of DED varies with age, ranging from 5% to 30% (Lemp & Foulks 2007). This variation depends heavily on research location, demographics, and diagnostic criteria. For example, studies employing both symptoms and signs as diagnostic criteria have found a prevalence of 8.7–30.1%, whereas studies assessing DED only by signs or symptoms report much higher prevalence estimates (Stapleton et al. 2017).

Schaumberg and colleagues conducted two large population studies to investigate the incidence of dry eyes in men and women and discovered that the frequency of DED in women increased with age, from 5.7% among those aged 50 to 9.8% among those aged 75 (Schaumberg et al. 2003). Similarly, a previous study conducted in Malaysia showed the prevalence of dry eye was higher in women compared to men, with increased risk factors such as autoimmune disorders, functional disorders, atopic diseases, and allergies amongst older age groups (Mohd-Ali et al. 2011).

The prevalence of DED in Malaysia varies widely, ranging from 14.5% to 92.1%, depending on the study population and diagnostic criteria used. The first prospective prevalence study conducted at the University Malaya Medical Centre (UMMC) found that 14.5% of 200 outpatients had dry eye symptoms and positive clinical indicators (Jamaliah & Fathilah 2002). Another study in Kuala Lumpur reported a 14.6% prevalence among 850 participants using the McMonnies Dry Eye Questionnaire (Mohd-Ali et al. 2011). In contrast, a study among medical students at Universiti Sains Malaysia (USM) exposed to visual display terminals (VDTs) found a high prevalence of 92.1% (John et al. 2023). A study in Kuantan reported a crude prevalence of 48.5% in an optometric outpatient sample, with age-adjusted rates of 43% for women under 50 years and 68.4% for those aged 50 and above (Aljarousha et al. 2018).

These findings differ significantly due to the specific subgroups targeted and the assessment tools utilized. The earlier studies evaluated general outpatient and urban populations, resulting in a more conservative prevalence of around 14% (Jamaliah & Fathilah 2002; Mohd-Ali et al. 2011). Conversely, the exceptionally high prevalence reported by John et al. (2023) reflects a highly specific, high-risk group with intensive daily VDT exposure, which likely captures transient, screen-induced symptoms rather than chronic disease. Meanwhile, Aljarousha et al. (2018) captured a middle ground (48.5%) by sampling patients already seeking optometric care, who inherently have a higher likelihood of existing ocular complaints. Ultimately, these differences in prevalence reflect varying study populations, diagnostic methods, and environmental factors, underscoring the need for further research to explore the factors influencing DED prevalence and develop appropriate interventions.

2.6 DRY EYE SYMPTOMS

The primary symptomatic reaction associated with dry eye was initially identified as discomfort (Lemp 1995). In 2007, the concept of symptoms was expanded to include visual disturbance. Although the term "discomfort" was included in the initial TFOS DEWS report, the definition was broadened to include visual symptoms in recognition of self-reported experiences of transient blurring, which were found to correlate with poor tear film quality (Djalilian et al. 2017). The TFOS DEWS II updated this by using the phrase "accompanied by ocular symptoms". This broader term encompasses a wider range of potential symptoms beyond just discomfort and visual disturbance, ensuring the definition remains comprehensive and globally applicable (Craig et al. 2017).

A few of the symptoms of DED are burning, itching, redness, discomfort, ocular tiredness, impaired vision, visual disruption, and foreign body sensation in the eyes. (Jahanbani-Ardakani et al. 2021; Lemp 2008). Individuals with DED may also have discharge, easily tired eyes, and excessive tears (Chia et al. 2003; Mussi et al. 2021). Due to the loss of sensitive receptors within the cornea, it is also common for patients to experience moderate to severe symptoms in the absence of abnormal ocular surface indications or for patients to experience relatively mild symptoms despite having severe clinical signs (Deschamps et al. 2013). These differences highlight the importance of comprehending symptom analysis and ocular surface signals (Barabino et al. 2016). Understanding the diverse array of symptoms associated with DED is crucial for early identification, accurate diagnosis, and appropriate management of the condition. By recognizing and addressing these symptoms, healthcare professionals can work towards improving the ocular health and quality of life of individuals affected by DED.

Dry eye symptoms can be debilitating and affect psychologic health and overall sense of well-being. Therefore, the socioeconomic, environmental, and medical factors all have a part in the development of dry eye symptoms, which have a significant influence on the patient's daily life (Hasan 2021).

2.7 IMPACT OF DRY EYE ON VISUAL PERFORMANCE

The rising demands of modern life that necessitate continuous visual tasking are likely to have an impact on how it develops, as well as how it affects vision, other senses (Tsubota & Nakamori 1993; Wolkoff et al. 2005) and quality of life in relation to vision (Goto et al. 2002). In general, quality of life and visual function are significant outcomes in the assessment of therapy choices as well as the economic and societal effects of any ocular condition. In addition to report by Miljanović et al. (2007), there is mounting proof that DED influences quality-of-life indicators. Their results which show that men and women with DED who did and did not use artificial tears, respectively, had nearly three-fold and five-fold increased risks of having problems with activities like reading, computer use, and professional work, support and extend those of earlier studies by highlighting particular areas of functioning that are problematic for those with DED.

A visual task's ability to be completed depends on the human eye's ability to comprehend the task's finer details. Factors affecting visual performance can be influenced by various factors, including higher order aberrations (HOAs), contrast sensitivity, initial visual acuity, visual inspection, perceptual and visual-motor abilities, glistening in intraocular lenses, autistic traits, and cognitive function.

The precorneal tear film is the first refractive surface of the eye, making it crucial for maintaining good optical quality (Koh et al. 2002). Although most patients with DED have normal visual acuity during standard testing, tear film instability significantly reduces their overall visual performance. This instability leads to an increase in HOAs on the ocular surface (Liu et al. 2010). Unlike common refractive errors such as myopia or astigmatism, HOAs are highly irregular and cannot be corrected with regular spectacles and contact lenses, resulting in degraded visual clarity. Furthermore, a study by Koh et al. (2008) explored the phenomenon of 'short break-up time (BUT) dry eye,' where tear film instability was observed without ocular surface damage or tear deficiency. They noted an increase in HOAs over time, which worsened visual quality, even without underlying damage to the ocular surface.

HOAs, defined as optical aberrations that remain following the optimal correction of defocus and astigmatism with conventional spherocylindrical lenses, can significantly influence retinal image quality, the accommodation response of the eyes and the relative focal plane of different regions of the entrance pupil (Collins et al. 2006; Liang & Williams 1997; Plainis et al. 2005). The presence of HOAs can degrade visual quality by causing blurring and reducing contrast sensitivity. Since HOAs have an effect on contrast sensitivity and visual performance, they are significant indicators of vision quality and need consideration (Oshika et al. 2006).

Contrast sensitivity is crucial for visual performance, including tasks such as reading, object recognition, and driving, as it refers to the ability to distinguish different levels of contrast in visual stimuli. In individuals with DED, tear film instability disrupts the ocular surface, causing light to scatter unpredictably as it passes through the eye. This scattering reduces visual sharpness, diminishes contrast sensitivity, and affects tasks that rely on high visual acuity, particularly in low-light or high-glare conditions. The tear film plays a vital role in maintaining a smooth optical surface necessary for sharp images, and when unstable, it interferes with the eye's ability to focus light efficiently. Consequently, the quality of the retinal image is reduced, especially in low-contrast environments such as night driving or when exposed to glare from headlights (Herbaut et al. 2019; Kaštelan et al. 2024). These disruptions are particularly relevant in scenarios requiring precise contrast detection, such as driving, where low light and glare amplify the effects of tear film instability, ultimately impairing visual performance.

2.8 ASSESSMENT AND DIAGNOSTIC TEST FOR DRY EYE

In alignment with the TFOS DEWS diagnostic methodology, particularly the recent updates from TFOS DEWS III (2025), diagnosing DED requires a step-wise approach. The guidelines explicitly emphasize starting the diagnostic process with patient-reported outcome measures (questionnaires) to establish the presence of ocular symptoms, reinforcing DED as a fundamentally symptomatic disease (Craig et al. 2017; Wolffsohn et al. 2017, 2025). These subjective tools provide a comprehensive understanding of the disease's impact on daily life, enhancing clinical diagnosis, patient communication, and targeted treatments (Hoffman et al. 2022; Weinfurt & Reeve 2022).

Once symptoms are established, the diagnosis proceeds to clinical tests that confirm a loss of homeostasis in the tear film and/or ocular surface. Traditional clinical tests, such as the Schirmer test, remain widely used due to their low cost and simplicity, despite limitations like lack of standardization and only assessing tear production (McGinnigle et al. 2012; Phadatare et al. 2015). To directly address the core mechanisms outlined in the evolving TFOS DEWS definitions, the Tear Break-Up Time (TBUT) test, especially the non-invasive version (NIBUT), is favored for its reliability in detecting tear film instability (Kaido et al. 2014; Lemp et al. 2012; Nichols et al.

2004). Finally, essential physiological assessments, such as osmolarity testing, are utilized to identify the tear hyperosmolarity central to the disease (Craig et al. 2017; Wolffsohn et al. 2025).

2.9 OCULAR SURFACE DISEASE INDEX (OSDI) QUESTIONNAIRE

The diagnosis process for DED often starts with symptom screening using instruments like the Ocular Surface Disease Index (OSDI), followed by clinical examinations that assess the amount and quality of the tear film (Fineide et al. 2022). A number of studies have examined and validated the OSDI questionnaire as a viable and trustworthy instrument for measuring the subjective symptoms of DED compared to other dry eye surveys to assess its discriminative capacity in detecting objective indications of DED (Irkec & Group 2007; Lu et al. 2018; Midorikawa-Inomata et al. 2019; Schiffman et al. 2000; Wang et al. 2019). These studies underscore the OSDI's reliability and validity across different languages and populations, further supporting its utility in clinical and research settings for evaluating the severity of dry eye symptoms and correlating them with clinical signs of the disease. Moreover, studies like Kyei et al. (2018) and Rodriguez-Garcia et al. (2023) have demonstrated the OSDI's strong correlation with other dry eye questionnaires, solidifying its position as a leading instrument for assessing dry eye severity.

The OSDI questionnaire is a well-validated and widely used tool for assessing ocular surface symptoms and evaluating the severity of DED (Amparo et al. 2015; Barber et al. 2018; Hashmani et al. 2021; Miller et al. 2010; Özcura et al. 2007). The Allergan's Outcomes Research Group developed the 12-item OSDI questionnaire to measure the symptoms of ocular irritation associated with DED and its consequences on vision-related activities. The initial 40-item questionnaire was eventually shortened to the final 12 items based on the accuracy and reliability of the patient data. The final OSDI questionnaire is organized into three parts. The first part focuses on dry eye symptoms, the second part addresses functional limitations such reading or watching television, and the third assesses ocular symptoms caused by environmental factors (Schiffman et al. 2000).

The OSDI questionnaire is a useful adjunct to previous clinical and subjective evaluations of dry eye since it provides a quantified evaluation of the frequency of dry eye symptoms and their impact on vision-related performance. It also possesses the necessary psychometric properties to be used as a clinical trial endpoint for DED (Schiffman et al. 2000). The OSDI questionnaire has been used to assess treatment efficacy in combination therapies for meibomian gland dysfunction (Lee et al. 2022). Additionally, it has been instrumental in exploring the relationship between clinical indicators and dry eye symptoms (Pult et al. 2013). Overall, the OSDI questionnaire serves as a valuable tool for evaluating ocular symptoms, gauging the severity of DED, and understanding its impact on vision-related quality of life. Its broad applicability and strong performance have contributed to its widespread use in both research and clinical practice.

In Malaysia, the OSDI questionnaire has been translated into Malay to cater to the local population's language needs and to eliminate language barriers in diagnosing and managing dry eye disease (Rahman et al. 2017). The translation process included rigorous steps such as forward and backward translation, synthesis, and quality evaluation to ensure cultural and linguistic appropriateness. The Malay version of the OSDI demonstrated good reliability, with a Cronbach's alpha of 0.77, indicating its effectiveness in assessing dry eye symptoms among Malay-speaking individuals (Rahman et al. 2017). This adaptation has facilitated more accurate assessments and improved patient care in the region, supporting broader research efforts and enhancing clinical outcomes.

2.10 INTRODUCTION OF MESOPIC, PHOTOPIC AND SCOTOPIC VISION

The human visual system can adjust to a broad variety of adaptive brightness levels. The capacity of human vision to work successfully over the immense 10 000-million-fold range of lighting levels to which it may be exposed, from starlight to intense sunshine, is arguably its most essential achievement, as seen in Figure 2.5.

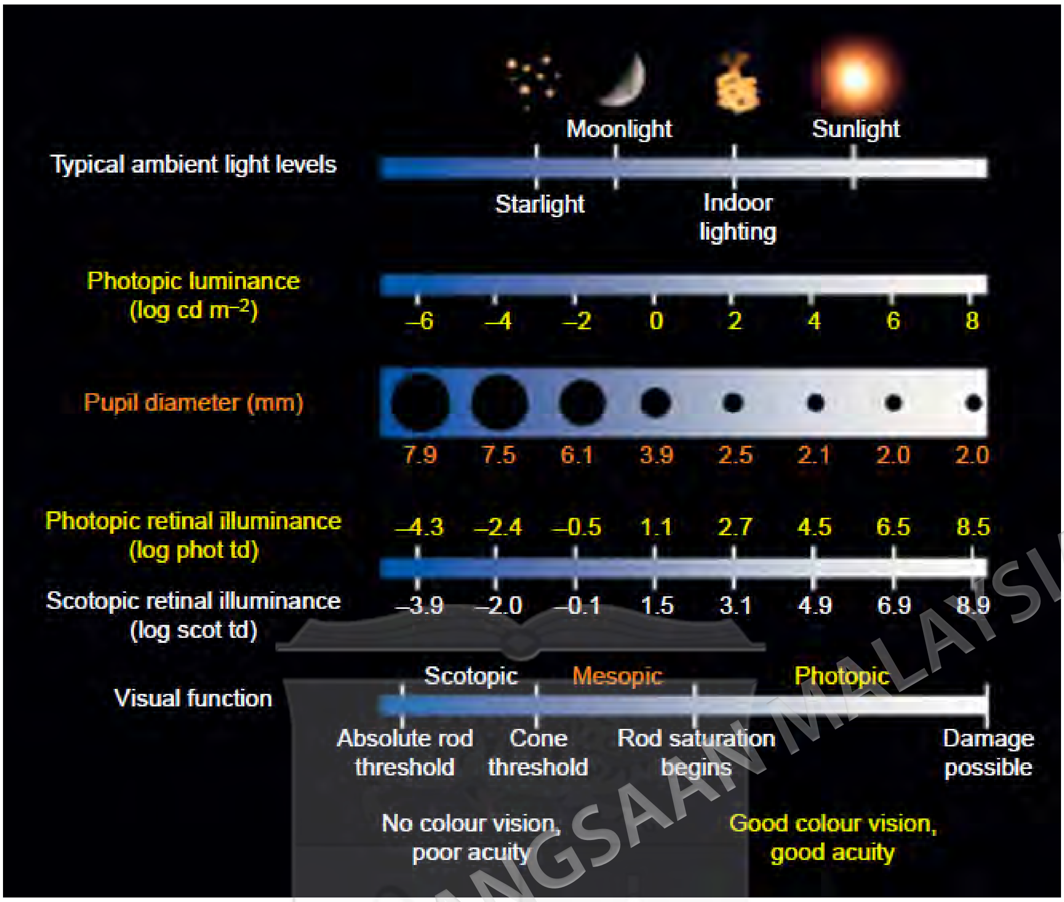

Figure 2.5 Light level encountered in everyday life and their corresponding luminance and visual function classification

Source: Barbur & Stockman 2010

Furthermore, it accomplishes this in spite of the constraints placed on it by specific neurons within the visual system, many of which have dynamic ranges of just around 100 times. It is impossible to regulate sensitivity throughout such a wide range without making concessions. Sharing the range between two distinct types of photoreceptors, the less-sensitive cones that operate at higher photopic levels and the more sensitive rods that function at lower scotopic levels—allows for a compromise. The two types of photoreceptors collaborate at intermediate mesopic levels (Mustafi et al. 2009). The trade-off between enhanced temporal and spatial acuity at higher light levels and enhanced sensitivity at lower light levels is another significant trade-off. High sensitivity is no longer required when light levels rise, and it is exchanged for gains in temporal and spatial acuity. The rod system has a lower acuity and a higher sensitivity that are consistent with its operation at lower light levels. These modifications take place independently inside the rod and cone systems (Barbur & Stockman 2010; Wang & Kefalov 2011) .

A switch to the rod system occurs in scotopic conditions (luminance less than 0.001cd/m2), when photon levels are low and spatial and temporal summation is crucial. The rod system responds more slowly, has poorer spatial resolution, and has limited color perception, despite being more sensitive to the low luminance environment (Barbur & Stockman 2010; Pokorny et al. 2006).

Although the human retina has between six and seven million cones overall, roughly five percent of all retinal photoreceptors, the visual acuity depends on as little as 100,000 cones. Cones react faster than rods but are less sensitive to light. In the upper mesopic and photopic range, at greater light intensities, cones and their post receptoral pathways function effectively (Mahabadi & Al Khalili 2023). Over the majority of this range, light adaptation systems inside the retina guarantee that cone photoreceptor activity adapts to variations in light intensity to produce a useable dynamic range of roughly 100, which stays generally independent of light level. When the light intensity falls, the cone system enhances its sensitivity by expanding the spatial and temporal extents across which light is summed, resulting in decreased spatial and temporal acuity. (Barbur & Stockman 2010).

Photopic vision occurs in bright light conditions where cone photoreceptors dominate, such as during daytime or in well-lit indoor environments. Examples of photopic environments include outdoor activities in sunlight, office work under fluorescent lighting, and reading under a desk lamp. Scotopic vision, on the other hand, occurs in low-light conditions where rod photoreceptors are predominant. Examples of scotopic environments include star-gazing on a clear night, navigating a dark room, and walking outdoors under dim moonlight.

Mesopic vision refers to the range of light intensities in which both rod and cone signals contribute to the visual response. This range stretches slightly over a thousand-fold from cone threshold to rod saturation and includes light intensities commonly observed in occupational settings (Pokorny & Cao 2010). The spectral makeup of the illuminant plays a crucial role in defining the relative intensities of rod and cone signals at mesopic levels (van Bommel & van Bommel 2015). As the degree of light is reduced and/or the spectral composition of the illuminant is changed, significant variations in visual performance are noticed across the visual field. The constant rise in rod signals as the light level decreases causes changes in the overall spectrum sensitivity of the eye, which has implications for the visual performance of the illuminant spectral power distribution (SPD) (i.e., the intensity of the light as a function of wavelength).

Photopic and scotopic features have been used to model mesopic luminous efficiency functions. However, mesopic visual sensitivity cannot be anticipated by summing rod and cone responses alone due to rod-cone interactions and the significant disparities between the rod and cone systems (Stockman & Sharpe 2006). Within the mesopic zone, the relative contributions of rods and cones as well as their post-receptoral pathways are continually changing. These variations are caused by changes in ambient light levels, the spectral makeup of the light that is accessible, retinal eccentricity, and the retina's state of adaptation (Maniglia et al. 2018; Shin et al. 2004). Additionally, the effects of optical properties on visual function, such as pupil size, aberrations, and ocular media, vary within the mesopic zone based on ambient light levels and the spectral composition of the available light. These factors determine how much light is reflected, scattered, and transmitted within the eye (Barbur & Stockman 2010).

Mesopic luminous efficiency is challenging to quantify or predict due to its intrinsic complexity and dependence on the outputs of both rod and cone photoreceptors. The characteristics of the post-receptoral pathways by which the rod and cone signals are relayed also differ from one another, in addition to variations in the spectrum sensitivity of the photoreceptors. Changes in light levels in the mesopic range cause these pathways' nature and balance to fluctuate continuously (Fryc et al. 2021; Stockman & Sharpe 2006).

Night driving is a primary example of a mesopic environment. The combination of headlights, street lights, and low natural light creates conditions where both rod and cone cells in the eyes are active. In addition, the everyday activities under mesopic conditions include any outside activities during the early evening, such as running or playing sports under street lights or other artificial illumination.

2.11 VISUAL CHALLENGES IN NIGHT DRIVING WITH DRY EYE

Driving at night is an essential part of modern life, but glare from vehicle headlights significantly affects a driver's contrast sensitivity, especially under low light conditions. This visual disturbance reduces the eye's ability to distinguish between different levels of contrast, which is crucial for tasks like object detection and depth perception. Glare overwhelms the retinal image, leading to a temporary reduction in visual clarity, particularly in mesopic (low light) conditions where the eye's sensitivity is already compromised. Studies show that glare can scatter light in the eye, further impairing contrast sensitivity and making it more difficult to see objects, particularly in low-contrast environments like night driving or when exposed to other strong light sources (Anderson & Holliday 1995; Puell et al. 2004). In individuals with DED, where contrast sensitivity is already reduced due to tear film instability, glare makes night driving even more hazardous (Haycock et al. 2019; Hu et al. 2022). This visual impairment is compounded by disability glare, which reduces the clarity of objects and increases discomfort, particularly when detecting pedestrians or judging distances (Alcón Gil et al. 2021; Theeuwes et al. 2002). Pedestrians are up to seven times more likely to be killed in accidents at night, and such accidents are more severe (Mohamed et al. 2013; Sullivan & Flannagan 2007). If the driver has DED, the visual disturbance caused by glare and reduced contrast sensitivity is exacerbated, worsening the risk of accidents (Boadi-Kusi et al. 2021).

The National Highway Traffic Safety Administration (NHTSA) in the United States received complaints from over 5000 respondents regarding discomfort and disability caused by headlight glare. These respondents, ranging in age from 18 to 74 and beyond, reported that 37% found the glare disturbing (Singh & Perel 2004). This data highlights the significance of vision-related issues during night driving, which is already a risky activity even for drivers without any visual impairments. The frequency of these problems is concerning, especially since older drivers, who often report visual difficulties while driving at night, are particularly vulnerable. Even in the absence of ocular diseases, a significant proportion of older individuals approximately one-third of those over the age of 50, experience difficulties with night driving (Evans et al. 2020; Gruber et al. 2013; Naumann et al. 2014). Research further supports these concerns, with studies showing that night driving exacerbates vision-related challenges, making it even more hazardous for those with visual impairments (Kimlin et al. 2016; Maniglia et al. 2018; Tong et al. 2010).

In addition to age and ocular conditions, demographic factors such as gender and the duration of night driving exposure also influence driving performance. Previous studies have shown that there are gender differences in night driving challenges. Female drivers frequently report higher levels of perceived difficulty and greater glare sensitivity, which makes them more likely to restrict their night driving compared to male drivers (Brabyn et al. 2005; Sarkin et al. 2013). Furthermore, the amount of time a driver spends driving at night can affect their visual fatigue and performance. Drivers who are frequently exposed to low-light environments and continuous oncoming headlight glare may experience visual strain over time. This reduces driving comfort and increases driving difficulty (Garcia & Lopez 2023). On the other hand, drivers who rarely drive at night may also experience more perceived difficulty because they lack recent adaptation to the nighttime driving environment (Santos & Torres 2022). As a result, it is important to investigate how these demographic factors, specifically gender and average time of night driving, interact with visual conditions to predict self-reported night driving difficulty.

Night driving presents unique challenges and is a prime example of a mesopic environment where both rod and cone cells in the eyes are active. When examining the visual difficulties of nighttime driving, it is important to take into account the numerous variations in the road environment that exist between day and night. The illumination provided by ambient lighting sources, including streetlights and moonlight, as well as the driver's own car's headlights and those of approaching cars, is of interest. Visual performance can be strongly impacted by these sources of illumination (both in terms of absolute values and fluctuations in these levels). Street lighting illumination varies depending on the kind of road, traffic volume, and a variety of other factors. It is commonly known that street lighting lowers the likelihood of crashes at night.

According to a previous analysis of road lighting and collisions, placing streetlights on unlit roads can cut the probability of a crash by more than half (55%) at night (Beyer & Ker 2009). Recognizing that the lighting levels for nighttime roads tend to give just a limited amount of information regarding the dynamic light and glare levels faced under actual nighttime roadways is also crucial. Examples of these include incoming headlights, signage, and other traffic signals.

The illumination from a car's headlights is three-dimensional of the traffic environment to enhance nighttime visibility for drivers and other users of the road. The design and configuration of the headlights also affect the level of illumination such as whether the headlights are set to high or low beam. It is significant to note that light levels for headlights and the nighttime road environment are frequently measured using illuminance or luminance metres that employ the photopic spectral luminosity efficiency function that is relevant for photopic vision at light levels $>3cdm^{-2}$ (Alferdinck 2006). While headlights undoubtedly help to improve the lighting of the road, they may also have unfavourable glare effects that make it harder for drivers to react to other road users, such as other cars, bicycles, and pedestrians. Studies on closed and open roads have shown that headlamp glare makes it more difficult for drivers to see road hazards, as well as real (Whetsel Borzendowski et al. 2015; Wood et al. 2005, 2012) and simulated pedestrians, at night (Theeuwes et al. 2002).

It is noteworthy to note that studies have revealed that drivers tend to underestimate the detrimental impact of glare on their nighttime vision and their ability to identify pedestrians (Whetsel Borzendowski et al. 2015). It has also been demonstrated that mesopic rather than traditional photopic measures of visual function are the best predictors of the negative effects of glare on closed road driving performance, which has implications for foretelling the nighttime visual challenges that particular drivers will face (Kimlin et al. 2017). The decrease in visual function that takes place at these low light levels is well documented (Gillespie-Gallery et al. 2013) and impacts both more fundamental components of visual perception, such as visual acuity and contrast sensitivity, as well as more complicated ones, such as visual search in the face of distractions (Walkey et al. 2006). As a result, the visual environment is considerably worsened when driving at night, which has a significant impact on visual performance (Wood 2020).

Patients with DED frequently report difficulty performing vision-related daily activities, as reported in previous quality-of-life surveys (Tong et al. 2010). For many people all over the world, driving is an essential part of their daily routine. Despite the fact that visual acuity is the most commonly used screening test when applying for a driver's licence, many other aspects of visual function are undoubtedly important in supporting effective vehicle control (Owsley & McGwin 2010). Night driving presents distinct challenges for individuals with DED, primarily due to the reduced contrast sensitivity, glare intolerance, and visual disturbances that characterize the condition. Contrast sensitivity, the ability to distinguish objects from their background in low-light conditions, is crucial for safe driving at night. Individuals with DED often experience decreased contrast sensitivity because of tear film instability, which disrupts the smooth optical surface of the eye (Koh et al. 2017). Studies have shown that under mesopic (low-light) conditions, glare from oncoming headlights can significantly worsen this issue, as it scatters light in the eye and reduces visual clarity (Maniglia et al. 2018).

The phenomenon of disability glare, where bright headlights reduce object visibility and increase discomfort, is even more pronounced in people with DED (Puell et al. 2004). Research by Kimlin et al. (2020) highlights those older drivers, many of whom suffer from DED, report greater difficulty with glare, impairing their night driving performance. Additionally, Woi et al. (2025a) found that individuals with unstable tear films face further visual challenges, including poor distance judgment and difficulty detecting pedestrians at night. Tear film instability diminishes visual clarity, especially in low-light situations, thereby increasing the risk of accidents during night driving.

Furthermore, the presence of higher-order aberrations (HOAs) during night driving exacerbates visual impairment by causing halos around bright light sources, making it harder to judge distances (Artal 2014). These disturbances, coupled with the already compromised vision in individuals with DED, make night driving particularly dangerous. Therefore, managing dry eye symptoms and improving tear film stability could significantly enhance visual performance and safety during night driving (Woi et al. 2025a).

2.12 VISION AND NIGHT DRIVING QUESTIONNAIRE (VND-Q)

The Vision and Night Driving Questionnaire (VND-Q) is an open-access self-reported measure of vision-related night driving difficulties (Kimlin et al. 2016). The VND-Q comprises a range of items related to driving tasks that vary in difficulty level, such as judging the distance to other moving cars and driving in poor weather at night. The VND-Q is frequently used to evaluate vision-related night driving challenges. The VND-Q scores have been shown to be associated with night driving performance in older drivers (Kimlin et al. 2020). Another study with drivers ranging in age from 20 to 72 years old revealed a positive correlation between age and VND-Q scores (Antwi-Adjei et al. 2021). A recent study investigated the relationship between drivers' self-reported driver skills and their perceived night driving difficulties using VND-Q among young and older drivers (Ozturk & Merat 2023). Interestingly, higher VND-Q scores were found in young drivers with higher self-reported safety skills but lower self-reported perceptual-motor skills. These findings emphasize the importance of understanding and addressing night driving difficulties, especially among different age groups, to enhance overall road safety.

With improving living standards, particularly in emerging economies, vehicle ownership becomes more attainable for a larger portion of the population (Chu et al. 2022). This phenomenon also overwhelms Malaysia; the active drivers in Malaysia are approximately 10.4 million (Malaysian Road Transportation Department, 2023). Given the enormous number of drivers in Malaysia, a self-reported outcome measure like the VND-Q would be beneficial for healthcare professionals to evaluate patients' self-reported vision-related difficulties when driving at night. However, the VND-Q is developed for English speakers, but Malay is the official language and the most widely used language in Malaysia (Soon et al. 2021). To date, there is no vision-related night driving questionnaire for the visually normal population available in Malay. A translation of the English version of VND-Q into Malay is needed to ensure that the questionnaire accurately reflects the cultural and linguistic context of the target population and that the responses obtained are meaningful and relevant to the individual being assessed. In order to determine the validity and reliability of the Malay version of VND-Q among Malaysians, one component of this study was translating the English version into Malay.

2.13 THE ROLE OF SELF-ESTEEM IN NIGHT DRIVING

The impact of self-esteem on night driving is a multidimensional problem that has been researched from numerous angles. The study by Baumeister et al. (2003) discovered that those with poor self-esteem had greater cortisol levels when presented with difficult driving scenarios, indicating a possible relationship between self-esteem and stress reaction when driving. According to Pyszczynski et al. (2004), mortality salience increased hazardous driving behaviour among those who regarded their driving abilities as a source of self-esteem, indicating that self-esteem may impact driving behaviour under psychological situations. Vogel and Mitchell (2017) highlight the need for future research to explore the role of driving-related self-esteem, particularly its specific influence on driving behaviour.

Furthermore, the mediating function of self-esteem in individual psychological and social behaviours, implying that self-esteem may play an important role in influencing driving behaviour via its effect on psychological processes (Wang et al. 2022). Similar with the study by Holland et al. (2002) emphasized the moderating role of self-esteem in driving-related cognitive dissonance, showing how individuals with different self-esteem levels justify or rationalize their driving behaviour. Moreover, the significance of understanding the circumstances on which self-esteem is founded, implying that different parts of self-esteem may have diverse consequences on behaviour, particularly driving behaviour (Pimentel et al. 2018).

Overall, the synthesis of these references suggests that self-esteem may play a multifaceted role in influencing driving behaviour, particularly in the context of night driving. Although the existing literature does not directly address this context, self-esteem has been shown to impact stress responses, risky driving behaviour, and psychological processes, all of which can collectively influence an individual's behaviour behind the wheel at night.

2.14 THE ROSENBERG SELF-ESTEEM SCALE (RSES) QUESTIONNAIRE

Various self-report instruments have been developed to assess self-esteem, each differing in focus, structure, and application context. Among these, the Rosenberg Self-Esteem Scale (RSES) is one of the most widely used and validated tools for measuring global self-esteem. The RSES questionnaire is a popular self-esteem assessment tool. It was created in 1965 by Morris Rosenberg. The measure is made up of ten items that evaluate a person's overall self-esteem. On a Likert scale, participants were asked to score their degree of agreement with each item, ranging from strongly agree to strongly disagree (Gezgin & Ann Dev 2018).

The RSES questionnaire has been widely used in studies to investigate many facets of self-esteem. It has been used to study the etiology of self-esteem as well as its link to mental health, academic achievement, social consequences, and other psychological categories (Ajmal et al. 2018; Akhter & Ferdous 2019; Chai et al. 2020; Pimentel et al. 2018). The tool has been utilized in research with a wide range of participants, including teenagers from various cultural and racial origins, university students, people with dementia, and football players (Clare et al. 2020; Musculus & Lobinger 2018; Supple et al. 2013).

The RSES is brief, simple, straightforward, easy to administer, and has a long history of use (Li et al. 2019). The RSES's psychometric qualities have been tested in a variety of groups and languages. Several studies have been conducted to investigate its reliability, validity, and factorial equivalence in various cultural situations (Galanou et al. 2014; Gómez-Lugo et al. 2016). According to a report from Khan et al. (2020), driving and self-esteem are related where drivers who believe driving is important for their self-esteem are more likely to accept risks when driving. This study emphasises the connection between self-esteem and driving especially night driving. The RSES was translated into Malay by Jamil (2006), with the Malay version demonstrating good internal consistency, as indicated by a Cronbach’s alpha of 0.80. Overall, the RSES Malay version is considered a valid and reliable instrument for assessing self-esteem in the Malaysian context.

CHAPTER III

METHODOLOGY

3.1 INTRODUCTION

Previous chapter has pointed out the definition, classification, risk factor, causes, sign and symptoms of DED that related to night driving. Hence, the study to explain the relationship between the dry eye symptoms with the difficulty of night driving amongst adults is crucial. A primary purpose of this study is to investigate whether a significant linkage exists between dry eye symptoms and difficulty driving at night in Malaysian adults. Moreover, this chapter describes the translation and validation of the Vision and VND-Q into Malay (VND-Q-M), as well as the procedures involved in using the OSDI, VND-Q-M, and RSES questionnaires for data collection and statistical analysis.

3.2 STUDY DESIGN

The research adopted a cross-sectional, survey-based design. The study was conducted in two distinct phases: Phase 1 involved the translation and validation of the VND-Q-M. Phase 2 focused on examining the correlations and identifying predictors between dry eye symptoms, self-esteem, and night driving difficulties among Malaysian adults.

3.3 STUDY LOCATION AND DURATION

The study was conducted nationwide across Malaysia. To facilitate data collection among active drivers, the survey was distributed electronically via various social media platforms. The data collection was carried out in two distinct phases: Phase 1 (translation and validation of the VND-Q-M) was conducted from July 2022 to

November 2022, and Phase 2 (the main cross-sectional survey) took place from November 2022 to August 2023.

3.4 SAMPLE SIZE

The study was conducted in two phases, requiring separate sample size determinations for each phase.

3.4.1 Phase 1: Translation and Validation Study

Prior to the main study, the VND-Q-M questionnaire underwent content validation by six experts to ensure the relevance and clarity of the items. Following expert validation, a pilot study was conducted to evaluate the instrument's reliability and construct validity through Exploratory Factor Analysis (EFA). The sample size for this phase was determined using the respondents-per-item rule of thumb, which recommends between 10 to 15 respondents per item to adequately perform factor analysis (Hair et al. 2019). As the VND-Q-M consisted of eight items, a target sample size of 120 drivers was established to evaluate the clarity, feasibility, and construct validity of the instrument prior to proceeding to the main study.

3.4.2 Phase 2: Main Cross-Sectional Survey

The target population for the main study consisted of active adult drivers aged between 16 to 40 years in Malaysia, totaling 6,753,765 individuals (Malaysian Road Transport Department 2021). To determine the minimum required sample size, a 95% confidence level, a 5% margin of error and a 50% population variability were utilized. Based on the sample size determination table developed by Krejcie & Morgan (1970), the minimum required sample size was 384 drivers. To account for potential non-response, participant dropout, or incomplete survey submissions which are common in online survey distributions, the calculated sample size was inflated by approximately 10% to 15%. This resulted in an adjusted target sample size of approximately 420 to 440 participants. A purposive sampling strategy was employed to recruit participants who met the study's inclusion criteria.

3.5 INCLUSION AND EXCLUSION CRITERIA

To ensure the selection of suitable participants for this study, specific inclusion and exclusion criteria were established. These criteria were designed to identify individuals who met the study's objectives while minimizing potential confounding factors.

3.5.1 Inclusion Criteria

1. Malaysian citizen: To ensure a geographically homogenous sample familiar with local driving conditions.

2. Aged 18 to 40 years: To target active adult drivers while minimizing age-related ocular diseases as confounding factors.

3. Holds a valid Malaysian driving license: To guarantee participants meet legal and national driving standards.

4. Vision fit for driving: To confirm baseline visual acuity, isolating dry eye as the primary visual variable being studied.

5. At least a year of driving experience: To exclude novice driver errors that could independently affect driving difficulty.

6. Driving at night at least once a week: To ensure participants have recent and relevant experience with nighttime driving.

3.5.2 Exclusion Criteria

1. Physical frailty: To eliminate physical limitations that could independently impair driving ability.

2. Systemic disease affecting driving or cognition: To exclude conditions that compromise reaction times or cognitive functions.

3. Ocular disease or abnormality other than DED: To ensure visual disturbances are attributed strictly to dry eye, avoiding confounders like glaucoma or retinopathy.

4. History of ocular or refractive surgery: To eliminate post-surgical visual aberrations that could mimic or confound DED symptoms.

3.6 ETHICS APPROVAL

Ethics approval was obtained from the Research Ethics Committee National University of Malaysia (UKM PPI/111/8/JEP-2022-103) (Appendix A). All procedures were conducted in accordance with the Declaration of Helsinki. Prior to participation, all experts and participants were provided with a Patient Information Sheet (Appendix B), and informed consent (Appendix C) was obtained electronically.

3.7 TRANSLATION AND VALIDATION OF THE VND-Q

To ensure the Vision and Night Driving Questionnaire (VND-Q) was suitable for use among the Malaysian population, a systematic translation and validation process was undertaken. This process aimed to maintain the conceptual integrity of the original instrument while adapting it to the cultural and linguistic context of Malay-speaking respondents. The following subsections describe the procedures involved in the translation, content and construct validation, and reliability testing of the Malay version of the VND-Q.

3.7.1 Forward-Backward Translation Process

The Vision and Night Driving Questionnaire (VND-Q) was translated from English to Malay following the World Health Organization's (WHO) guidelines, which recommend a forward-backward translation process to ensure conceptual equivalence and cultural relevance (World Health Organization 1996). Initially, two (2) experts (a linguistic expert and an optometry professional) proficient in both languages performed the forward translation. This was followed by a backward translation conducted by two (2) separate of experts with similar backgrounds, translating the Malay version back into English. To finalize and validate the translated questionnaire, a harmonization meeting was held with five (5) bilingual authors. This team carefully compared the backward-translated version with the original questionnaire, addressing any linguistic discrepancies and refining expressions to maintain the integrity of the instrument. The discussions ensured that the final Malay VND-Q was a true reflection of the original, ready for use in the intended context.

3.7.2 Validation of VND-Q Malay questionnaire

The validation of the Malay Vision and Night Driving Questionnaire (VND-Q) involved a two-step process: content validation and construct validation. For content validation, six (6) bilingual vision care experts, including four (4) optometry lecturers with PhDs and two (2) clinical optometrists, were selected to assess the questionnaire's translation. Table 3.1 presents the profile of the expert panel involved in the content validation process. They received detailed instructions about the study and their role via email and agreed to review the items. Using a 4-point Likert scale, they evaluated each item for relevance, clarity, and understandability, providing written comments to improve the questionnaire. Only items with a Content Validity Index (CVI) of at least 0.80 were kept (Yusoff et al. 2021).

Table 3.1 Panel of bilingual vision care experts for VND-Q content validation

Panel Expert	Qualification	Position/Role	Servicing Year(s)
1	PhD (Optometry)	Lecturer	34
2	PhD (Optometry)	Lecturer	28
3	PhD (Optometry)	Lecturer	25
4	PhD (Optometry)	Lecturer	20
5	MSc (Optometry)	Clinical Optometrist	18
6	MSc (Optometry)	Clinical Optometrist	17

Construct validation was performed through an Exploratory Factor Analysis (EFA) using Principal Axis Factoring (PAF) with Promax rotation, which helped identify latent constructs and ensure the questionnaire's factors were interpretable. A purposive sample of 120 participants, aged 20 to 42 years old (mean age = 28.33 ± 6.38 years), was recruited based on specific criteria: Malaysian nationality, proficiency in Malay, possession of an active driving license, regular night driving, a recent eye examination, and no ocular disease. They completed the two-part VND-Q on Google Forms, which included demographic data and the questionnaire items. This process took place over three months, enabling a thorough examination of the questionnaire's construct validity.

3.7.3 Internal Reliability of VND-Q Malay Questionnaire

To assess the reliability of the responses, the Cronbach's Alpha coefficient was calculated. A value exceeding 0.7 was deemed acceptable, indicating that the questionnaire items were consistently interpreted by the respondents and could be considered reliable (Yusoff et al. 2021). This step ensured that the instrument would yield dependable data for the main study.

3.8 MEASUREMENT INSTRUMENTS

Several validated instruments in the Malay language were employed in this study to ensure accurate and culturally relevant data collection. These included the Ocular Surface Disease Index (OSDI) for assessing dry eye symptoms, the Vision and Night Driving Questionnaire (VND-Q) for evaluating vision night driving difficulty, and the Rosenberg Self-Esteem Scale (RSES) to measure self-esteem levels. All instruments used have been previously validated for use in the Malaysian population.

3.8.1 Dry eye symptoms assessment: Ocular Surface Disease Index (OSDI) questionnaire

The OSDI questionnaire is a 12-item questionnaire designed to assess subjective DED and its effects on vision-related activities of daily living over the previous week (Walt et al. 1997). Ocular symptoms (3 questions), vision-related functions (6 questions), and environmental triggers (3 questions) are the three subscales of this questionnaire. The total score on the OSDI ranges from 0 to 100 points and is calculated by multiplying the total score of all questions by 25 and dividing the result by the number of valid answers. A maximum score of 100 points per subscale can be obtained using this method. To address Objective 2, the respondent's DED was classified into categories of normal (0–12 points), mild (13–22 points), moderate (23–32 points), and severe (33–100 points) based on the standard OSDI grading scale (Schiffman et al. 2000). This questionnaire was translated into Malay and has an internal consistency of 0.77, which indicates that it is reliable (Rahman et al. 2017).

3.8.2 Self-reported quality of night driving assessment: Vision and Night Driving Questionnaire (VND-Q)

The Vision and Night Driving Questionnaire (VND-Q) were used to assess vision-related night driving difficulties (Kimlin et al. 2016). It's a nine-item, five-point Likert-type scale-based self-reported measure of vision-related night driving difficulties, with responses ranging from "no difficulty" to "extreme difficulty." The ordinal VND-Q score can be converted to a Rasch-scaled interval-level score ranging from 0 to 10 by summing the item response scores, making the VND-Q score suitable for parametric statistics. A higher or more positive score indicates more vision-related night driving difficulties, while a lower or more negative score indicates fewer difficulties. The Malay version of VND-Q was translated and validated to be used for this study.

3.8.3 Self-Esteem assessment: Rosenberg Self-Esteem Scale-Malay (RSES-M) questionnaire

The Rosenberg Self-Esteem Scale (RSES) were used as a measure of global self-esteem; assessing one's overall sense of self-worth (Rosenberg 1965). It has 10 items with four points Likert scale ranging from one (strongly disagree) to four (strongly agree). The maximum score would be 40 and the minimal score would be 10. Higher total RSES scores indicate higher self-esteem. The RSES questionnaire has been translated into Malay with an overall Cronbach's alpha of 0.80 (Jamil 2006).

3.9 PROCEDURES

The complete online data collection form (Appendix E), which included the OSDI, VND-Q-M, and RSES questionnaires were distributed to participants both online and in person, following a sequential procedural flow. First, participants' demographic information was collected, including age, gender, ethnicity, occupation, state, and area of residence. In this same initial section, participants also answered open-ended questions about the types of vehicles they drive, average night driving days in a week, and average night driving time in a 24-hour period. To ensure vision met the driving licence requirement of at least 6/12 (Ministry of Health Malaysia 2011), self-reported vision status was assessed using two questions adapted from the World Health Survey (WHO 2002): whether they had difficulty seeing and recognizing someone familiar across the road in the previous month, and when they last had their eyes checked. Following this demographic and screening phase, the core questionnaires were self-administered sequentially by the participants: the VND-Q-M (Part B), the OSDI-M (Part C), and the RSES-M (Part D). Finally, the surveys were submitted, and the total scores for all three questionnaires were calculated. The data collection occurred over a period of three months, ensuring a diverse range of participants and driving experiences.

3.10 DATA ANALYSIS

The data analysis methodology was tailored to address each specific research objective. The analysis was performed using the Statistical Package for Social Sciences (SPSS) Version 26.0 (IBM Corp, Armonk, NY). Prior to inferential analysis, data normality was assessed using the Kolmogorov-Smirnov test to justify the use of non-parametric statistics. The following outlines the procedures and statistical tests employed.

Objective 1: Content Validity, Construct Validation and Reliability Analysis

The questionnaire underwent a forward-backward translation process to ensure its appropriateness for the target population. Subsequently, the Content Validity Index (CVI) was calculated, including both the item-level content validity index (I-CVI) and the scale-level content validity index (S-CVI) (Yusoff 2019). The I-CVI for each item was computed as the proportion of experts giving a rating of 3 or 4 on a 4-point relevance scale, i.e., *I-CVI = (number of experts rating 3 or 4 ÷ total number of experts)*. At the scale level, two approaches were applied: (1) the average method (S-CVI/Ave), calculated as the mean of the I-CVI scores across all items, and (2) the universal agreement method (S-CVI/UA), calculated as the proportion of items that achieved unanimous expert ratings of 3 or 4, i.e., *S-CVI/UA = (number of items with universal agreement ÷ total items)* (Polit & Beck 2006). A score of 1 was assigned when there was 100% agreement among experts (UA method), with an acceptable CVI value being at least 0.83 for a panel of six experts (Polit et al. 2007; Polit & Beck 2006).

For construct validation, Exploratory Factor Analysis (EFA) was conducted using the Principal Axis Factoring (PAF) method with Promax rotation. Prior to EFA, the correlation matrix was examined for factorability, applying Barlett's test of sphericity ($p < 0.05$) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (> 0.50). Communality values were required to exceed 0.2 (Child 2006), and factors were retained based on eigenvalues greater than one (Yong & Pearce 2013), with the total variance explained by these factors needing to be at least 50% (Samuels 2017). Reliability of the scale was assessed by computing Cronbach's alpha, with a value above 0.7 deemed indicative of good reliability (Terwee et al. 2007).

Objective 2: Comparison Across OSDI Categories

The Kruskal-Wallis test was utilized to compare Vision and Night Driving Questionnaire (VND-Q) scores across different Ocular Surface Disease Index (OSDI) categories (normal, mild, moderate, and severe dry eye), which is appropriate for non-parametric data.

Objective 3: Association Between VND-Q and OSDI Scores

To assess the relationship between VND-Q and OSDI scores, Spearman's rho correlation coefficient was calculated. This non-parametric measure was chosen due to its ability to detect monotonic relationships without assuming normal distribution of the variables.

Objective 4: Predictive Modelling

Multiple Linear Regression (MLR) analysis was conducted to predict the effect of dry eye symptoms, self-esteem level, age, gender, and average night driving time on night driving difficulty scores. Variables included in the MLR were selected based on their significance value of $p < 0.20$ in preliminary analyses using Spearman's rho correlations. This broader screening prevents the premature exclusion of potentially important predictors or confounders, adhering to established statistical modeling guidelines (Hosmer et al. 2013). These preliminary analyses explored the relationships of VND-Q scores with OSDI scores, RSES scores, age, and duration of night driving, as well as its association with gender.

CHAPTER IV

RESULTS

4.1 INTRODUCTION

The study reveals the intricate relationship between ocular symptoms and the issues drivers face when traveling at night, culminating in a regression analysis that identifies the principal factors contributing to these challenges. This chapter synthesizes the pivotal findings from the comprehensive survey, examining the association between dry eye symptoms and the nighttime driving difficulties encountered by Malaysian adult drivers. Utilizing the culturally adapted Malay Vision and Night Driving Questionnaire (VND-Q-M), the Ocular Surface Disease Index (OSDI), and the Rosenberg Self-Esteem Scale (RSES), the data were analyzed to explore the extent to which dry eye severity affects night driving difficulties. This study was conducted in two distinct phases, each characterized by specific objectives. Phase 1 of the study concentrated on validating the Malay version of the VND-Q, while Phase 2 focused on the study's objectives to investigate correlations, and possible predictors pertaining to the VND-Q scores.

4.2 FIRST PHASE: TRANSLATION AND VALIDATION OF THE VISION AND NIGHT DRIVING QUESTIONNAIRE (VND-Q) INTO THE MALAY LANGUAGE

The Malay version of the VND-Q (VND-Q-M) was successfully translated and validated. Content validity was high, with indices of relevance, clarity, and understandability all exceeding 0.98. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.79, indicating good factorability. Exploratory factor analysis (EFA) using Principal Axis Factoring (PAF) with Promax rotation identified two distinct factors within the questionnaire. The internal consistency of the VND-Q-M was excellent, as indicated by a Cronbach's alpha of 0.84. These results confirm the reliability of the VND-Q-M for assessing night driving difficulties related to vision.

4.2.1 Translation

The translation process was carried out as described in the Methodology chapter. To ensure conceptual and semantic equivalence, several minor discrepancies identified between the forward and backward translations were resolved during the expert harmonization meeting. For example, specific prepositions and terms were heavily debated and rephrased to improve sentence fluency and cultural appropriateness; the term "due to" was harmonized to "*disebabkan*" rather than "*akibat*" to ensure natural flow (Item 4). Furthermore, the translation for "oncoming headlights" (Item 4) was refined from the literal "*arah hadapan*" to the more contextually accurate "*arah bertentangan*" for Malaysian drivers. Similarly, grammatical structures were adjusted for readability, such as simplifying the formal "*menganggarkan*" to "*menganggar*" (Items 7 and 8) and refining "*dalam keadaan hujan*" to "*ketika hujan*" (Item 9). Through these detailed amendments, a consensus was reached on all nine original items. Table 4.1 presents the original English items alongside the harmonized Malay-translated version prior to the subsequent content validation phase.

Table 4.1 The nine-item Malay version of VND-Q (original and translated version)

Item	Original (English)	Translated (Malay)
1.	Seeing dark coloured cars when driving at night?	*Melihat kereta berwarna gelap semasa memandu waktu malam?*
2.	Seeing pedestrians or animals on the road side when driving at night?	*Melihat pejalan kaki atau haiwan di tepi jalan semasa memandu waktu malam?*
3.	Reading Street signs when driving at night?	*Membaca papan tanda jalan semasa memandu waktu malam?*
4.	Seeing the road because of oncoming headlights when driving at night?	*Melihat jalan disebabkan lampu depan kereta dari arah bertentangan semasa memandu waktu malam?*
5.	Seeing because of glare when driving at dawn or dusk?	*Melihat disebabkan silau semasa memandu waktu subuh atau senja?*
6.	Adjusting after passing headlights from oncoming cars when driving at night?	*Penyesuaian selepas melepasi lampu depan kereta dari arah hadapan semasa memandu waktu malam?*
7.	Judging the distance to your turn-off or exit while driving at night?	*Menganggar jarak ke jalan susur atau jalan keluar semasa memandu waktu malam?*
8.	Judging the distance between you and other moving cars when driving at night?	*Menganggar jarak di antara anda dengan kereta lain yang sedang bergerak semasa memandu waktu malam?*
9.	Seeing the road in rain or poor weather when driving at night?	*Melihat jalan ketika hujan atau cuaca buruk semasa memandu waktu malam?*

4.2.2 Content Validation

Table 4.2 shows the item-level content validity index (I-CVI) and scale-level content validity index (S-CVI) values of the nine-item Malay version of VND-Q. The average of the I-CVI scores for all items on the scale (S-CVI/Ave) values for all three components in term of relevance=0.98, clarity=0.93, and understandability=0.94, were greater than 0.83. However, the I-CVI values for clarity and understandability of Item 6 were only 0.50. Three out of the six experts commented that the purpose of Item 6 could be confused with that of Item 4. Both items were related to the vision affected by oncoming headlights from vehicles during night driving. Item 4 inquired about the difficulty of seeing the road because of oncoming headlights when driving at night, while Item 6 inquired about the difficulty of adjusting after passing headlights from oncoming cars when driving at night. Item 4 was precisely asking for road visibility, but it was not clear that the term “adjusting” in Item 6 was referring to the vision or the vehicle. A harmonized meeting was conducted among authors and the discrepancies were discussed before any amendment was made to the questionnaire.

Table 4.2 The CVI values for the nine-item Malay version of VND-Q by six experts

Item	Relevance			Clarity			Understandability		
	Experts in Agreement	**I-CVI**	**UA**	**Experts in Agreement**	**I-CVI**	**UA**	**Experts in Agreement**	**I-CVI**	**UA**
1	6	1.0	1	6	1.0	1	6	1.0	1
2	6	1.0	1	6	1.0	1	6	1.0	1
3	6	1.0	1	6	1.0	1	6	1.0	1
4	6	1.0	1	5	0.83	0	6	1.0	1
5	6	1.0	1	6	1.0	1	6	1.0	1
6	5	0.83	0	3	0.50	0	3	0.5	0
7	6	1.0	1	6	1.0	1	6	1.0	1
8	6	1.0	1	6	1.0	1	6	1.0	1
9	6	1.0	1	6	1.0	1	6	1.0	1
	S-CVI/Ave	0.98		**S-CVI/Ave**	0.93		**S-CVI/Ave**	0.94	
	S-CVI/UA		0.89	**S-CVI/UA**		0.78	**S-CVI/UA**		0.89

I-CVI: item-level content validity index; UA: universal agreement (1: achieve 100% expert agreement; 0: do not achieve 100% expert agreement); S-CVI/Ave: average of the I-CVI scores for all items on the scale; S-CVI/UA: proportion of items on the scale that achieve a scale of 3 or 4 by all experts; VND-Q: Vision and Night Driving Questionnaire

Following the discussion and taking all the experts' input into consideration, Item 6 was removed. Item 4, Item 7, and Item 9 were rephrased based on the suggestions of experts. The CVI values for all components were recalculated after the amendment. All I-CVI and S-CVI values of the eight-item Malay version of VND-Q were equal to or greater than 0.83 as shown in Table 4.3. The final Malay version of VND-Q (VND-Q-M) is shown in Appendix D.

Table 4.3 The CVI values for the eight-item Malay version of VND-Q by six experts (Item 6 was removed)

Item	Relevance			Clarity			Understandability		
	Experts in Agreement	**I-CVI**	**UA**	**Experts in Agreement**	**I-CVI**	**UA**	**Experts in Agreement**	**I-CVI**	**UA**
1	6	1.0	1	6	1.0	1	6	1.0	1
2	6	1.0	1	6	1.0	1	6	1.0	1
3	6	1.0	1	6	1.0	1	6	1.0	1
4	6	1.0	1	5	0.83	0	6	1.0	1
5	6	1.0	1	6	1.0	1	6	1.0	1
7	6	1.0	1	6	1.0	1	6	1.0	1
8	6	1.0	1	6	1.0	1	6	1.0	1
9	6	1.0	1	6	1.0	1	6	1.0	1
	S-CVI/Ave	1.0		**S-CVI/Ave**	0.98		**S-CVI/Ave**	1.0	
	S-CVI/UA		1.0	**S-CVI/UA**		0.88	**S-CVI/UA**		1.0

I-CVI: item-level content validity index; UA: universal agreement (1: achieve 100% expert agreement; 0: do not achieve 100% expert agreement); S-CVI/Ave: average of the I-CVI scores for all items on the scale; S-CVI/UA: proportion of items on the scale that achieve a scale of 3 or 4 by all experts; VND-Q: Vision and Night Driving Questionnaire

4.2.3 Construct Validation

The demographic analysis of the 120 participants who involved in construct validation and reliability analysis is reported in Table 4.4. The participants were predominantly female (64.2%) and employed (60.8%), with a mean age of 28.33 years (±6.38 SD) and an age range of 20 to 42 years. All participants held an active driving license, and the mean duration of driving experience was 9.32 ±6.45 years. The frequency of night driving per week averaged at 3.98 ±2.15 times and nearly three-quarters (74.2%) drove five or more nights per week, indicating a moderately high level of nighttime driving activity among the participants.

Table 4.4 Demographic characteristics of participants

Demographic Factor		Phase 1 (n=120)
Gender	Male	43 (35.8%)
	Female	77 (64.2%)
Age (years)	Mean ±SD	28.33 ±6.38
Occupation	Student	47 (39.2%)
	Employed	73 (60.8%)
Driving License Status	Active	120 (100%)
Years of Driving Experience	1-2 years	35 (29.2%)
	3-4 years	39 (32.5%)
	5 and more years	46 (38.3%)
Weekly Night Driving Frequency	1-2 times weekly	13 (10.8%)
	3-4 times weekly	18 (15.0%)
	5-6 times weekly	29 (24.2%)
	Every day of the week	60 (50.0%)

Note: SD = Standard Deviation, % = Percentage, n = total participant(s)

The minimum score of VND-Q-M is 8, indicating no difficulty, while the maximum score is 40, indicating the greatest difficulty. The distribution of VND-Q-M mean score in Phase 1 was 18.18 ±5.44, suggesting low to moderate experiences in night driving difficulties among the participants.

In this study, exploratory factor analysis (EFA) was used to validate the constructs. Principal Axis Factoring (PAF) with Promax rotation was the technique employed in EFA. The p-value of Barlett's test of sphericity was smaller than 0.001 and the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.79. The sample was proved adequate for factor analysis. Two factors with eigenvalues greater than one (Factor 1=3.83, Factor 2=1.17) were identified as underlying the eight items. The two-factor model accounted for 51.24% (Factor 1=42.14%, Factor 2=9.11%) of the variance in the questionnaire data with a factor correlation of 0.57. Factor 1 was labelled "visibility" while Factor 2 labelled "distance judgement". Factor loading for each item was listed in Table 4.5. All factors had loadings at values of 0.40 or greater. Item 1 to Item 5 were loaded on the "visibility" factor, while Item 7 and Item 8 were loaded on the "distance judgement" factor. Item 4, Item 5, and Item 9 had cross-loadings, but the ratios of loadings were smaller than 75% for Item 4 and Item 5 (Samuels 2017). Item 9 had almost equal loading on both factors. Hence, it was not categorized as either of these factors.

Table 4.5 EFA for the eight-item Malay version of VND-Q (PAF with Promax rotation)

Item	Factor 1	Factor 2
1. Seeing dark coloured cars when driving at night? *1. Melihat kereta berwarna gelap semasa memandu waktu malam?*	0.74§	-0.07
2. Seeing pedestrians or animals on the road side when driving at night? *2. Melihat pejalan kaki atau haiwan di tepi jalan semasa memandu waktu malam?*	0.93§	-0.12
3. Reading Street signs when driving at night? *3. Membaca papan tanda jalan semasa memandu waktu malam?*	0.67§	-0.41
4. Seeing the road because of oncoming headlights when driving at night? *4. Melihat jalan disebabkan lampu depan kereta dari arah bertentangan semasa memandu waktu malam?*	0.63§	0.17
5. Seeing because of glare when driving at dawn or dusk? *5. Melihat disebabkan silau semasa memandu waktu subuh atau senja?*	0.40§	0.12
7. Judging the distance to your turn-off or exit while driving at night? *7. Menganggar jarak ke jalan susur atau jalan keluar semasa memandu waktu malam?*	-0.09	0.84§
8. Judging the distance between you and other moving cars when driving at night? *8. Menganggar jarak di antara anda dengan kereta lain yang sedang bergerak semasa memandu waktu malam?*	-0.01	0.68§
9. Seeing the road in rain or poor weather when driving at night? *9. Melihat jalan ketika hujan atau cuaca buruk semasa memandu waktu malam?*	0.45¶	0.42¶

§ Factor loadings ≥ .40 were considered significant and retained.
¶ Items with cross-loadings, i.e., similarly high loadings on more than one factor.

4.2.4 Reliability

Table 4.6 shows the Cronbach's alpha values for each factor and all eight items. For Factor 1, which assesses visibility (Item 1-5), a Cronbach's Alpha of .803 was obtained, suggesting a strong reliability among these items. Factor 2, focusing on distance judgement (Items 7 and 8), demonstrated a Cronbach's Alpha of .693, indicating moderate reliability. Meanwhile, grouping either Factor 1 or Factor 2 with item 9 resulted in strong and good Cronbach's Alpha values of .834 and .735, respectively. The combination of items from Factor 1 and Factor 2 revealed a good Cronbach's Alpha value of approximately .805. The overall scale, encompassing all eight items (Items 1-5, 7-9), achieved the highest Cronbach's Alpha of .841, further affirming the scale's high internal consistency. These results suggest that the eight-item Malay version of the VND-Q is a reliable measure for assessing visibility and distance judgement.

Table 4.6 Cronbach's Alpha for the eight-item Malay version of VND-Q

Item	Cronbach's Alpha
Factor 1 - Visibility (Item 1-5)	0.803
Factor 2 - Distance judgement (Item 7 and 8)	0.693
Factor 1 + item 9 (Item 1-5 and 9)	0.834
Factor 2 + item 9 (Item 7, 8 and 9)	0.735
Factor 1 + Factor 2 (Item 1-5, 7-8)	0.805
All eight-item (Item 1-5, 7-9)	0.841

4.3 SECOND PHASE: RELATIONSHIP BETWEEN DRY EYE SYMPTOMS AND NIGHT DRIVING DIFFICULTIES

The OSDI, VND-Q-M, and RSES questionnaires were distributed to 373 participants, showed that VND-Q-M scores significantly varied across OSDI categories (normal, mild, moderate and severe dry eye) ($p < .001$), especially when comparing between normal to mild and moderate to severe categories. A positive correlation was found between VND-Q-M and OSDI scores ($p < .001$), suggesting that increased dry eye symptoms are linked to greater night driving difficulty. Multiple regression analysis identified OSDI as a significant predictor of VND-Q-M scores, while RSES and gender were not. These findings showed that dry eye symptoms substantially impact night driving difficulty.

4.3.1 Participant Response, Demographic Characteristics and Comparative Analysis

A total of 931 participants responded to the online survey. Among these responses, 404 questionnaires were fully completed. Following data screening and filtering based on the study's inclusion and exclusion criteria, 31 responses were excluded, resulting in a final analytic sample of 373 drivers. Although the final sample size was slightly lower than the initially calculated minimum of 384, a post-hoc statistical evaluation was conducted to confirm its adequacy. First, recalculating the margin of error for a population of over 6.7 million at a 95% confidence level with n = 373 yielded a margin of error of 5.07%. This marginal increase of 0.07% from the targeted 5.00% is considered negligible and highly acceptable in contemporary survey-based research.

Furthermore, an evaluation of statistical power confirmed the sample was highly adequate for the planned predictive modeling. According to Green's (1991) rule of thumb for multiple linear regression ($n \geq 50 + 8m$), a model with three final predictors requires a minimum of 74 participants. Additionally, a post-hoc power analysis indicated that a sample size of 373 provides greater than 99% statistical pow er ($1 - \beta > 0.99$) to detect a medium effect size ($f^2 = 0.15$) at an alpha level of 0.05 for the regression model (Cohen 1988). Therefore, it remained statistically sufficient to support the required analyses and successfully achieve the objectives of the study.

The demographic characteristics of the 373 participants in Phase 2 were detailed in Table 4.7. Phase 2 participants were predominantly female (56.6%) and employed (83.6%), with a mean age of 30.98 ±5.22 years, and all held an active driving license. The cohort was ethnically diverse, with Malay participants representing the majority (85.0%). Participants were highly experienced drivers, with 78.8% reporting five or more years of driving experience. Night driving frequency varied, with 35.9% driving 1-2 times a week and 18.2% driving every night. The average duration of night driving was 96.03 ±89.03 minutes.

Table 4.7 Demographic characteristics of participants

Demographic Factor		Phase 2 (n=373)
Gender	Male	162 (43.4%)
	Female	211 (56.6%)
Age (years)	Mean ±SD	30.98 ±5.219
Ethnicity	Malay	317 (85.0%)
	Chinese	8 (2.1%)
	Indian	8 (2.1%)
	Bumiputra	32 (8.6%)
	Others	8 (2.1%)
Occupation	Student	30 (8.0%)
	Employed	312 (83.6%)
	Unemployed	31 (8.3%)
Driving License Status	Active	373 (100%)
Years of Driving Experience	1-2 years	44 (11.8%)
	3-4 years	35 (9.4%)
	5 and more years	294 (78.8%)
Weekly Night Driving Frequency	1-2 times weekly	134 (35.9%)
	3-4 times weekly	105 (28.2%)
	5-6 times weekly	66 (17.7%)
	Every day of the week	68 (18.2%)
Average Duration of Night Driving (minutes)	Mean ±SD	96.03 ±89.03
	Median (IQR)	60 (30-120)

Note: SD = Standard Deviation, % = Percentage, n = total participant(s), IQR = Interquartile Range

Table 4.8 shows the distribution of VND-Q-M, OSDI and RSES scores in Phase 2. The data was not normally distributed, as indicated by the Kolmogorov-Smirnov test ($p < .001$). The overall sample of 373 participants reported a mean VND-Q-M score of 16.50 (SD = 5.86) and a median of 15 (IQR = 12-20), indicating moderate self-reported night driving difficulties. The OSDI scores, which measure dry eye symptoms, had a mean of 20.17 (SD = 14.15) and a median of 18.75 (IQR = 8.33-31.25), suggesting a moderate level of dry eye symptoms. The RSES scores, assessing self-esteem, showed a mean of 28.47 (SD = 5.90) and a median of 29 (IQR = 25-33), indicating that most participants have a relatively high level of self-esteem.

Table 4.8 Distribution of VND-Q-M, OSDI and RSES scores in Phase 2

Gender	N	VND-Q-M score		OSDI score		RSES score	
		Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)
Overall	373	16.50 ±5.86	15 (12-20)	20.17 ±14.15	18.75 (8.33-31.25)	28.47 ±5.90	29 (25-33)
Male	162	15.87 ±6.06	14 (11-19)	17.43 ±13.31	16.67 (6.25-25)	28.87 ±5.73	30 (25-33)
Female	211	16.99 ±5.67	16 (13-21)	22.28 ±14.44	18.75 (12.5-31.25)	28.16 ±6.03	28 (25-33)

Note: SD = Standard Deviation, n = total participant(s), IQR = Interquartile Range

To investigate the differences in night driving difficulties, dry eye symptoms, and self-esteem between genders, the Independent-Samples Mann-Whitney U Test was employed, respectively. The results of this test indicated a statistically significant difference in VND-Q-M scores between male and female participants (U = 19486.5, p = .020). Similarly, the test also showed a significant difference in OSDI scores between genders (U = 20390.0, p = .001). Female participants had higher VND-Q-M and OSDI scores than male participants. Meanwhile, the analysis of RSES scores revealed no statistically significant difference between male and female participants (U = 15945.5, p = .266).

Table 4.9 summarizes the score values for the VND-Q-M. Under the "Visibility" factor, participants reported the least difficulty with "Reading street signs when driving at night", which had an average score of 1.67 (SD = 0.80) and a median score of 1 (IQR = 1-2). In contrast, "Seeing the road because of oncoming headlights when driving at night" posed the greatest challenge in this category, with the highest average score of 2.53 (SD = 1.12) and a median score of 2 (IQR = 2-3). The total visibility score averaged 10.20 (SD = 3.75), with a median score of 10 (IQR = 8-12), highlighting moderate difficulty in this domain. For the "Distance Judgement" factor, participants perceived "Judging the distance between their car and other moving vehicles at night" as relatively easier, with the lower average score of 1.55 (SD = 0.79) and a median score of 1 (IQR = 1-2). In comparison, another item, "Judging the distance to your turn-off or exit while driving at night" was slightly more challenging, with an average score of 1.82 (SD = 0.93) and a median score of 2 (IQR = 1-2). The total distance judgement score averaged

3.37 (SD = 1.57), with a median score of 3 (IQR = 2-4). The "Other" factor with only one item, "Seeing the road in rain or poor weather at night" was identified as the most challenging task overall compared to the other factors. It received the highest difficulty ratings across all items, with an average score of 2.93 (SD = 1.20) and a median score of 3 (IQR = 2-4).

Table 4.9 Score values for the VND-Q-M

Item	Mean ±SD	Median (IQR)
Visibility:		
1. Seeing dark coloured cars when driving at night? *1. Melihat kereta berwarna gelap semasa memandu waktu malam?*	1.83 ±0.87	2 (1-2)
2. Seeing pedestrians or animals on the road side when driving at night? *2. Melihat pejalan kaki atau haiwan di tepi jalan semasa memandu waktu malam?*	2.00 ±0.94	2 (1-3)
3. Reading Street signs when driving at night? *3. Membaca papan tanda jalan semasa memandu waktu malam?*	1.67 ±0.80	1 (1-2)
4. Seeing the road because of oncoming headlights when driving at night? *4. Melihat jalan disebabkan lampu depan kereta dari arah bertentangan semasa memandu waktu malam?*	2.53 ±1.12	2 (2-3)
5. Seeing because of glare when driving at dawn or dusk? *5. Melihat disebabkan silau semasa memandu waktu subuh atau senja?*	2.17 ±1.07	2 (1-3)
Total score	10.20 ±3.75	10 (7-12)
Distance Judgement:		
7. Judging the distance to your turn-off or exit while driving at night? *7. Menganggar jarak ke jalan susur atau jalan keluar semasa memandu waktu malam?*	1.82 ±0.93	2 (1-2)
8. Judging the distance between you and other moving cars when driving at night? *8. Menganggar jarak di antara anda dengan kereta lain yang sedang bergerak semasa memandu waktu malam?*	1.55 ±0.79	1 (1-2)
Total score	3.37 ±1.57	3 (2-4)
Other:		
9. Seeing the road in rain or poor weather when driving at night? *9. Melihat jalan ketika hujan atau cuaca buruk semasa memandu waktu malam?*	2.93 ±1.20	3 (2-4)

Note: SD = Standard Deviation, IQR = Interquartile Range

4.3.2 Comparative Analysis of VND-Q Scores Among OSDI Categories

The Kolmogorov-Smirnov test indicated non-normality for all except the VND-Q-M scores in the OSDI moderate category. The VND-Q-M and OSDI scores across different categories of dry eye severity are shown in Table 4.10. The OSDI categories are divided into normal, mild, moderate, and severe. The results show that the self-reported VND-Q-M scores increased with the severity of dry eye symptoms based on OSDI. Based on the descriptive analysis, participants with no dry eye symptoms (normal) reported the least night driving difficulties, while the participants with severe dry eye symptoms reported the greatest night driving difficulties.

Table 4.10 The self-reported night driving difficulty (VND-Q-M) across different dry eye symptoms (OSDI) categories

OSDI Category	n	OSDI		VND-Q-M	
		Mean ±SD	Median (IQR)	Mean ±SD	Median (IQR)
Normal	113	4.78 ±3.67	4.17 (2.08-8.33)	13.56 ±4.44	13 (10-16)
Mild	111	16.70 ±2.69	16.67 (14.58-18.75)	15.05 ±4.48	14 (12-18)
Moderate	76	27.08 ±3.25	27.08 (23.96-31.25)	19.18 ±6.16	19 (14-23)
Severe	73	42.09 ±7.96	39.58 (35.42-45.83)	20.49 ±6.01	21 (15-25)

Note: SD = Standard Deviation, n = total participant(s), IQR = Interquartile Range

The variation of scores across different categories were further confirmed using the Kruskal-Wallis test. The test was highly significant, $\chi 2(3) = 82.713$, $p < .001$, suggesting differences in self-reported night driving difficulty among different levels of dry eye symptoms. The post-hoc analysis using Bonferroni correction was conducted to identify significant differences between the groups (Table 4.11). After applying the Bonferroni adjustment, there was no significant difference in dry eye symptom severity between the normal and mild groups (adjusted $p > .05$), nor between the moderate and severe groups. Although the normal versus mild comparison initially showed significance ($p = .018$), this did not remain significant after adjustment (adjusted $p = .108$). In contrast, comparisons between normal versus moderate; normal versus severe; mild versus moderate; and mild versus severe; all revealed highly significant differences both before and after adjustment, with p-values remaining at smaller than .001. There was an increase in night driving difficulties when the dry eye symptoms were more severe, except between normal versus mild, and moderate versus severe groups.

Table 4.11 Pairwise comparisons of VND-Q-M score between OSDI categories

Comparison	Mean Rank Difference	Sig.	Adj.Sig. (Bonferroni)
Normal vs Mild	34.05	0.018	.108
Normal - Moderate	105.15	0.000	0.000**
Normal - Severe	126.89	0.000	0.000**
Mild - Moderate	71.1	0.000	0.000**
Mild - Severe	92.84	0.000	0.000**
Moderate - Severe	21.74	0.218	1.000

Note: Each row tests the null hypothesis that the sample distributions are the same. Significance values have been adjusted by the Bonferroni correction for multiple tests; **p < .01.

4.3.3 Determination of Associations and Predictors for Night Driving Difficulty

The analysis of the relationships between self-reported night driving difficulty, as measured by the VND-Q-M, and other variables which were dry eye symptoms using OSDI, self-esteem using RSES, age, and average time spent driving at night, was conducted using Spearman's rho correlation coefficient as shown in Table 4.12. The results indicated several significant findings. There is a moderately strong positive correlation (r_s = .489, $p < .001$) between VND-Q-M and OSDI scores. This suggests that greater severity of dry eye symptoms is correlated with greater night driving difficulties. A significant negative correlation (r_s = -.168, p = .001) was found between VND-Q-M and RSES scores, indicating that higher self-esteem is correlated with fewer night driving difficulties. In contrast, there was no significant correlation found between VND-Q-M scores and age (r_s = -.029, p = .574) or between VND-Q-M scores and the duration of night driving (r_s = -.056, p = .277).

Table 4.12 Spearman correlations between VND-Q-M score, OSDI score, RSES score, age, and duration of night driving

Variable	1	2	3	4	5
1. VND-Q-M Score	—	.489**	-.168**	-.029	-.056
2. OSDI Score		—	-.213**	-.025	.039
3. RSES Score			—	.131*	.009
4. Age (Years)				—	-.102*
5. Duration of Night Driving (min)					—

Note: VND-Q-M = Malay version of Vision and Night Driving Questionnaire; OSDI = Ocular Surface Disease Index; RSES = Rosenberg Self-Esteem Scale; All values represent Spearman's rho (r_s); Values below the diagonal are omitted for simplicity; *p < .05; **p < .01.

Additionally, the significant negative correlation ($r_s = -.213$, $p < .001$) between OSDI and RSES scores indicates that higher dry eye symptoms are correlated with lower self-esteem. There is also a significant positive correlation ($r_s = .131$, $p = .011$) between RSES scores and age, suggesting that as people age, their self-esteem tends to increase. Conversely, no significant correlation was found between RSES scores and the duration of night driving ($r_s = .009$, $p = .857$). A significant negative correlation ($r_s = -.102$, $p = .049$) between age and the duration of night driving suggests that older individuals tend to drive less at night. All significant correlations found in this study were considered weak, except for the correlation between VND-Q-M and OSDI scores. These results indicate that each variable alone does not strongly predict the VND-Q-M score.

A multiple regression analysis was performed to predict VND-Q-M scores based on OSDI scores, RSES scores, and gender. The model was statistically significant, explaining 23.1% of the variance in VND-Q-M scores (adjusted R2 = .225, F(3, 369) = 36.982, p < .001). The regression formula derived from the model was VND-Q-M score = 13.896 + (.192 × OSDI score) − (.053 × RSES score) + (.148 × gender). Within the model, OSDI scores emerged as the only significant predictor capable of explaining a significant proportion of unique variance in VND-Q-M scores (sr2 = .20, p < .001). Table 4.13 presents the coefficients for multiple regression analysis predicting VND-Q-M scores.

Table 4.13 Coefficients for multiple regression analysis predicting VND-Q-M scores

Variable	B	Std. Error	Beta	t	p-value
(Constant)	13.896	1.694		8.203	< .001*
OSDI Score	.192	.020	.464	9.807	< .001*
RSES Score	-.053	.046	-.053	-1.139	.256
Gender	.148	.547	.013	.270	.787

Note: VND-Q = Vision and Night Driving Questionnaire; OSDI = Ocular Surface Disease Index; RSES = Rosenberg Self-Esteem Scale.

Regression diagnostics indicated no issues with multicollinearity, as evidenced by tolerance values greater than 0.1 and Variance Inflation Factor (VIF) values close to 1, suggesting that the predictors were not highly correlated with each other. Additionally, residual statistics suggested that the residuals were approximately normally distributed around a mean of zero, indicating that the model fits the data well (Figure 4.1).

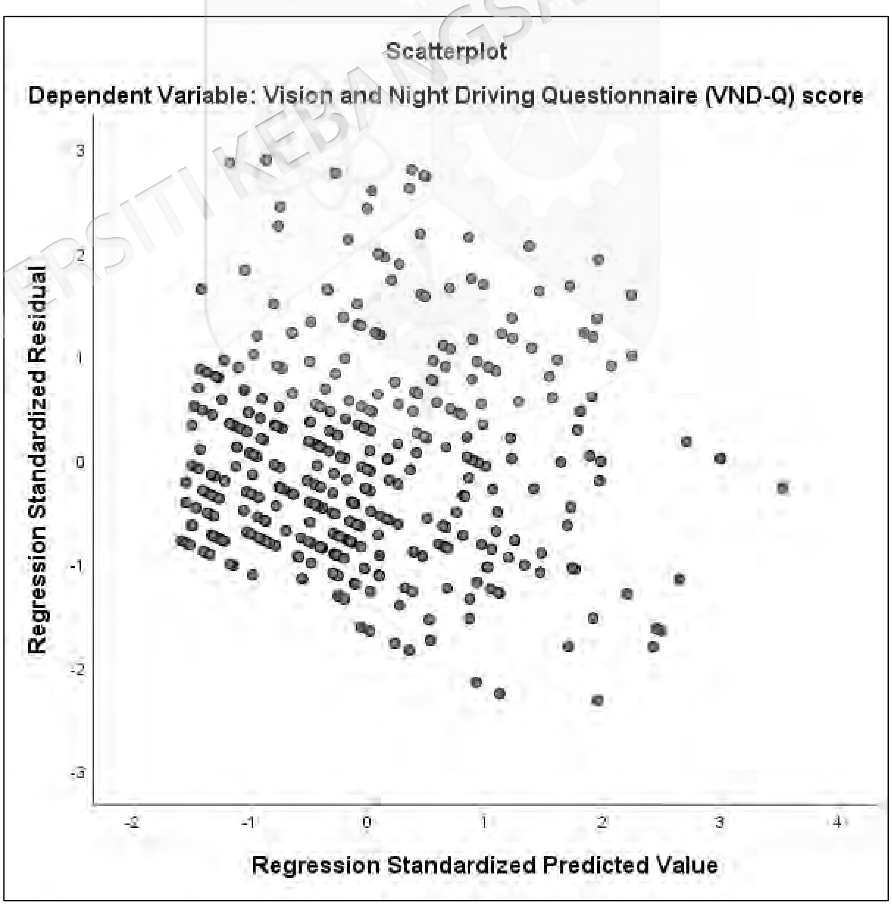

Figure 4.1 Scatterplot of VND-Q-M scores versus OSDI scores

CHAPTER V

DISCUSSION

5.1 INTRODUCTION

This discussion interprets key findings on how dry eye symptom severity relates to night driving difficulties. The study's insights, drawn from data collected using the Malay version of the Vision and Night Driving Questionnaire (VND-Q-M), the Ocular Surface Disease Index (OSDI), and the Rosenberg Self-Esteem Scale (RSES), are placed into the broader context of related research. While the OSDI emerged as a significant predictor of night driving difficulty, reflecting a notable correlation between the severity of dry eye symptoms and the reported challenges, other factors such as self-esteem and gender did not hold predictive value in the multivariate model. This chapter aims to elucidate the practical implications of these findings for the enhancement of night time driving safety and ocular health, acknowledging the study's limitations and suggesting avenues for future research to build upon the current understanding of how dry eye symptoms may impact driving performance at night.

5.2 PHASE 1: TRANSLATION AND VALIDATION OF VND-Q-M

Phase 1 of this study successfully translated and validated the VND-Q-M. The findings were previously published by Woi et al. (2025b), who documented the systematic translation and validation process of the Malay version of the VND-Q-M.

5.2.1 Translation Process and Content Validity

The use of culturally adapted assessment instruments is especially important in the healthcare sector because it ensures that self-reported measures are conceptually coherent, clearly articulated, and contextually appropriate across diverse populations

(Beaton et al. 2000; Guillemin et al. 1993). In line with this, the VND-Q was translated into Malay through a forward-backward translation process to preserve its conceptual and linguistic integrity.

Content validity was assessed by six optometry experts who reviewed the items for relevance, clarity, and understandability using a structured CVI approach. The I-CVI values for clarity and understandability of Item 6 were lower than 0.83. The experts questioned the similarity of Item 4 and Item 6. Both items address visual difficulties caused by oncoming headlights during night driving. Item 4 clearly asks about problems seeing the road when headlights shine toward the driver, whereas Item 6's use of "adjusting" is ambiguous. The term "adjusting" is not obvious whether it refers to the driver's vision adapting or to adjusting vehicle controls after the headlights pass. A well-constructed questionnaire item should be brief and focused on a single concept to minimize the risk of confusion or misinterpretation, as suggested in best practices for instrument development (Singh 2017). A consensus was reached that Item 6 should be removed. Following the minor semantic harmonizations made during the initial translation phase, the I-CVI and S-CVI values increased significantly after the removal of Item 6. These findings indicate that the VND-Q-M has a high relevance to the target measurement content, good clarity and is easily understood.

This rigorous translation and content validation process ensures that the questionnaire captures the intended constructs accurately and aligns with best practices in cross-cultural instrument adaptation and validation. Sousa & Rojjanasrirat (2011) highlight the importance of using a systematic, multi-step approach involving forward and backward translation, expert panel review, and pilot testing to ensure conceptual and cultural equivalence. The involvement of professionals familiar with the content area and native speakers of the target language can greatly enhance the clarity and relevance of the translated tool. These principles were applied in this study to produce a version of the VND-Q-M that is both culturally appropriate and methodologically sound, thereby improving the tool's validity.

5.2.2 Construct Validity

The construct validation of the VND-Q-M through exploratory factor analysis (EFA) revealed two distinct factors, highlighting the multifaceted nature of night driving difficulties. This differs from the original version developed by Kimlin et al. (2016) which was found to be unidimensional. The emergence of two factors in the Malay version suggests a possible cultural or linguistic influence on how night driving difficulties are perceived or may reflect a broader interpretation of the construct in the local context. All factor loadings were equal to or greater than 0.40, which was considered high and stable. According to Guadagnoli & Velicer (1988), loadings of 0.40 and above are generally acceptable in factor analysis, especially when supported by adequate sample size, as they indicate reliable and interpretable factor structures.

The first factor, "visibility," encompassed items related to the visibility of various objects during night driving, reflecting the significant impact of lighting and glare on driving conditions. The “visibility” factor consisted of five items (Item 1 to Item 5), addressing the visibility of dark-coloured cars, pedestrians, animals, street signs, and roads at night, including the effect of glare under low illumination (Table 4.10). Visibility during night driving is highly affected by ambient lighting, as well as headlights from the driver’s own and oncoming vehicles. A Cochrane review found that street lighting can reduce nighttime crash risk by up to 55% (Beyer & Ker 2009). Improved headlight performance has also been associated with lower crash rates at night (Brumbelow 2022). Glare from oncoming headlights has been found to reduce visibility and increase the risk of accidents (Bullough et al. 2008). These findings support the identification of visibility as a key dimension in evaluating night driving difficulty.

The second factor, "distance judgement", focused on the ability to judge distances in nighttime conditions. This factor consisted of two items that described the distance judgement during night driving. Item 7 asked about the distance judgement for turn-off or exit during night driving, while Item 8 questioned the distance judgement between the driver’s own vehicle and other moving vehicles during night driving. Accurate distance judgment is critical in driving decisions, especially when merging or pulling out of intersections. A study by Gould et al. (2012) reported that drivers have greater difficulty judging speed and distance of vehicles in low-light conditions. This may be due to impaired motion perception under mesopic lighting, where rod photoreceptor function dominates, causing moving objects to appear slower (Gegenfurtner et al. 1999).

Item 9, cross-loaded onto both “visibility” and “distance judgement” factors, as it addressed the challenge of reduced road visibility during poor weather at night. This item captures the compounding effect of weather and lighting conditions. The poor weather conditions exacerbate the difficulty of night driving. Research indicates that drivers reduce speed significantly in adverse weather, which further complicates night driving (Jägerbrand & Sjöbergh 2016). In Malaysia, with its high annual rainfall of 80% per year, which is between 2000mm and 2500mm (Department of Information Malaysia n.d.), the likelihood of encountering poor weather at night is considerable, making Item 9 especially relevant.

The factor structure identified in this study supports the construct validity of the Malay version by revealing a clear and interpretable two-factor solution. The divergence from Kimlin et al. (2016)’s unidimensional model highlights how regional linguistic nuances and environmental contexts such as inconsistent road lighting and varying driving conditions in Malaysia compared to countries like Australia where lighting standards are stricter, along with different driving cultures, can influence the way individuals interpret night driving challenges. For instance, urban areas like Kuala Lumpur may experience uneven or insufficient street lighting, which can affect visibility and depth perception at night. Said et al. (2024) provided empirical evidence showing that many Malaysian roads, including those in urban settings, fail to meet recommended standards for nighttime lighting. This technical deficiency likely contributes to drivers’ perceived difficulty with “visibility” and “distance judgment”, supporting the emergence of these two factors in the VND-Q-M. Certain terms or phrases in the translated version may also carry slightly different meanings or emotional weight, influencing how the items are grouped. As a result, the questionnaire may have become more attuned to how drivers in this population experience night driving difficulties. A study by Wood (2020) also highlighted the complexity of night driving environments, noting the combined challenges of low illumination, glare from headlights, and impaired contrast sensitivity. These findings align with the conceptual basis of the VND-Q-M, which aims to assess real-world visual challenges encountered during night driving, challenges that standard visual acuity tests may not capture. Overall, the findings affirm that the VND-Q-M measures culturally meaningful and contextually relevant aspects of night driving difficulty.

While the original English VND-Q was validated as a single, unidimensional construct (Kimlin et al. 2016), the EFA in the current study revealed a two-factor model comprising "visibility" and "distance judgment". This structural divergence likely stems from differences in the sample population and visual function variability. In Kimlin’s study, which primarily involved older adults, whose age-related declines in visual function such as low contrast visual acuity (VA) and reductions in contrast sensitivity function (CSF) have been widely documented to impair overall visual performance, especially under low-light and glare conditions (Higgins et al. 1998; Owsley et al. 2002). These generalized declines may lead to a more homogenous experience of night driving challenges, reflected in the unidimensional structure observed in their study.

In contrast, the younger population in the current study likely exhibits greater variability in visual performance, particularly in contrast sensitivity (CS) and low contrast visual acuity (VA). These differences suggest that individual variability in visual performance influences night driving abilities, especially in low-contrast environments. For instance, Wood et al. (2014) showed that younger drivers outperformed older drivers in detecting pedestrians at night, with motion sensitivity linked to contrast sensitivity acting as a key predictor. Similarly, Bartholomew et al. (2016) found substantial variability in scotopic VA and contrast sensitivity among young adults, even those with excellent daylight vision. These studies highlight that contrast sensitivity and low contrast VA significantly affect night driving performance, supporting the "visibility" and "distance judgment" factors in our two-factor model. Although these factors were not directly measured in this study, they offer valuable insights into the two-factor structure revealed by the EFA, emphasizing the importance of assessing visual performance variability when evaluating night driving difficulties.

Additionally, distance judgment may be more distinctly influenced by differences in stereopsis and the useful field of view (UFOV), which tend to deteriorate with age but are preserved or more variable among younger adults. Ball et al. (1993) demonstrated that reductions in UFOV were significantly associated with higher crash risk among older drivers, emphasizing the role of attentional visual processing in driving safety. Similarly, Owsley & McGwin (2010) reported that diminished UFOV and depth perception impair older drivers' ability to judge the distance and speed of other vehicles accurately, contributing to errors in gap judgment and decision-making. These findings support the observation that younger adults may experience a broader range of distance-related visual performance, potentially contributing to the emergence of a distinct distance judgment factor in the VND-Q-M.

Furthermore, cultural and environmental factors in Malaysia such as frequent rainfall, narrow rural roads with inconsistent lighting, abrupt changes in elevation, and a high prevalence of motorcycles and mixed traffic likely create a more complex night driving environment compared to those in high-income countries (Jägerbrand & Sjöbergh 2016; Said et al. 2024). These conditions are consistent with findings reporting that poor weather and inadequate lighting significantly impact driver behaviour and visibility. Moreover, Wood (2020) emphasized that unfamiliar or poorly designed road infrastructure intensifies night driving difficulties, particularly in regions with diverse traffic patterns.

The translation and cultural adaptation of the VND-Q into Malay may have introduced slight interpretive differences in the meaning of certain items, aligning with the cross-cultural adaptation challenges highlighted by Guillemin et al. (1993). Such variation in item comprehension may influence how individuals perceive and respond to questionnaire items, thereby contributing to the emergence of a two-factor model in the Malay version. Additionally, methodological differences between studies may also explain the discrepancy in factor structures (Costello & Osborne 2005; Fabrigar et al. 1999). This study employed Principal Axis Factoring (PAF) with Promax rotation, which, unlike Principal Component Analysis (PCA) used in Kimlin's original study, better identifies latent constructs by analyzing shared variance among items. Promax rotation, being oblique, accommodates interrelated constructs such as "visibility" and “distance judgment” that PCA’s orthogonal rotation methods may overlook. As such, the use of PAF and Promax may have allowed for a more nuanced capture of the multifactorial nature of night driving experiences in the local context.

Together, these cultural, environmental, and methodological distinctions underscore the complexity of night driving challenges in Malaysia and highlight the importance of using context-sensitive self-reported measures to assess their multidimensional nature. Overall, the identification of two factors in VND-Q-M reinforces the need to consider multiple dimensions when evaluating vision-related driving difficulties. These findings suggest further research is necessary to develop and refine appropriate assessment procedures that can accurately capture the distinct aspects of night driving difficulties.

5.2.3 Reliability Examination

Assessing internal consistency using Cronbach's alpha is crucial for establishing the questionnaire's trustworthiness and stability. The internal consistency of the VND-Q-M, as measured by Cronbach's alpha, was commendably high (0.84), indicating a reliable interrelation of questionnaire items and suggesting that all eight items should be included. This closely aligns with the reliability of the original English VND-Q, which yielded a Rasch person reliability index of 0.90 (Kimlin et al. 2016). This high level of internal consistency confirms the VND-Q-M as a dependable tool for assessing night driving difficulty in the study population. The reliability findings support the potential of the questionnaire to be used in future research as well as in applied clinical and occupational contexts. These include professional drivers, transportation workers, delivery personnel, and shift-based industries groups for whom understanding and addressing the impact of night driving difficulties is critical. By targeting these high-risk environments, the VND-Q-M can serve as a valuable tool for identifying individuals who may benefit from further visual function evaluation or intervention. This is consistent with prior research emphasizing the need for reliable tools to evaluate visual difficulties in task-specific contexts, especially in occupations requiring optimal visual performance under low illumination (Owsley & McGwin 2010; Wood 2020). These studies highlight the importance of assessing real-world visual challenges such as glare sensitivity, contrast perception, and motion detection in settings like night driving, thereby supporting the practical value of VND-Q-M in such environments.

5.3 PHASE 2: RELATIONSHIP BETWEEN DRY EYE SYMPTOMS AND NIGHT DRIVING DIFFICULTIES

Phase 2 of this study explored the relationship between dry eye symptoms and night driving difficulties using three key measures: the OSDI to assess dry eye symptoms, the VND-Q-M to evaluate night driving difficulties, and the RSES to measure self-esteem. The analysis revealed a significant positive correlation between VND-Q-M and OSDI scores, indicating that participants with more severe dry eye symptoms reported greater night driving difficulties. Multiple regression analysis confirmed that dry eye symptoms were a significant predictor of night driving difficulties, while self-esteem and gender were not. These findings provide valuable insights into how dry eye symptoms impacts driving safety, particularly in low-light conditions.

5.3.1 Demographic Profile and Key Findings

The overall sample of 373 participants reported moderate levels of both night driving difficulty and dry eye symptoms, as reflected by the mean VND-Q-M and OSDI scores, respectively. This suggests that even within a relatively young and visually healthy population (aged 18–40 years), many drivers already perceive some level of visual limitation during night driving. The presence of moderate night driving difficulty among younger drivers underscores that such impairments are not confined to older adults or those with diagnosed ocular disease.

The analysis of individual item scores from the eight-item VND-Q-M revealed nuanced insights into specific visual challenges faced by drivers at night. Under the "Visibility" domain, participants found "Reading street signs" the least problematic task, while "Seeing the road because of oncoming headlights" received the highest difficulty rating. This reflects how glare from headlights can significantly compromise nighttime visibility, consistent with findings from Wood (2020), who emphasized the role of glare sensitivity in nighttime driving impairment, particularly in the presence of dry eye symptoms and optical aberrations.

The overall visibility score indicating moderate perceived difficulty in this domain. In contrast, under the "Distance Judgement" domain, tasks like judging the distance between moving vehicles were rated as relatively easier, while estimating distances to road exits posed slightly more difficulty. The overall score for distance judgement reflects low to moderate difficulty, suggesting that while spatial perception remains mostly intact, specific visual cues especially under dynamic lighting may present challenges. This is more evident when comparing the two items within distance judgment: judging the distance to moving vehicles was rated easier, while judging the distance to road exits was perceived as more challenging. These findings suggest that spatial judgment, though generally intact, may be more affected by higher cognitive load tasks, such as estimating distances in dynamic conditions, compared to simpler tasks like judging distance to stationary vehicles. These findings highlight that spatial judgment is less impacted than contrast-related visibility in the presence of dry eye symptoms.

The most significant challenge was reported under the "Other" domain, specifically for "Seeing the road in rain or poor weather at night," which had the highest mean score. This is supported by previous studies such as Owsley & McGwin (2010), who identified adverse weather conditions as a critical contributor to driving difficulty, particularly when combined with ocular surface irregularities. This result underscores how visual function impairments are further amplified in complex environmental conditions.

Compared to the original English version of the VND-Q developed by Kimlin et al. (2016), our study’s item-level mean scores follow a similar pattern of difficulty ranking. Both versions identified glare and headlight issues as primary sources of night driving challenges. However, our Malay version slightly differs in that the weather-related visibility issue was rated highest in difficulty, which may reflect regional differences in environmental exposure or cultural perceptions of driving risk. These item-level patterns reinforce the cross-cultural validity of the VND-Q while emphasizing the unique contextual factors influencing night driving performance in Malaysian populations.

These findings collectively emphasize that visibility-related tasks, especially those involving glare and low contrast, are particularly susceptible to disruption in individuals with glare complaints. The high item scores for oncoming headlights and poor weather suggest potential areas for intervention, such as glare-reducing strategies, to mitigate night driving difficulties in this population.

For dry eye symptoms, a study by Cai et al. (2022) reported comparable OSDI score distributions in Asian populations, reinforcing the generalizability of our findings in the regional context. In tropical climates like Malaysia, where air-conditioned environments and extended digital device use are common, the moderate OSDI scores observed in this cohort may reflect environmental factors exacerbating dry eye symptoms. Studies by Muñoz-Villegas et al. (2024) and Patel et al. (2023) suggest that environmental factors such as low humidity, dry indoor air, and screen time contribute to the worsening of dry eye symptoms. Prolonged exposure to air-conditioned spaces can reduce tear film stability, while digital device use lowers blink rates, both of which are well-documented factors contributing to ocular discomfort in tropical and high-tech environments.

In terms of psychological well-being, the relatively high average RSES score in this study supports prior findings from Orth et al. (2010) and Sowislo & Orth (2013), which suggest that self-esteem tends to stabilize or increase during early adulthood. This period is often associated with key life events such as career progression and social relationships, which promote self-affirmation and emotional stability.

In addition, gender-based comparisons in our study revealed statistically significant differences in both VND-Q-M and OSDI scores between male and female participants. Female participants reported higher VND-Q-M and OSDI scores, suggesting they experienced more pronounced night driving difficulties and dry eye symptoms. This observation aligns with findings from previous studies indicating that women are more prone to dry eye symptoms, largely due to hormonal fluctuations, particularly involving androgen levels in regulating meibomian gland and lacrimal function (Craig et al. 2016; Stapleton et al. 2017). Additionally, women may report greater sensitivity to glare and visual disturbances under low-light conditions, potentially exacerbating night driving challenges (Brabyn et al. 2005; McGwin Jr & Brown 1999). Women also exhibit significantly greater somatic symptom burden than men, characterized by increased bodily distress, symptom frequency, intensity, and variety (van Wijk & Kolk 1997). This may contribute to the observed differences in subjective severity and difficulty. Conversely, no significant gender difference was found in RSES scores, indicating that perceived self-esteem levels were comparable between male and female participants in this sample. This is consistent with findings by Sowislo & Orth (2013), who concluded in their meta-analysis that gender differences in self-esteem are generally small and tend to narrow in adulthood. These findings underscore the importance of considering gender in the analysis of visual function and symptom reporting related to driving performance.

5.3.2 Association of Night Driving Difficulty Across Dry Eye Symptom Severity

The results revealed a statistically significant difference in night driving difficulty across dry eye symptom severity categories. Post-hoc pairwise comparisons further supported the trend that higher dry eye symptom severity is linked to greater difficulty in night driving. This study found a significant positive correlation between the VND-Q-M and the OSDI, indicating that individuals with more severe dry eye symptoms tend to experience greater difficulties with night driving, reinforcing the relevance of symptom categorization in assessing functional impairments.

The findings of this study align with existing literature, which has also highlighted the impact of dry eye on visual performance and daily activities. Dry eye symptoms can lead to blurred vision due to unstable tear film or insufficient tear production, which disrupts light refraction and reduces image clarity (Koh 2016). Additionally, glare from headlights and other light sources can become more pronounced in individuals with dry eye, as their eyes are more sensitive to bright lights, particularly in low-light conditions like night driving. Light scatter occurs when an irregular tear film causes light to scatter unevenly across the eye, further impairing contrast sensitivity and overall visual clarity, which can compromise tasks requiring detailed vision, such as reading or driving (Patel et al. 2023; Szczotka-Flynn et al. 2019).

Our findings are consistent with Deschamps et al. (2013), who found that individuals diagnosed with dry eye exhibited significantly impaired driving performance under scotopic condition, similar to the challenges reported in our study. Tong et al. (2010) also examined the impact of symptomatic dry eye on various vision-related daily activities in a general Southeast Asian population. Although driving was identified as one of the affected tasks, their study did not assess performance under specific lighting conditions nor stratify outcomes based on symptom severity. Our results, however, show that night driving difficulties were more pronounced in participants with severe dry eye symptoms, highlighting the importance of symptom severity in driving performance. Similarly, findings from Miljanović et al. (2007) and Barabino et al. (2016) align closely with ours, demonstrating that individuals with severe dry eye symptoms experience greater difficulty in tasks requiring visual attention, such as reading and driving. These suggest that the severity of dry eye symptoms directly correlates with the degree of visual impairment, especially in conditions requiring high visual attention, such as driving at night.

Although previous studies have not specifically examined the role of symptom severity, our study underscores its importance in understanding vision-related challenges, such as night driving, particularly in low-light conditions where visual disturbances are more pronounced. Given that our findings are based on self-reported symptoms rather than objective visual function tests, future research could explore whether clinical measures such as contrast sensitivity or tear film stability align with perceived difficulty and inform more targeted support approaches, as suggested by Woi et al. (2025a), who found that poor tear film stability and severe dry eye symptoms contribute to night driving difficulties.

The impact of dry eye symptoms on night driving safety has been well-documented in several studies (Deschamps et al. 2013; Miljanović et al. 2007). Wood (2020) reviewed the general visual, lighting, and visibility challenges associated with nighttime driving but did not focus specifically on dry eye symptoms. However, her discussion on how low-light conditions can exacerbate visual impairments provides a relevant context for understanding how symptoms like glare and reduced contrast sensitivity, common in dry eye, might interfere with night driving performance.

Physiologically, DED compromises the structural integrity of the tear film, resulting in an irregular corneal refractive surface that causes HOAs and forward light scattering (Koh 2016). Under scotopic and mesopic (low-light) conditions, the pupil naturally dilates, exposing a larger area of this irregular surface. This dilation drastically amplifies visual degradation, directly resulting in debilitating disability glare, halos, and a profound reduction in contrast sensitivity (Khirat et al. 2024; Puell et al. 2006). Furthermore, Wu et al. (2020) observed that disability glare can reduce contrast sensitivity in both central and peripheral vision, profoundly impairing visual performance in low contrast environments such as night driving.

Crucially, this physiological mechanism directly explains the categorical severity trends observed in this study. The statistical analysis (Table 4.11) revealed a significant increase in night driving difficulty when transitioning from normal/mild to moderate/severe OSDI categories. This transition likely represents a critical physiological threshold where tear film instability becomes severe enough that it can no longer maintain a smooth optical surface between blinks, triggering the sudden onset of these optical aberrations during the sustained visual attention required for driving. While the OSDI is a subjective symptom scale, and clinical discordance between subjective symptoms and objective corneal signs can occur, these findings strongly suggest that the moderate symptom threshold aligns with a critical breakdown in functional optical quality. These findings highlight that low-light conditions act as a catalyst, exacerbating the physiological challenges associated with dry eye symptoms and directly translating them into categorical driving impairments.

The relationship between dry eye symptoms and night driving difficulties observed in this study aligns with earlier research demonstrating that symptoms like glare and unstable vision can impair performance in visually demanding tasks. Studies by Goto et al. (2002) and Koh et al. (2002) found that tear film instability, a key feature of dry eye, compromises visual clarity in low-light environments by reducing contrast sensitivity and increasing higher-order aberrations. These findings are consistent with our study, where participants reported greater difficulty with visual tasks during night driving, particularly under low-light conditions, likely due to similar physiological disruptions. Our self-reported survey results confirm that glare (Items 4 and 5) and reduced contrast sensitivity (across all items, given the focus on nighttime conditions) are critical factors influencing driving performance in such environments. In line with this, the recent systematic review by Rhee et al. (2022) highlighted a consistent association between tear film metrics and degraded optical quality in individuals with dry eye, reinforcing the relevance of these physiological changes in night driving.

Additionally, the correlation analysis between the VND-Q-M and OSDI supports previous findings linking subjective dry eye symptom scores with self-reported visual performance deficits, especially in tasks requiring clear vision in low-light conditions. Hiraoka et al. (2015) demonstrated the impact of mesopic conditions on functional visual acuity, particularly emphasizing how dry eye symptoms can degrade visual performance in such environments, reinforcing the findings of our study. The connection between self-reported symptoms and visual function is further supported by Miljanović et al. (2007), who found that individuals with dry eye reported greater difficulty in tasks requiring visual attention, such as driving. This emphasizes the subjective nature of dry eye symptoms and their strong influence on functional limitations. The broader literature, including Herbaut et al. (2018), further emphasizes the need for tailored management strategies to address the impact of dry eye symptoms on visual quality and daily functioning.

However, not all studies report consistent trends. For instance, Abetz et al. (2011) found that while dry eye symptoms were associated with daily discomfort, they did not necessarily correspond with driving-specific performance limitations, potentially due to individual differences in coping mechanisms and task relevance. Their study utilized a self-reported questionnaire to assess the impact of dry eye on everyday life, focusing on a general population rather than specifically targeting drivers, which may explain the differences in findings. Vehof et al. (2014) similarly observed that the burden of dry eye symptoms did not always predict functional impairment across all life domains, indicating that adaptive strategies or symptom tolerance might influence perceived impact. Their study, which was conducted on a British female cohort, highlighted prevalence and risk factors for dry eye but did not specifically examine night driving performance or its impact on visual function, as this study did. This difference in focus and methodology, including the focus of this study on active drivers and the use of validated questionnaires like the OSDI and VND-Q-M, likely contributed to the differing results.

The absence of significant differences between moderate and severe symptom groups after Bonferroni adjustment suggests a potential plateau in functional limitations, where worsening dry eye symptoms beyond the moderate level do not correspond with greater perceived night driving difficulty. This aligns with Barabino et al. (2016), who observed stabilization in quality-of-life impact despite clinical deterioration in severe dry eye, and Herbaut et al. (2018), who noted that tear film disruption and optical quality may level off in severe cases. These findings imply that while symptoms worsen, functional deficits such as night driving difficulties may not progress further beyond a certain threshold.

Similarly, the non-significant difference between normal and mild dry eye symptom categories post-adjustment suggests that mild symptoms and below may not significantly impact night driving performance. This could be attributed to subtle physiological changes or compensatory strategies employed by individuals to manage mild visual discomfort. A study by Koh (2016) noted that visual disturbances such as fluctuating vision and glare are more pronounced in individuals with severe dry eye, supporting the notion that mild symptoms may have a limited impact on night driving. Therefore, this reinforces the idea that interventions targeting dry eye symptoms may need to focus more on individuals with moderate to severe symptoms, where the impact on night driving is more pronounced.

5.3.3 Associated Factors with VND-Q-M

The negative correlation between VND-Q-M and RSES suggests that individuals with lower self-esteem report more difficulties with night driving. This finding is consistent with Orth et al. (2010), who demonstrated that self-esteem influences task performance, including driving. Orth et al. (2010) showed that individuals with higher self-esteem tend to perform better in various tasks, including driving, due to greater confidence. Our study corroborates this, showing that participants with lower self-esteem reported more difficulty with night driving, possibly due to reduced confidence in navigating challenging environments like low-light conditions. This supports the idea that psychological well-being, particularly self-esteem, influences how individuals perceive and manage difficulties such as night driving.

Additionally, a significant negative correlation between OSDI and RSES scores suggests that participants with more severe dry eye symptoms reported lower self-esteem. This finding aligns with Tawfik et al. (2024), who observed that chronic ocular discomfort can lead to psychological strain, including reduced self-confidence and increased emotional distress. The relationship between dry eye symptoms and self-esteem in our study supports this, suggesting that individuals with more severe symptoms may experience a diminished sense of self-worth, especially when symptoms impact daily functioning like driving.

Similarly, van der Vaart et al. (2015) reported that individuals with dry eye disease often experience lower well-being and greater psychosocial stress, particularly when symptoms interfere with activities like work or mobility. Our findings further reinforce this, showing that participants with more severe dry eye symptoms reported greater difficulty with night driving, highlighting the broader psychological impact of dry eye.

Interestingly, while RSES was negatively correlated with OSDI, it showed a positive correlation with age. This suggests that although self-esteem generally increases with age due to life experience and emotional maturity (Orth et al. 2010), such improvements may not fully offset the impact of dry eye symptoms on task-specific confidence. This highlights the need to consider how chronic symptoms interact with psychological constructs in the context of activities like night driving.

The lack of a significant correlation between age, time spent driving at night, and VND-Q-M scores suggests that these factors do not directly correlate with self-reported night driving difficulties in this study. This could be attributed to the narrow age range of participants (18-40 years), where all individuals are likely within a similar stage of adult development. As such, differences in perceived night driving difficulty may not arise from age alone. Additionally, factors other than age, such as psychological adaptation, coping mechanisms, and lifestyle, may play a more significant role in self-reported difficulties. Research by Owsley & McGwin (2010) and Wood & Owens (1994) emphasized the interplay between visual, behavioural, and psychosocial factors in driving performance, particularly during complex tasks like night driving.

Similarly, the lack of significant correlation between time spent driving at night and night driving difficulty indicates that experience alone does not necessarily lead to less perceived difficulty. Though one might expect that increased exposure to night driving could result in better adaptation, the results show that perceived difficulty remains largely unaffected by experience. This aligns with previous research, such as Martinez & Silva (2021), which highlighted that perceived difficulty is more influenced by external factors and coping strategies than by the sheer amount of driving experience. These findings suggest that the challenges of night driving are likely shaped by individual adaptations and external demands rather than the frequency of the activity itself.

In younger adults, other factors such as lifestyle or occupational demands might influence night driving behaviour more than visual impairments. Younger adults have more flexibility in avoiding night driving if they feel discomfort, while older adults may have fewer options due to more established routines (Santos & Torres 2022). Moreover, occupational requirements, like shift work or jobs requiring frequent night driving, could lead to younger adults driving more at night, which may contribute to their self-reported difficulties differently than visual performance alone (Garcia & Lopez 2023). Additionally, psychological resilience and compensatory strategies, such as familiarity with routes or adjusting driving style, may help mitigate the effects of visual impairments in younger adults (Bowers 2019; Charlton & Starkey 2013). Therefore, self-reported difficulties in night driving are shaped not only by visual impairments but also by a complex interaction of behavioural, psychosocial, and environmental factors.

5.3.4 Predictive Modeling of Night Driving Difficulty

The OSDI emerged as a significant predictor of night driving difficulty, affirming the substantial influence of dry eye symptoms on the ability to drive at night. This finding aligns with existing literature, particularly the work of Bron et al. (2014), who emphasized the clinical implications of dry eye disease, especially how symptom severity can impair functional tasks like driving. They highlighted the need for effective management strategies that address both the visual and functional limitations caused by dry eye symptoms, which is consistent with our study's findings. Cutrupi et al. (2023) further support this by documenting the real-life impact of dry eye disease on daily activities, including driving. Their study underscores those individuals with severe dry eye symptoms, especially those experiencing glare sensitivity and reduced contrast sensitivity, report greater difficulty in low-light conditions, which aligns with our study's findings. Similarly, Sheppard et al. (2023) discuss therapeutic strategies for managing dry eye disease and note that early intervention is crucial for preventing functional impairments, such as those observed in night driving. These studies collectively emphasize the importance of managing dry eye symptoms, not just to alleviate discomfort but to improve functional performance, particularly in tasks requiring visual clarity like night driving.

However, the analysis revealed that neither self-esteem, as measured by the RSES, nor gender was a significant predictor of night driving difficulty in the final regression model. Although initial correlation analyses showed significant associations with the outcome, these factors did not retain their predictive power when considered alongside OSDI in the multivariate context. This suggests that dry eye symptoms have a more direct impact on night driving difficulty than self-esteem or gender. Furthermore, the effects of self-esteem and gender on night driving may be mediated by other psychological or behavioural factors not captured in this study, such as coping mechanisms and emotional responses to visual challenges. A study by Neff (2011) emphasized that low self-esteem could lead to anxiety or reduced confidence, which can impair performance in various tasks, including night driving. Emotional states, particularly negative feelings, can also negatively impact task performance and driving efficiency, as shown by Jeon et al. (2014), who demonstrated that specific emotions can influence driving performance and perceived workload. These findings highlight the importance of considering emotional and behavioural factors alongside visual impairments in understanding night driving difficulties. Future research could further investigate how these factors collectively affect driving performance in low-light conditions.

CHAPTER VI

CONCLUSION

6.1 INTRODUCTION

This chapter summarizes the findings, contributions, limitations, and recommendations of the study. The primary aim of this research was to explore the association between dry eye symptoms and night driving difficulties in Malaysian adults. Through a two-phase study design, this research provides insights into the multifaceted challenges of night driving, focusing on the role of dry eye symptoms, self-esteem, and gender. By analysing data obtained from the Malay version of the Vision and Night Driving Questionnaire (VND-Q-M), the Ocular Surface Disease Index (OSDI), and the Rosenberg Self-Esteem Scale (RSES), the study provides a comprehensive understanding of the impact of dry eye symptoms on night driving performance. This chapter outlines the key findings of the study, discusses its contributions to the field, and identifies the limitations, followed by practical, policy, and research recommendations to enhance night driving safety for individuals suffering from dry eye symptoms.

6.2 SUMMARY OF KEY FINDINGS

The research revealed several important findings regarding the relationship between dry eye symptoms and night driving difficulties:

6.2.1 Phase 1: Translation and Validation of VND-Q-M

The Malay version of the Vision and Night Driving Questionnaire (VND-Q-M) was successfully translated and validated, achieving high content validity and internal consistency. The exploratory factor analysis (EFA) identified two key factors:

"visibility" and "distance judgment," which are critical components of night driving difficulties. These factors represent distinct aspects of night driving, with visibility issues (such as glare and oncoming headlights) emerging as particularly significant challenges. This finding aligns with global research indicating that glare sensitivity and reduced contrast sensitivity are major contributors to night driving difficulties.

6.2.2 Phase 2: Relationship Between Dry Eye Symptoms and Night Driving Difficulty

The second phase of the study confirmed that dry eye symptoms, as measured by the OSDI, significantly correlate with increased night driving difficulties. A moderately strong positive correlation was found between the OSDI and VND-Q-M scores, indicating that more severe dry eye symptoms are associated with greater difficulty in night driving. Regression analysis further revealed that dry eye symptoms were the most significant predictor of night driving difficulties, while self-esteem and gender did not significantly contribute when considered alongside dry eye symptoms in the multivariate model.

The demographic analysis revealed a predominantly female and employed sample, with high levels of night driving frequency. Gender differences were noted, with female participants reporting higher VND-Q-M and OSDI scores, suggesting they experience more significant night driving difficulties and dry eye symptoms compared to males in this study cohort. Consequently, public health interventions and occupational safety guidelines regarding night driving must be particularly sensitive to the disproportionate burden experienced by female drivers.

Furthermore, the findings confirmed that individuals classified with severe dry eye symptoms based on OSDI scores reported the greatest night driving difficulties, particularly in specific visually demanding tasks such as navigating oncoming headlights and poor weather. This highlights the importance of considering symptom severity when addressing night driving difficulties and suggests that effective management of dry eye symptoms could potentially improve driving safety, especially in low-light conditions.

6.3 CONTRIBUTIONS OF THE STUDY

The study provides a culturally adapted version of the Vision and Night Driving Questionnaire (VND-Q-M), making it more applicable to Malaysian adults. By identifying two factors, "visibility" and "distance judgment", this research offers a more nuanced understanding of night driving difficulties. This two-factor model contrasts with previous unidimensional approaches, highlighting the importance of assessing both visual clarity and spatial perception in driving performance. The use of validated tools, such as the OSDI and RSES, further enhances the study's robustness in understanding the complex relationship between dry eye symptoms, self-esteem, and night driving difficulties.

The study provides valuable insights into the practical implications of dry eye symptoms for public safety. By identifying dry eye severity as a key predictor of night driving difficulties, the research underscores the need for effective symptom management strategies. This includes the use of glare-reducing eyewear, artificial tears, and other interventions designed to mitigate the impact of dry eye symptoms on nighttime driving. The findings suggest that healthcare professionals should prioritize early detection and intervention, particularly for individuals whose occupations involve frequent night driving.

6.4 LIMITATION

The majority of the participants were young adults, predominantly female, and employed. As the questionnaire was distributed online, the demographic profile may not fully represent the broader Malaysian population across different geographical locations and socio-economic backgrounds. Individuals from rural areas, lower-income groups, or without reliable internet access may have been underrepresented. Future research should aim to recruit participants from diverse regions and socio-economic strata to better capture variations in dry eye symptoms and night driving difficulties. The study relied on self-reported questionnaires, which may introduce response bias. Participants might have over- or under-reported their difficulties with night driving and dry eye symptoms based on personal perceptions or experiences. Objective measures, such as contrast sensitivity tests and driving simulations, could complement the self-reported data and provide a more accurate assessment of night driving performance.

The cross-sectional nature of the study limits the ability to draw conclusions about the long-term effects of dry eye symptoms on night driving difficulties. Longitudinal studies are needed to assess how changes in dry eye symptoms, self-esteem, and driving performance over time influence night driving difficulties.

6.5 RECOMMENDATIONS

Healthcare providers, particularly optometrists and ophthalmologists, should focus on early detection and management of dry eye symptoms, especially in individuals who frequently drive at night. The use of tools like the OSDI and VND-Q-M can help identify individuals at risk of experiencing night driving difficulties. Effective interventions, including glare-reducing lenses and artificial tears, should be recommended to mitigate the impact of dry eye symptoms on night driving.

Public health campaigns should raise awareness about the impact of dry eye symptoms on night driving and provide education on managing symptoms effectively. Improving road conditions and street lighting, especially in areas prone to adverse weather conditions, can also help enhance night driving safety.

Future research should explore the relationship between dry eye symptoms and other contributing factors, such as environmental conditions, cognitive load, and emotional resilience. Longitudinal studies could examine the long-term effects of dry eye interventions on night driving performance. Research should also investigate how psychological factors, such as self-esteem and coping mechanisms, interact with visual impairments to influence driving performance. Furthermore, because this study identified significant gender disparities in symptom burden, future clinical studies should explicitly investigate the role of hormonal fluctuations in tear film instability among female drivers. Additionally, future research should incorporate objective clinical metrics, such as contrast sensitivity testing and objective scatter index (OSI), to formally map the self-reported subjective difficulties observed in this cohort to physiological optical degradation.

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APPENDIX A

ETHICAL APPROVAL LETTER

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

PUSAT PENGURUSAN PENYELIDIKAN DAN INSTRUMENTASI • *CENTRE FOR RESEARCH AND INSTRUMENTATION MANAGEMENT*

Rujukan : UKM PPI/111/8/JEP-2022-103
Tarikh : 25 Mac 2022

Dr. Woi Pui Juan
Program Optometri dan Sains Penglihatan
Pusat Kajian Kesihatan Komuniti (ReaCH)
Fakulti Sains Kesihatan
Universiti Kebangsaan Malaysia

Y.Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan,

KELULUSAN ETIKA MENJALANKAN PENYELIDIKAN DI UKM

Tajuk : *Elucidating the association between dry eye symptoms and night driving difficulty in Malaysian adults*

Perkara yang tersebut di atas adalah dirujuk.

Sukacita dimaklumkan, Jawatankuasa Etika Penyelidikan UKM meluluskan permohonan penyelidikan Y.Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan bagi tajuk diatas. Tempoh kelulusan penyelidikan adalah **24 Mac 2022 – 23 Disember 2023**. Sila kemukakan sebarang Laporan **Kesan Sampingan, Laporan Kemajuan Setiap 6 Bulan** dan **Laporan Akhir** sebaik sahaja penyelidikan tamat kepada Jawatankuasa Etika Penyelidikan UKM.

Sukacita diingatkan projek penyelidikan ini hanya boleh dijalankan setelah mendapat **surat kelulusan menjalankan penyelidikan** dari Timbalan Dekan Penyelidikan Fakulti.

Sekian, terima kasih.

Yang benar,

PROFESOR DR. MOHD SHAHRIR MOHAMED SAID
Pengerusi
Jawatankuasa Etika Penyelidikan
Universiti Kebangsaan Malaysia

s.k. - **Pengarah**
Pusat Pengurusan Penyelidikan dan Instrumentasi (CRIM)
Universiti Kebangsaan Malaysia

- **Timbalan Dekan (Penyelidikan & Inovasi)**
Fakulti Sains Kesihatan
Universiti Kebangsaan Malaysia

Sekretariat Etika Penyelidikan Universiti Kebangsaan Malaysia
Tingkat 1, Blok Klinikal, Hospital Canselor Tuanku Muhriz,Pusat Perubatan UKM, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Cheras Kuala Lumpur.
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- **Ketua Program Optometri dan Sains Penglihatan**
  Fakulti Sains Kesihatan
  Universiti Kebangsaan Malaysia

- **Prof. Madya Dr. Haliza Binti Abdul Mutalib**
  Pusat Kajian Kesihatan Komuniti (ReaCH)
  Fakulti Sains Kesihatan
  Universiti Kebangsaan Malaysia

- **Dr. Mohd Harimi Bin Abd Rahman**
  Pusat Kajian Rehabilitasi & Keperluan Khas (iCaReHab)
  Fakulti Sains Kesihatan
  Universiti Kebangsaan Malaysia

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  56000 Kuala Lumpur.

- **Nooraida Syafiqah Binti Azmil Syukri (A170468)**
- **Purani A/P Pathmanathan (A169816)**
- **Selena Sieh Yi Han (A169814)**
  Program Optometri dan Sains Penglihatan
  Fakulti Sains Kesihatan
  Universiti Kebangsaan Malaysia

- Fail Surat Kelulusan 2022

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

PUSAT PENGURUSAN PENYELIDIKAN DAN INSTRUMENTASI • *CENTRE FOR RESEARCH AND INSTRUMENTATION MANAGEMENT*

NAME OF ETHICS COMMITTEE/IRB: Research Ethics Committee, The National University of Malaysia	**ETHICS COMMITTEE/IRB REF NO:** **UKM PPI/111/8/JEP-2022-103**
PROTOCOL TITLE: Elucidating the association between dry eye symptoms and night driving difficulty in Malaysian adults	
PRINCIPAL INVESTIGATOR: Dr. Woi Pui Juan Oprometry & Vision Science Program Centre for Community Health Studies (ReaCH) Faculty of Health Sciences The National University of Malaysia	

The following items [X] have been received and reviewed in connection with the above study to be conducted by the above investigator.

Documents

[X] Research Application Form
[X] Research Proposal / Protocol
[ ] Publication Policy
[X] Non-Disclosure Agreement
Information Sheet: -
[X] Malay [X] English
Consent Form: -
[X] Malay [X] English
Questionnaire: -
[X] Malay [ ] English
Curriculum Vitae of Researcher: -
[X] Principal [X] Co-researcher [X] Student
[X] Good Clinical Practice Certificate (GCP)
[ ] Project Agreement

The Research Ethics Committee, The National University of Malaysia operates in accordance to the International Conference of Harmonization Good Clinical Practice Guidelines.

Comments (if any): ______________________

Date of Approval: 24 March 2022

PROFESSOR DR. MOHD SHAHRIR MOHAMED SAID
Chairman
Research Ethics Committee
The National University of Malaysia

UNIVERSITI KEBANGSAAN MALAYSIA
The National University of Malaysia

SEKRETARIAT ETIKA PENYELIDIKAN UKM • *UKM RESEARCH ETHICS COMMITTEE*

Rujukan : UKM PPI/111/8/JEP-2022-103
Tarikh : 13 Mei 2022

Dr. Woi Pui Juan
Program Optometri dan Sains Penglihatan
Pusat Kajian Kesihatan Komuniti (ReaCH)
Fakulti Sains Kesihatan
Universiti Kebangsaan Malaysia

Y.Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan,

PEMAKLUMAN PENAMBAHAN PENYELIDIK BERSAMA

Tajuk Penyelidikan : *Elucidating the association between dry eye symptoms and night driving difficulty in Malaysian adults*

Dengan segala hormatnya merujuk perkara diatas.

2. Sukacita dimaklumkan, Jawatankuasa Etika Penyelidikan UKM telah mengambil maklum permohonan penambahan penyelidik bersama untuk penyelidikan Y.Bhg. Profesor/Datuk/Dato'/Datin/Tuan/Puan bagi tajuk di atas. Nama penyelidik tambahan adalah seperti di bawah:-

Bil	Nama	Alamat / Institusi
1.	Wan Muhammad Hirzi Bin Wan Din (P117160)	Program Optometri dan Sains Penglihatan Fakulti Sains Kesihatan Universiti Kebangsaan Malaysia

3. Penambahan penyelidik bersama perlu mendapat kelulusan dari bahagian penyelidikan fakulti atau Pengarah Pusat/Institut untuk didaftarkan dalam Sistem Maklumat Penyelidikan Universiti (SMPU).

Sekian, terima kasih.

Yang benar,

PROFESOR DR. MOHD SHAHRIR MOHAMED SAID
Pengerusi
Jawatankuasa Etika Penyelidikan
Universiti Kebangsaan Malaysia

s.k. - **Pengarah**
Pusat Pengurusan Penyelidikan dan Instrumentasi (CRIM)
Universiti Kebangsaan Malaysia

- **Timbalan Dekan (Penyelidikan & Inovasi)**
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UNIVERSITI KEBANGSAAN MALAYSIA
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- **Ketua Program Optometri dan Sains Penglihatan**
  Fakulti Sains Kesihatan
  Universiti Kebangsaan Malaysia

- **Prof. Madya Dr. Haliza Binti Abdul Mutalib**
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  Pusat Kajian Rehabilitasi & Keperluan Khas (iCaReHab)
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  Universiti Kebangsaan Malaysia

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- Fail JEP-2022-103

APPENDIX B

PATIENT INFORMATION SHEET

PATIENT INFORMATION SHEET

Research Title:

Elucidating the association between dry eye symptoms and night driving difficulty in Malaysian adults

Introduction:

You are invited to participate in a research study. Before participating in this study, it is important that you take time to read and understand the information in this Information Sheet.

Purpose of Study:

Dry eye syndrome (DES) is a multifactorial condition that results in symptoms of discomfort, visual disturbance and tear film instability with potential damage to the ocular surface. Patients with DES commonly complain of difficulties in performing vision-related daily activities such as driving. Driving is a crucial daily activity of modern living which includes night driving. DES increases the unwanted irregular astigmatism or higher-order aberrations (HOAs) and also reduces the contrast sensitivity. These visual degradations caused by DES are more relevant at night when the pupil is dilated, such as during night driving. This study aims to investigate the impact of dry eye symptoms on self-reported night driving difficulty in Malaysian adults.

What will the study involve?

Your demographic data include age, gender, ethnicity, occupation, state and area of residence will be collected. You are going to answer the Ocular Surface Disease Index (OSDI) and Vision and Night Driving (VND-Q) questionnaires. The OSDI questionnaire is to assess subjective DES and the effects of DES on the vision-related activities of daily living within the previous week while the VND-Q questionnaire is to assess the vision-related night driving difficulties. Besides, you are going to have a tear film stability measurement through non-invasive tear film break up time (NIBUT) test at Optometry Clinic, UKM.

Risks and Benefits:

There is no risk in this study as the NIBUT is a non-invasive method of measuring your tear film break up time.

DES can be one of the factors to predict the night driving difficulty score, which can provide important cues for alerting clinicians to the need for giving the appropriate management of DES. Your participation could help us to improve on the management of DES to minimise the risk of dangerous night driving which may lead to road accident.

Do I have to take part?

Participation into this study is voluntary. If you agree to take part, you will be asked to sign the "Informed Consent Form". You will be given a copy of the form and this Information Sheet.

If you do not fulfill the inclusion and exclusion criteria, your data will not be used and will be withdrawn from this study.

The right to withdraw

You have the right to withdraw from the experiment at any time without affecting the future study.

Data & Confidentiality:

The result of the data obtained will be reported in a collected manner with no reference to a specific individual. Hence, the data from each individual will remain confidential.

Payment and compensation:

You do not have to pay for participating in this study. Similarly, no payment is available to you for participating in this study.

Who can I ask about the study?

If you have any questions, you can contact the research team.

Principal Investigator

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Faculty of Health Sciences

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APPENDIX C

INFORMED CONSENT FORM

PARTICIPANT INFORMED CONSENT FORM

Research Title: Elucidating the association between dry eye symptoms and night driving difficulty in Malaysian adults

Researcher's Name: ....

I, ……………………………………………, IC No : ……………………......

- have read the information in the Participant Information Sheet **including information regarding the risk in this study.**
- have been given time to think about it and all of my questions have been answered to my satisfaction.
- understand that I may freely choose to withdraw from this study at anytime without reason and without repercussion
- understand that my anonymity will be ensured in the write-up.

I voluntarily agree to be part of this research study, to follow the study procedures, and to provide necessary information to the doctor, nurses, or other staff members, as requested.

…………………………………	…………………..
(Signature)	(Date)
……………………………….	……………………………….
Witness (if any)	Researcher
……………………………….	……………………………….
(Signature)	(Signature)
……………………………….	……………………………….
(IC Number)	(IC Number)
…………………………..…	……………………………….
(Date)	(Date)

APPENDIX D

THE MALAY VERSION OF VND-Q (VND-Q-M)

Soal Selidik Penglihatan dan Pemanduan Waktu Malam Versi Bahasa Melayu (VND-Q-M)

Soal selidik ini adalah berkaitan kesukaran penglihatan anda semasa memandu waktu malam. Bagi setiap soalan, sila pilih jawapan yang paling tepat menggambarkan situasi anda dan jawab **seolah-olah anda sedang memakai kaca mata atau kanta sentuh yang biasanya anda gunakan (jika ada) ketika memandu waktu malam**. Sila jawab setiap soalan dengan tepat dan secepat yang boleh. Elakkan daripada menghabiskan terlalu banyak masa pada mana-mana soalan.

Berapakah tahap kesukaran yang anda alami, atau mungkin alami, semasa aktiviti memandu waktu malam dalam situasi di bawah?

Penglihatan:	
1. Melihat kereta berwarna gelap semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
2. Melihat pejalan kaki atau haiwan di tepi jalan semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
3. Membaca papan tanda jalan semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
4. Melihat jalan disebabkan lampu depan kereta dari arah bertentangan semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
5. Melihat disebabkan silau semasa memandu waktu subuh atau senja?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5

Penilaian Jarak:	
6. Menganggar jarak ke jalan susur atau jalan keluar semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
7. Menganggar jarak di antara anda dengan kereta lain yang sedang bergerak semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5
Lain-lain:	
8. Melihat jalan ketika hujan atau cuaca buruk semasa memandu waktu malam?	Tidak sukar________1 Sedikit sukar_______2 Sederhana sukar_____3 Banyak sukar_______4 Sangat sukar_______5

APPENDIX E

COMPLETE ONLINE DATA COLLECTION FORM

SOAL SELIDIK TENTANG PERKAITAN ANTARA GEJALA MATA KERING DAN KESUKARAN PEMANDUAN WAKTU MALAM DALAM KALANGAN DEWASA MALAYSIA

Assalamualaikum dan Salam Sejahtera,

Tujuan kajian ini adalah untuk menganalisis perkaitan antara gejala mata kering dan kesukaran pemanduan waktu malam dalam kalangan dewasa Malaysia (UKM PPI/111/8/JEP-2022-103).

Saya dengan ini ingin menjemput saudara/saudari untuk mengisi soal selidik ini sekiranya saudara/saudari memenuhi kriteria di bawah:

- Warganegara Malaysia
- Berumur 18 hingga 40 tahun
- Pemegang lesen memandu yang aktif
- Mempunyai pengalaman memandu tidak kurang daripada setahun
- Memandu waktu malam sekurang-kurangnya sekali seminggu

Maklum balas yang telah diberikan akan kekal sulit dan hanya akan digunakan bagi tujuan kajian dan untuk memenuhi sebahagian keperluan bagi Sarjana Sains Kesihatan Optometri, di bawah Fakulti Sains Kesihatan, Universiti Kebangsaan Malaysia.

Soal selidik ini mengandungi beberapa bahagian seperti berikut:
Bahagian A: Demografi
Bahagian B: Soal Selidik Penglihatan & Pemanduan Waktu Malam Versi Bahasa Melayu
Bahagian C: Indeks Penyakit Permukaan Okular© (Ocular Surface Disease Index, OSDI©) Versi Bahasa Melayu
Bahagian D: Skala Harga-Diri Rosenberg Versi Bahasa Melayu

Terima kasih atas kerjasama dan masa yang saudara/saudari luangkan untuk menjawab soal selidik ini.

Untuk sebarang pertanyaan, saudara/saudari boleh menghubungi para penyelidik seperti yang tertera di bawah. Sekian.

Pelajar Sarjana:
Wan Muhammad Hirzi bin Wan Din
p117160@siswa.ukm.edu.my

Penyelia:
Dr. Woi Pui Juan
woipj@ukm.edu.my

Program Optometri dan Sains Penglihatan,
Pusat Kajian Kesihatan Komuniti,
Fakulti Sains Kesihatan,
Universiti Kebangsaan Malaysia.

* Indicates required question

1. Email *

2. Saya bersetuju untuk menjawab soal selidik ini dan memberi maklumat yang diperlukan bagi tujuan penyelidikan kajian ini. *

Mark only one oval.

- Setuju
- Tidak Setuju

Bahagian A: Demografi

3. Kewarganegaraan *

Mark only one oval.

- Warganegara Malaysia
- Bukan warganegara Malaysia

4. Jantina *

Mark only one oval.

- Lelaki
- Perempuan

5. Umur *

6. Pekerjaan *

7. Etnik/Kaum *

Mark only one oval.

- Melayu
- Cina
- India
- Bumiputra
- Lain-lain (Sila nyatakan di bawah)
- Other:

8. Adakah anda mempunyai lesen memandu yang aktif? *

Mark only one oval.

- Ya
- Tidak

9. Sudah berapa tahun anda memandu? *

Mark only one oval.

- Kurang 1 tahun
- 1-2 tahun
- 3-4 tahun
- 5 tahun dan lebih

10. Berapa kali anda memandu waktu malam dalam seminggu? *

Mark only one oval.

- Tiada
- 1-2 kali seminggu
- 3-4 kali seminggu
- 5-6 kali seminggu
- Setiap hari dalam seminggu

11. Berapa lama anda memandu waktu malam dalam sehari? (sila bagi jawapan dalam minit atau jam) *

12. Jenis kenderaan yang digunakan semasa memandu waktu malam *

Mark only one oval.

- Kereta (termasuk lori dan bas)
- Motosikal
- Semua di atas

Tahap Penglihatan

13. Adakah anda memakai cermin mata atau kanta sentuh semasa memandu waktu malam? *

Mark only one oval.

- Ya bagi cermin mata (Sila jawab soalan berikut dengan mengambil kira cermin mata anda)
- Ya bagi kanta sentuh (Sila jawab soalan berikut dengan mengambil kira kanta sentuh anda)
- Tiada
- Other:

14. Dalam 30 hari yang lalu, berapa banyak kesukaran yang anda hadapi untuk melihat dan mengecam seseorang yang anda kenali di seberang jalan (iaitu dari jarak kira-kira 20 meter)? *

Mark only one oval.

- Tiada
- Ringan
- Sederhana
- Sukar
- Sangat sukar/Tidak boleh dilakukan

15. Dalam tempoh 30 hari yang lalu, berapakah kesukaran yang anda hadapi untuk melihat dan mengecam objek pada jarak posisi lengan atau semasa membaca? *

Mark only one oval.

- Tiada
- Ringan
- Sederhana
- Sukar
- Sangat sukar/Tidak boleh dilakukan

16. Pilih mana-mana jawapan yang berkaitan dengan tahap kesihatan anda; pilihan jawapan boleh lebih daripada satu (jika berkaitan) *

- Kelemahan fizikal (physical frailty)
- Sejarah penyakit sistemik yang boleh menjejaskan pemanduan atau pemikiran kognitif
- Sejarah penyakit mata atau keabnormalan selain daripada sindrom mata kering
- Sejarah pembedahan okular termasuk pembedahan refraktif
- Tiada yang di atas

17. Bilakah kali terakhir anda melakukan pemeriksaan kesihatan? *

Mark only one oval.

- 2 minggu lepas
- 3 bulan lepas
- 6 bulan lepas
- 1 tahun lepas
- lebih daripada 1 tahun

Bahagian B: Soal Selidik Penglihatan dan Pemanduan Waktu Malam Versi Bahasa Melayu

Soal selidik ini adalah berkaitan kesukaran penglihatan anda semasa memandu waktu malam. Bagi setiap soalan, sila pilih jawapan yang paling tepat menggambarkan situasi anda dan jawab seolah-olah anda sedang memakai kaca mata atau kanta sentuh yang biasanya anda gunakan (jika ada) ketika memandu waktu malam. Sila jawab setiap soalan dengan tepat dan secepat yang boleh. Elakkan daripada menghabiskan terlalu banyak masa pada mana-mana soalan.

Berapakah tahap kesukaran yang anda alami, atau mungkin alami, semasa aktiviti memandu waktu malam dalam situasi di bawah?

18. Melihat kereta berwarna gelap semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

19. Melihat pejalan kaki atau haiwan di tepi jalan semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

20. Membaca papan tanda jalan semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

21. Melihat jalan disebabkan lampu depan kereta dari arah bertentangan semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

22. Melihat disebabkan silau semasa memandu waktu subuh atau senja? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

23. Menganggar jarak ke jalan susur atau jalan keluar semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

24. Menganggar jarak di antara anda dengan kereta lain yang sedang bergerak semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

25. Melihat jalan ketika hujan atau cuaca buruk semasa memandu waktu malam? *

Mark only one oval.

- Tidak sukar
- Sedikit sukar
- Sederhana sukar
- Banyak sukar
- Sangat sukar

Bahagian C. Indeks Penyakit Permukaan Okular© (Ocular Surface Disease Index, OSDI©) Versi Bahasa Melayu

Soal selidik ini adalah berkaitan Indeks Penyakit Permukaan Okular. Bagi setiap soalan, sila pilih jawapan yang paling tepat menggambarkan situasi anda. Sila jawab setiap soalan dengan tepat dan secepat yang boleh. Elakkan daripada menghabiskan terlalu banyak masa pada mana-mana soalan.

Pernahkah anda mengalami sebarang perkara berikut sepanjang minggu lepas?

26. Mata yang sensitif terhadap cahaya? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tiada

27. Mata berpasir? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tiada

28. Mata sakit atau pedih? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tiada

29. Penglihatan kabur? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tiada

30. Penglihatan lemah/terhad? *

Mark only one oval.

Sepanjang masa

Sangat kerap

Kerap

Tidak kerap

Tiada

Adakah masalah mata anda menghalang anda daripada melakukan sebarang aktiviti berikut sepanjang minggu lepas?

31. Membaca? *

Mark only one oval.

Sepanjang masa

Sangat kerap

Kerap

Tidak kerap

Tidak berkaitan

32. Memandu pada waktu malam? *

Mark only one oval.

Sepanjang masa

Sangat kerap

Kerap

Tidak kerap

Tidak berkaitan

33. Bekerja dengan menggunakan komputer atau mesin bank (ATM)? *

Mark only one oval.

Sepanjang masa

Sangat kerap

Kerap

Tidak kerap

Tidak berkaitan

34. Menonton televisyen (TV)? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tidak berkaitan

Pernahkah mata anda berasa tidak selesa dalam situasi berikut sepanjang minggu lepas?

35. Keadaan berangin? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tidak berkaitan

36. Tempat atau kawasan berkelembapan rendah (sangat kering)? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tidak berkaitan

37. Kawasan berhawa dingin? *

Mark only one oval.

- Sepanjang masa
- Sangat kerap
- Kerap
- Tidak kerap
- Tidak berkaitan

Bahagian D: Skala Harga-Diri Rosenberg Versi Bahasa Melayu

Soal selidik ini adalah berkaitan sikap anda terhadap kehidupan pada keseluruhannya. Bagi setiap soalan, sila pilih jawapan yang paling tepat menggambarkan situasi anda. Sila jawab setiap soalan dengan tepat dan secepat yang boleh. Elakkan daripada menghabiskan terlalu banyak masa pada mana-mana soalan.

38. Pada keseluruhannya saya berpuashati dengan diri saya. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

39. Saya rasa saya mempunyai beberapa kualiti yang baik. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

40. Kadangkala saya rasa tidak berguna langsung. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

41. Saya boleh melakukan pekerjaan seperti kebanyakan orang lain. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

42. Saya rasa saya tidak mempunyai apa-apa untuk dibanggakan. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

43. Kadangkala saya sememangnya rasa tidak berguna. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

44. Saya rasa saya seorang yang berharga, sekurang-kurangnya pada tahap yang sama dengan orang lain. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

45. Saya berhajat untuk mempunyai lebih hormat pada diri saya sendiri. *

Mark only one oval.

- Sangat tidak setuju
- Tidak setuju
- Berkecuali
- Setuju
- Sangat setuju

46. Setelah mengambilkira segala-galanya, saya cenderung berasa yang saya seorang yang gagal. *

Mark only one oval.

Sangat tidak setuju

Tidak setuju

Berkecuali

Setuju

Sangat setuju

47. Saya mengambil sikap positif terhadap diri saya *

Mark only one oval.

Sangat tidak setuju

Tidak setuju

Berkecuali

Setuju

Sangat setuju

Soalan TAMAT

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Google Forms

APPENDIX F

JOURNAL PUBLICATIONS

Med & Health Jan 2025; 20(1): 104-115 https://doi.org/10.17576/MH.2025.2001.06

ORIGINAL ARTICLE

Translation, Validation and Reliability Testing of The Vision and Night Driving Questionnaire from English into the Malay Language

WOI PJ[1]*, WAN DIN WMH[1], AZMI SYUKRI NS[1], ABD RAHMAN MH[2], MUTALIB HA[1], BHANDARI M[3]

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Received: 02 Apr 024 / Accepted: 11 Jun 2024

ABSTRAK

Pemanduan waktu malam adalah aspek penting dalam mobiliti, dan status penglihatan adalah salah satu faktor yang mempengaruhi prestasi pemanduan waktu malam. Soal Selidik Penglihatan dan Pemanduan Waktu Malam (VND-Q) yang mempunyai sembilan item dibangunkan untuk menilai kesukaran penglihatan semasa memandu waktu malam. Kajian ini bertujuan untuk menterjemahkan VND-Q versi Bahasa Inggeris ke Bahasa Melayu dan menentukan kesahan dan kebolehpercayaan VND-Q versi Bahasa Melayu (VND-Q-M) dalam kalangan penduduk Malaysia. Kaedah penterjemahan hadapan-belakang telah dilakukan untuk menterjemah VND-Q ke dalam Bahasa Melayu. Kesahan kandungan dinilai oleh enam pakar dalam bidang optometri. Seramai 120 orang pemandu dewasa Malaysia terlibat dalam pengesahan konstruk menggunakan analisis faktor penerokaan (EFA) dan ujian kebolehpercayaan menggunakan alpha Cronbach. Satu item telah dikeluarkan selepas mengambil kira pendapat semua pakar. Nilai indeks pengesahan kandungan (CVI) untuk perkaitan, kejelasan dan kebolehfahaman ialah 1.0, 0.98 dan 1.0, menunjukkan kesahan yang tinggi. Nilai p bagi ujian sfera Barlett adalah lebih kecil daripada 0.001 dan ukuran kecukupan pensampelan Kaisen-Meyer-Olkin (KMO) ialah 0.79. Melalui EFA, dua faktor telah diperoleh sebagai asas kepada soal selidik, yang mempunyai sejumlah lapan item (pemuatan faktor ≥0.4). Nilai alpha Cronbach ialah 0.84 untuk semua item, menunjukkan konsistensi dalaman yang tinggi. Kajian ini menyediakan bukti untuk ciri psikometrik VND-Q-M yang diubah suai. Keputusan kajian ini menunjukkan bahawa VND-Q-M yang diubah suai adalah instrumen yang sah dan

Address for correspondence and reprint requests: Woi Pui Juan. Center for Community Health Studies (ReaCH), Optometry and Vision Science Programme, Universiti Kebangsaan Malaysia, 50300 Kuala Lumpur, Malaysia. Tel: +603-9289 7480 Email: woipj@ukm.edu.my

PLOS ONE

RESEARCH ARTICLE

Relationship between tear film stability, dry eye symptoms, and night driving vision among Malaysian adults

Pui Juan Woi[1]*, Purani Pathmanathan[1], Selena Yi Han Sieh[1], Mohd Harimi Abd Rahman[2], Haliza Abdul Mutalib[1], Madhavendra Bhandari[3], Naufal Nordin[1], Wan Muhammad Hirzi Wan Din[1]

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Abstract

Background

Dry eye disease, a prevalent condition globally, affects the quality of the tear film and, subsequently, vision, especially during visually demanding tasks like driving at night. This study aims to evaluate the relationship between tear film stability, dry eye symptoms, and self-reported difficulties in night driving among Malaysian adults. Methods: Ninety participants aged 18-40 years with at least one year of night driving experience were recruited. Tear film stability was assessed using non-invasive tear break-up time (NIBUT), while dry eye symptoms were measured with the Ocular Surface Disease Index (OSDI). Night driving vision difficulties were evaluated using the Vision and Night Driving Questionnaire (VND-Q). Results: Participants with shorter NIBUT (mean = 3.95 ± 1.32 s; median = 3.97 s, IQR: 2.87-5.03 s) reported significantly greater difficulties in night driving compared to those with normal NIBUT (mean = 9.80 ± 3.86 s; median = 8.23 s, IQR: 6.90-11.70 s) ($p < 0.001$). Similarly, participants with severe dry eye symptoms had higher VND-Q scores (mean rank = 76.75) compared to those with asymptomatic to moderate symptoms (mean rank = 35.68–44.03) ($p < 0.001$). Spearman's correlation showed moderate negative associations between NIBUT ($r = -0.327$), OSDI ($r = -0.538$), and VND-Q scores. However, there was no significant correlation between NIBUT and OSDI score. Multiple regression analysis revealed that both NIBUT and OSDI significantly predicted the VND-Q score, explaining 43.2% of the variance ($p < 0.001$). Conclusions: The findings suggest that poor tear film stability and severe dry eye symptoms contribute to night driving difficulties. Future studies should explore interventions aimed at improving tear film stability and dry eye symptoms to enhance driving safety at night.

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