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Mathematical Regression Analysis of Oxygen Saturation for Driving Fatigue using Box-Behnken Design

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***Abstract*— Like many other countries, the number of fatigue-related traffic accidents in Malaysia have become an alarming concern. Mathematical modelling is the process of describing a real-world issue in mathematical terms to understand the original issue. Hence, this paper aims to develop a mathematical regression model to predict the relationship between five input variables namely (i) driving duration, (ii) driving speed, (iii) body mass index (BMI), (iv) types of roads and (v) gender and an output response (oxygen saturation level) as the causes of driving fatigue. The regression analysis utilized Box-Behnken design method by Design Expert (6.0.8) software. The results revealed that the Prob > F values for all input variables were less than 0.01%, implying that all the variables were significant in influencing the oxygen saturation level. The regression model was validated to determine its accuracy in predicting the output response. The analysis presented excellent prediction accuracy as the model was capable to predict the data within 95% predictive interval, which met the minimum quantitative condition of 90% predictive interval. Furthermore, the residual errors were less than 10%, indicating that the model has excellent accuracy in predicting the oxygen saturation. The model prediction is expected to be useful in guiding researchers and policy makers in road safety field to take measures in minimizing traffic accidents due to driving fatigue.**

***Keywords*—Oxygen saturation, regression analysis, driver fatigue, mathematical modelling, driving fatigue.**

I. Introduction

Many countries, including Malaysia, are rapidly becoming more motorized where the number of motor vehicles has shot up drastically in the past two decades. As a result, the quality of life and life satisfaction of individuals and communities have increased. However, these advantages have come with a significant drawback. Despite the Malaysian government's heavy investment in road infrastructure, the rate of motorization always outpaces the supply of physical infrastructure and institutional capacity [2].

This is in agreement with the drastic increment in the number of registered vehicles in Malaysia from 3,447,712 units in 1996 to 17,486,589 units in 2020 [3]. As a result, there has been a massive increase in road safety accidents. Figure 1 presents data on the rising number of road crashes in Malaysia with a record from 462,426 cases in 2012 to 567,516 cases in 2019. However, the rate was significant dropped in 2020 to 418,245 cases [1] due to the implementation of movement control order (MCO) during Covid-19 pandemic.

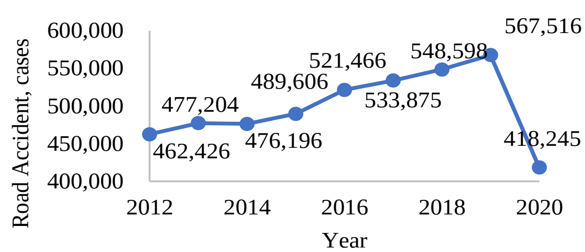

Figure 1. Statistics of Malaysia road accidents from 2012-2020 [1]

Driver inattention and distraction due to fatigue are the top contributors of traffic collisions [4]. Fatigue is a feeling of extreme physical and mental impairment [5], which is commonly related to tiredness or weakness. Driver fatigue negatively influences judgement and vision, slows reaction time and decision making and causes loss of focus amongst drivers [6]. According to the National Safety Council (NSC), each year, fatigue driving accounts for approximately 100,000 crashes, 71,000 injuries and 1,550 fatalities [7]. Under such circumstance, it is extremely urgent to control the road accident rates using a method that detects and monitors driving fatigue.

Recently, many studies are conducted on the effects of oxygen saturation on cognitive skills to indicate driving fatigue [8]. Driving is a complex task that requires assortment of cognitive skills.

Studies found that, high level saturated oxygen increases cognitive performance, including memory [8], verbal [9], n-back tasks [10] and visuospatial [11]. The Earth's atmospheric oxygen rate at the sea level altitude is approximately 21%. In such condition, the human's arterial oxygen saturation is constant at over 95%. If the human's oxygen intake is less than 95%, he or she is deemed fatigue [12]. According to a study, when driving fatigue increases, the blood oxygen saturation level in the driver's body drops [13]. As a result, it is reasonable to assume that low oxygen level can result in driving fatigue.

Therefore, this study formulated and validated a mathematical regression model using Box-Behnken design by Design Expert (6.0.8) software to predict the link between the input variables namely (i) driving duration, (ii) driving speed, (iii) body mass index (BMI), (iv) types of roads and (v) gender and an output response (oxygen saturation level) in signalling driving fatigue. The application of regression analysis in modelling and optimization has been widely employed in numerous fields due to its practicality and ease of use [14]. However, studies related to the regression modelling of driving fatigue specifically in oxygen saturation level are limited. Numerous causes influencing driving fatigue are still not modelled. The driver's oxygen saturation level is one of many factors that influence driving fatigue that has yet to be modelled.

II. METHODOLOGY

A. Participants

In this study, 12 subjects were involved, comprised of six males and six females. All subjects were aged between 20 to 25 years old, who at least had two years of driving experiences. The subjects represented three weight statuses, namely healthy, overweight and obese with BMI of 18.5-24.9 kg/m², 25.0-29.9 kg/m² and 30 kg/m² and above respectively. Regardless of participant's weight status, all subjects were healthy with no daily medication intake.

B. Experimental Design

To ensure the baseline fatigue was comparable in all participants before the driving test, the participants were requested to have at least 7.5 to 9 hours of good sleep the night before the experiment. Subjects with less amount of sleep, can result in sleep deprivation, hence having the potential to fall asleep while driving [15]. A regular lack of sleep may cause high blood pressure (hypertension) which could deteriorate driving performance. Therefore, before the driving test, Omron Evolv was used to test participants' blood pressure to ensure that they had normal blood pressure of less than 120 mmHg for systolic and less than 80 mmHg for diastolic, respectively. The participants were also strictly refrained from drinking beverages containing caffeine and alcohol for six hours before the experiment. The experiment was conducted during 9:00 am to 12:00 pm, the time of day when there are less fatigue-related car accidents reported [16]. One unit of Perodua Bezza GA T with automatic transmission was used throughout the driving experiment. A previous study found that external weather environment like ice, fog and rain could influence imperative cognitive skills required during driving, for example decision making [17]. Hence, the whole experiments were executed during sunny days. Two types of roads were used throughout the experiment, winding and monotonous at four different locations in Melaka. The driving tests on winding road were conducted from Paya Datok (2.403790, 102.198693) to Brisu (2.429859, 102.135178), whereas tests on monotonous road were conducted from Ayer Keroh Toll (2.301209, 102.310727) to Simpang Ampat Toll (2.444017, 102.192167) as shown in Figure 2. The driving speed and driving duration were observed and measured using a Google Map's speedometer application and a digital stopwatch respectively. The oxygen saturation level was measured using wireless pulse oximeter by placing the device on the driver's fingertip. The measurement was taken before commencing and right after completing the driving task. In this study, sixty-eight experimental runs were carried out. To maintain the integrity of data, each of the experiment was replicated, and then the average value was used.

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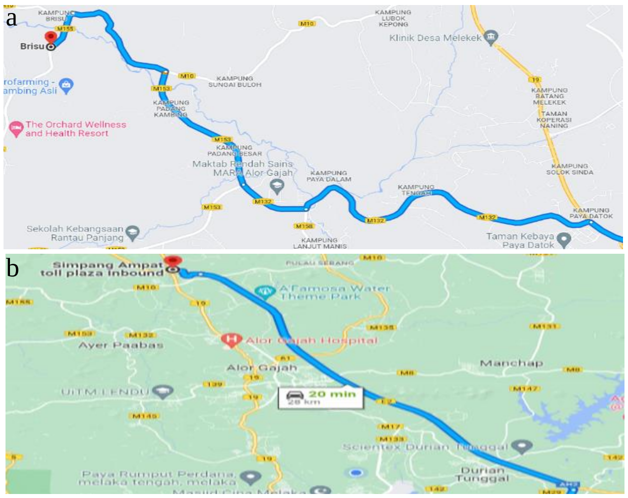

Figure 2. Driving route (a) winding road [Paya Datok (2.403790, 102.198693) to Brisu (2.429859, 102.135178)]; (b) monotonous road [Ayer Keroh Toll (2.301209, 102.310727) to Simpang Ampat Toll (2.444017, 102.192167)]

C. Regression Analysis

The goal of this study was to describe the relationship between the input variables namely (i) driving duration, (ii) driving speed, (iii) body mass index (BMI), (iv) types of roads and (v) gender and an output response (oxygen saturation level) in signalling driving fatigue. To achieve this, the Box-Behnken design was employed as this statistical technique is deemed effective to determine the regression model and optimize an output response which is affected by several independent variables [18]. The Box-Behnken data analysis was performed using the Design Expert (6.0.8) software. Figure 3 presents the steps involved in the Box-Behnken data analysis in this study.

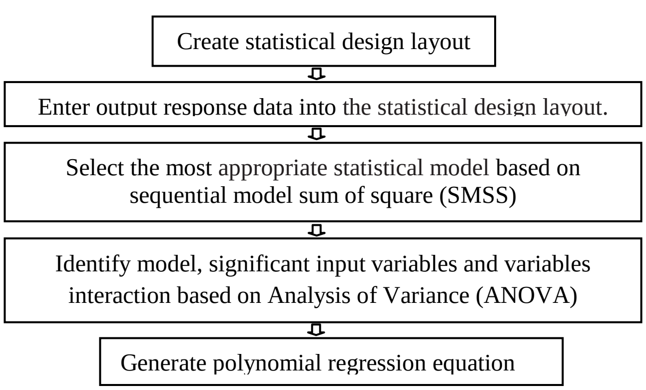

Figure 3. Flow of Box-Behnken data analysis

The statistical design layout was first created based on experimental design of input variables as shown in Table I. The output response data (oxygen saturation) were then entered into the statistical design layout. The regression variability and reduction errors were then quantified by sequential model sum of square (SMSS) in order to determine the most accurate polynomial model to represent the variables being modelled. The highest degree model with a p-value less than 0.10% was chosen to represent the model. The low p-value indicated that null hypothesis could be rejected. The predictor with less p-value was likely to be a meaningful addition to the model as the changes in the predictor's value were associated with the changes in the output response variable. Next, the selected model was analyzed using ANOVA to determine the appropriate model to represent the variables, significant input variables and the interaction between input variables and output response. The Prob>F statistics tested the overall significance of the mathematical model. The value of Prob>F indicated the probability that the null hypothesis of the model was true. If the Prob>F value was less than 0.10%, the model had a significant effect on the response variable. Finally, the polynomial regression equation which estimated the relationship of input and response variables of the model was generated.

TABLE I
DESIGN SUMMARY OF EXPERIMENTAL DESIGN (INPUT VARIABLE)

	Minimum	Maximum	Unit
Numeric Variable			
Driving Speed	80.00	100.00	km/h
Driving Duration	15.00	30.00	minute
BMI	18.50	35.00	kg/m²
Categorical Variable			
Type of Road	Winding	Monotonous	-
Gender	Female	Male	-

III. EXPERIMENTAL RESULTS AND DISCUSSION

A. Statistical Model Selection

The sequential model sum of square (SMSS) was carried out to determine the most appropriate statistical model to represent the variable being modelled as presented in Table II. The basis for the statistical model selection was subject to the two conditions: (i) highest order polynomial with Prob > F value less than 0.10% and (ii) models were suggested.

For all the responses, the linear statistical model was suggested by Design Expert (6.0.8) software to model the relationship between the input variables and output response.

TABLE II
SEQUENTIAL MODEL SUM OF SQUARES (SMSS) ANALYSIS

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Mean	6.400E+ 005	1	6.400E+ 005			
Linear	130.09	5	26.02	1805.65	< 0.0001	Suggested
2FI	0.20	10	0.020	1.52	0.1584	
Cubic	0.35	18	0.019	2.00	0.0439	Aliased
Residual	0.30	31	9.606E-003			
Total	6.401E+ 005	68	9413.78			

B. Analysis of Variance (ANOVA) for Response Surface Linear Model

The stability and appropriateness of the linear model were then corroborated through analysis of variance (ANOVA) to identify the interaction between input variables and output response.

TABLE III
ANOVA ANALYSIS FOR RESPONSE SURFACE LINEAR MODEL

Source	Sum of Squares	DF	Mean Square	F-Value	Prob > F	
Model	130.09	5	26.02	1805.65	< 0.0001	Significant
A	34.03	1	34.03	2361.74	< 0.0001	
B	30.03	1	30.03	2084.14	< 0.0001	
C	32.00	1	32.00	2220.77	< 0.0001	
D	18.01	1	18.01	1250.21	< 0.0001	
E	16.01	1	16.01	1111.41	< 0.0001	
Residual	0.89	62	0.014			
Lack of Fit	0.89	46	0.019			
Pure Error	0.000	16	0.000			
Cor Total	130.99	67				

The linear model F-value of 1805.65 indicated the model was significant. There is only a 0.01% chance that the "Model F-Value" this large could occur due to noise. In addition, the values of Prob>F for all input parameters (A= Driving Duration, B= Driving Speed, C= BMI, D= Types of Roads and E= Gender) were less than 0.01%, implying that all the input variables were significant in influencing the output response (oxygen saturation level). The models were not significant if the Prob>F values were greater than 0.01%. If there are many insignificant model terms, input parameter reduction might improve the model. The interaction of significant input variables on oxygen saturation level are presented in the following section:

Driving Duration: Figure 4a shows that as the driving duration increased from 15 minutes to 30 minutes, the oxygen saturation declined from 98.96% to 96.90% respectively. Driving involves a series of events such as sitting in traffic, maintaining a steady speed and braking that take a toll on stress levels. A study concluded that long hours driving time elicits a stress response over an extended period of time [19]. Stress can alter the respiratory rate like breath shortness and rapid breathing, as the airway between the nose and the lungs constricts [20] thereby, lowering oxygen saturation levels in the body [21]. A study which analyzed stress levels based on four methods of breathing yielded that, shallow and slow breathing made participants more anxious and less relaxed than other three conditions, which are breathing at usual depth and rate, (ii) breathing as a slower pace than usual and (iii) breathing shallower in normal pace [22]. Therefore, the stress caused by long periods of driving have an impact on the respiratory system's ability to provide oxygen normally.

Driving Speed: Figure 4b illustrates the changes of oxygen saturation which decreased from 97.04 % to 95.10% when the speeding increased from 80km/h to 100 km/h respectively. A task-capability interface model recommended that the vehicle speed selection could be affected by the driver's cognitive workload [23]. Drivers tended to change the speed maybe in order to adjust the task difficulty effectively and enhanced the vigilance levels, for example when driving during peak times, feeling out of control and being stuck in heavy traffic that could contribute to stress. A study investigated the emotional states among taxi drivers while on duty found that stress emotions like angry and sadness have significant impacts on rising driving speed [24]. As explained in the Figure 4a, a stressful person is prone to suffer respiratory symptoms like shortness of breath. This type of breathing disrupts the balance of oxygen in the body.

BMI: Figure 4c reflects the decrement in oxygen saturation from 98.77 % to 96.77 % when the BMI increased from 21.70 (healthy) to 35.00 (obese). This trend might be associated with the obesity-related health condition. A study found that obesity is a leading independent factor to a low oxygen saturation level with effects greater than other clinical contributors such as smoking and heart failure. The study concluded that the effect of obesity on lung function is by deteriorating oxygen exchange [25]. Obstructive sleep apnea-hypopnea (OSAH) is the most common type of sleep-related breathing disorder that has been linked to traffic crashes [26].

Obesity is consistently known as one of the main components contributing to OSAH, besides hypercholesterolemia, and hypertension [27]. OSAH is a chronic condition when the part or all of the upper airway is continually blocked while sleeping. The prevalence of OSAH in obese people is nearly twice that of normal- BMI category adults [28] as the fat deposits around the upper airway decrease the airway size and increase the airflow resistance [28. The condition decreases the oxygen flow to organs, hence, causing approximately 4% drop in oxygen saturation levels [29]. Low oxygen levels in the blood during sleep can lead to restless sleep and fatigue in the morning.

Types of Roads: Figure 4d presents the trend of oxygen saturation which declined from 95.49 % to 94.46 % when the road geometry changed from winding to monotonous. The results showed that the characteristics of road geometry and road side environment had a significant impact on driving performance by affecting oxygen saturation. When compared to a relatively challenging (winding) road condition, oxygen saturation dropped during low-demanding monotonous driving because this environment provided minimal geometric variety and required less task effort, leading to boredom and fatigue-related risks. The outcome is consistent with [30], since the driver's alertness was significantly reduced due to the monotony of the route design and surroundings. Another study revealed the consequence of passive fatigue through lane positioning and steering wheel control and concluded that drivers experience more passive fatigue symptoms in straight road environment than high-demanding curvy road (winding) [31].Under under-load driving conditions, the heart rate tends to beat faster than normal as the boredom has significant link to stress [32]. When the heart rates increase too rapidly, the blood pumping capability drops efficiently, hence, reducing the blood flow to the rest of the body including heart. Therefore, the boredom generated by a boring straight road with little sensory stimulation affects the heart rate's ability to provide oxygen normally.

Gender: Figure 4e depicts the reduction of oxygen saturation from 97.23% to 96.26% when the drivers changed from female to male. A study found that there are differences in the respiratory disorders between sexes [33] such as oxygen transport [34] and affinity of haemoglobin for oxygen [35]. A study investigated the differences in pulse oximetry among 209 young healthy subjects (132 women and 77 men), obtaining a compatible result as women have higher oxygen saturation level than men with 98.6% and 97.9% respectively [36].

The study suggested that the difference in sex hormones is the leading factor that influences the red blood cell development, resulting in significant changes for the cellular phase of respiration.

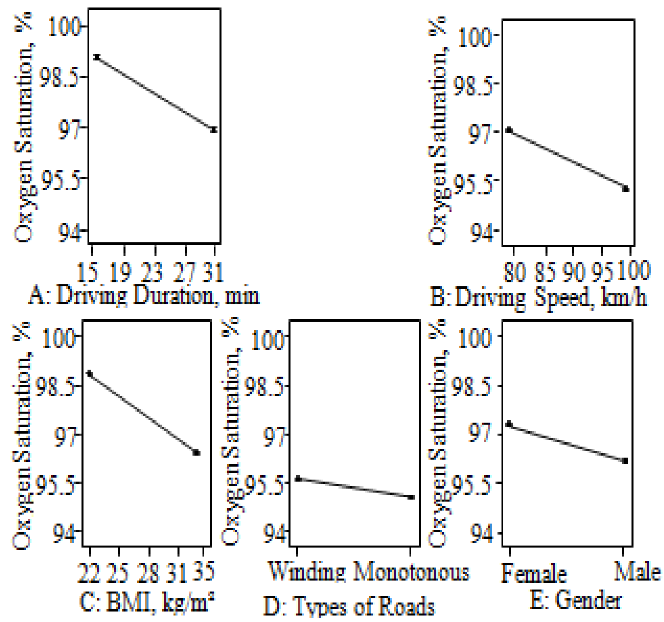

Figure 4. Interaction between input variables and output response (a) driving duration; (b) driving speed; (c) BMI; (d) types of roads; (e) gender

C. Polynomial Regression Equations

Table IV presents the polynomial regression equations to determine the relationship between the input and output variables. The original unit of each input variable as developed in statistical design layout was substituted into the equations to predict the oxygen saturation value.

TABLE IV
POLYNOMIAL REGRESSION EQUATION

Road: Winding	Gender: Female
Oxygen Saturation = +114.09036 - (0.13750 * Duration) - 0.096875 * Speed) - (0.15038 * BMI)	
Road: Monotonous	Gender: Female
Oxygen Saturation = +113.06095 – (0.13750 * Duration) – (0.096875 *Speed) – (0.15038 * BMI)	
Road: Winding	Gender: Male
Oxygen Saturation = +113.11978 – (0.13750 * Duration) – (0.096875 *Speed) – (0.15038 * BMI)	
Road: Monotonous	Gender: Male
Oxygen Saturation = +112.09036 – (0.13750 * Duration) – (0.096875 *Speed) – (0.15038 * BMI)	

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D. Regression Model Validation

The regression model was validated to quantify the model accuracy in predicting the oxygen saturation value by using two quantitative conditions:

1) The model can predict the output response value (oxygen saturation) within 90% of its low and high predictive interval. The developed polynomial regression equations were used to estimate the output response value.
2) The model has excellent accuracy if the residual error percentage is lower than 10% [37].

TABLE V
DATA VALIDATION (A= DRIVING DURATION, B= DRIVING SPEED, C= BMI, D= TYPES OF ROADS AND E= GENDER

Input Parameter	Predict -ion (%)	PI low (%)	PI high (%)	Actual (%)	Error (%)
A= 22.5 min B= 90 km/h C= 28.4 kg/m² D= Monotonous E= Female	97.0	96.7	97.2	97	0.02
A= 30.0 min B= 80 km/h C= 28.4 kg/m² D= Winding E= Male	97.1	96.8	97.3	97	0.02
A= 30.0 min B= 90 km/h C= 21.7 kg/m² D= Monotonous E= Female	97.0	96.7	97.2	97	0.05

The results indicate all three samples meet both quantitative conditions to accurately predict the oxygen saturation. First, the model is capable of predicting data within a 95% predictive interval, which meets the minimum quantitative criteria of a 90% predictive interval. Second, the residual errors are less than 10%, ranging from 0.02 % to 0.05%, indicating that the model has excellent accuracy in predicting the oxygen saturation.

IV. CONCLUSION

This study formulates and validates a mathematical regression model of oxygen saturation level as a factor of driving fatigue by using Box-Behnken design by Design Expert (6.0.8) software. The goal of this study is to develop the polynomial regression equation to describe the relationship between the input variables and output response.

Five input variables namely (i) driving duration, (ii) driving speed, (iii) BMI, (iv) types of roads and (v) gender are investigated as the factors that influence oxygen saturation level. The values of Prob>F for all input variables are less than 0.01%, implying that all factors are significant in influencing the oxygen saturation. The model is validated to determine its accuracy in predicting the output response. The model is capable of predicting the data within a 95% predictive interval, which meets the minimum quantitative constraint of 90% predictive interval. In addition, the residual errors are less than 10%, indicating that the model has excellent accuracy in predicting the oxygen saturation. The use of regression analysis to look into the health of the driver as a factor in driving fatigue is less prevalent. Most of the current studies focus on the perceptual, psychological, electrophysiology and biochemical based measurements to indicate driving fatigue. Therefore, the future study will investigate the influence of cognitive skills impairment like decision making and focusing on driving fatigue utilizing the same methodology. The findings of this study will help researchers and policymakers in the field of road safety take suitable measures to reduce road accidents. predicting the oxygen saturation.

REFERENCES

[1] MIROS. Road Accidents and Fatalities in Malaysia 2021; Available from: https://www.mot.gov.my/en/land/safety/road-accident-and-facilities.

[2] ESCAP, U., Review of developments in transport in Asia and the Pacific 2005. 2005.

[3] CEIC, Malaysia Number of Registered Vehicles, I.E.M.G.C. CEIC Data, Editor. 2021.

[4] Li, K., Y. Gong, and Z. Ren, A fatigue driving detection algorithm based on facial multi-feature fusion. IEEE Access, 2020. 8: p. 101244-101259.

[5] Ibrahim, M.S., et al., Development of Driving Fatigue Strain Index using Fuzzy Logic to Quantify Impairment Risk Levels of Cognitive Skills in Vehicle Driving. International Journal of Engineering Advanced Research, 2022(1): p. 121-139%V 4.

[6] Jiang, K., et al., Why do drivers continue driving while fatigued? An application of the theory of planned behaviour. Transportation Research Part A: Policy and Practice, 2017. 98: p. 141-149.

[7] Borelli, L. *Drowsy driving statistics and facts 2022*. 2022; Available from: https://www.bankrate.com/insurance/car/drowsy-driving-statistics/.

[8] Chung, S.C. and D.W. Lim, Changes in memory performance, heart rate, and blood oxygen saturation due to 30% oxygen administration. Int J Neurosci, 2008. 118(4): p. 593-606.

[9] Chung, S.C., et al., Effect of 30% oxygen administration on verbal cognitive performance, blood oxygen saturation and heart rate. Appl Psychophysiol Biofeedback, 2006. 31(4): p. 281-93.

[10] Kane, M.J., et al., Working memory, attention control, and the N-back task: a question of construct validity. J Exp Psychol Learn Mem Cogn, 2007. 33(3): p. 615-622.

[11] Chung, S.C., et al., Changes in reaction time when using oxygen inhalation during simple visual matching tasks. Neurosci Lett, 2009. 453(3): p. 175-7.

[12] Sung, E.-J., et al., Effects of oxygen concentrations on driver fatigue during simulated driving. Applied ergonomics, 2005. 36(1): p. 25-31.

[13] Kobayashi, F., et al., Blood pressure and heart rate variability in taxi drivers on long duty schedules. Journal of Occupational Health, 2002. 44(4): p. 214-220.

[14] Deshpande, R., M. Chinnan, and K. McWatters, Optimization of a chocolate-flavored, peanut–soy beverage using response surface methodology (RSM) as applied to consumer acceptability data. LWT-Food Science and technology, 2008. 41(8): p. 1485-1492.

[15] Davidović, J., D. Pešić, and B. Antić, Professional drivers' fatigue as a problem of the modern era. Transportation research part F: traffic psychology and behaviour, 2018. 55: p. 199-209.

[16] Di Milia, L., et al., Demographic factors, fatigue, and driving accidents: An examination of the published literature. Accident Analysis & Prevention, 2011. 43(2): p. 516-532.

[17] Li, X., X. Yan, and S.C. Wong, Effects of fog, driver experience and gender on driving behavior on S-curved road segments. Accident Analysis & Prevention, 2015. 77: p. 91-104.

[18] Behera, S.K., et al., Application of response surface methodology (RSM) for optimization of leaching parameters for ash reduction from low-grade coal. International Journal of Mining Science and Technology, 2018. 28(4): p. 621-629.

[19] Antoun, M., et al., The acute physiological stress response to driving: A systematic review. PLoS one, 2017. 12(10): p. e0185517.

[20] Aeschliman, S.D., et al., A preliminary study on oxygen saturation levels of patients during periodontal surgery with and without oral conscious sedation using diazepam. Journal of periodontology, 2003. 74(7): p. 1056-1059.

[21] Iamonaco, C., et al., Shortness of Breath. Handbook of Medicine in Psychiatry, 2020: p. 129.

[22] Conrad, A., et al., Psychophysiological effects of breathing instructions for stress management. Applied psychophysiology and biofeedback, 2007. 32(2): p. 89-98.

[23] Fuller, R., Towards a general theory of driver behaviour. Accident analysis & prevention, 2005. 37(3): p. 461-472.

[24] Kadoya, Y., S. Watanapongvanich, and M.S.R. Khan, How is emotion associated with driving speed? A study on taxi drivers in Japan. Transportation Research Part F: Traffic Psychology and Behaviour, 2021. 79: p. 205-216.

[25] Kapur, V.K., et al., Obesity is associated with a lower resting oxygen saturation in the ambulatory elderly: results from the cardiovascular health study. Respiratory care, 2013. 58(5): p. 831-837.

[26] Garvey, J.F., et al., Epidemiological aspects of obstructive sleep apnea. Journal of thoracic disease, 2015. 7(5): p. 920.

[27] Jehan, S., et al., Obstructive sleep apnea and obesity: implications for public health. Sleep medicine and disorders: international journal, 2017. 1(4).

[28] Peppard, P.E., et al., Longitudinal study of moderate weight change and sleep-disordered breathing. Jama, 2000. 284(23): p. 3015-3021.

[29] Wolk, R., T. Kara, and V.K. Somers, Sleep-disordered breathing and cardiovascular disease. Circulation, 2003. 108(1): p. 9-12.

[30] Larue, G.S., A. Rakotonirainy, and A.N. Pettitt, Driving performance impairments due to hypovigilance on monotonous roads. Accident Analysis & Prevention, 2011. 43(6): p. 2037-2046.

[31] Oron-Gilad, T. and A. Ronen, Road characteristics and driver fatigue: a simulator study. Traffic Injury Prevention, 2007. 8(3): p. 281-289.

[32] Merrifield, C. and J. Danckert, Characterizing the psychophysiological signature of boredom. Experimental brain research. Experimentelle Hirnforschung. Experimentation cerebrale, 2013. 232.

[33] Pollak, A. and R. Birnbacher, Preterm male infants need more initial respiratory support than female infants. Acta Paediatrica, 2004. 93(4): p. 447-448.

[34] Jones, P.P., Influence of gender on the sympathetic neural adjustments to alterations in systemic oxygen levels in humans. Clinical Physiology, 1999. 19(2): p. 153-160.

[35] Reybrouck, T. and R. Fagard, Gender differences in the oxygen transport system during maximal exercise in hypertensive subjects. Chest, 1999. 115(3): p. 788-792.

[36] Ricart, A., et al., Sex-linked differences in pulse oxymetry. Br J Sports Med, 2008. 42(7): p. 620-1.

[37] Baluch, N.H., C.S. Abdullah, and S. Mohtar, Maintenance management performance–An overview towards evaluating Malaysian palm oil mill. The Asian Journal of Technology Management, 2010. 3(1): p. 1-5.