CIVIL & ENVIRONMENTAL ENGINEERING | RESEARCH ARTICLE

Fitness for duty prediction model for bus driver of batik solo trans based on physical, mental, and work aspects

Bambang Suhardi1*, Anisa Rosyidasari2, Rahmaniayah Dwı Astutı2 and Iksan Adıasa3

Abstract: The development of fitness for duty models in bus drivers based on physical, mental, and work aspects is significant. The study aims to develop fitness for duty model for Batik Solo Trans (BST) drivers using a Psychomotor Vigilance Task (PVT), Visual Analogue Scale (VAS), Karolinska Sleepiness Scale (KSS), and logistic regression. Thirty bus drivers BST corridor 1 with the route Terminal Palur—Adi Sumarmo PP Airport supported the study with age, weight, height, sleep length, sleep quality, cigarette consumption, caffeine consumption, shift, attention, fatigue, sleepiness as independent variables and FFD as the dependent variable. The results showed that the assessment and evaluation of the fitness for duty level are pretty good. Based on the models that have been made, 90.9% of drivers are ready for duty. As much as 86.7% of bus drivers are right predicted. The value of adjusted R2 in the model is 68%. The ability of the model to predict its observational value is high (76%). VAS and KSS can be used to fit for duty of bus drivers, while PVT cannot be utilized. Fatigue and sleepiness affect the fitness for duty of bus drivers, while attention does not. Fatigue affects the level of sleepiness. The more tired, the higher the level of sleepiness felt. A shift has no significant effect on the level of attention, fatigue, and sleepiness. Shifts can affect the duration and quality of a driver’s sleep. The results of the logistic regression showed that the order of variables that had the most influence on the driver’s job readiness were age, cigarette consumption,
weight, sleep quality, changes in KSS, changes in PVT, changes in VAS, caffeine consumption, shifts, height, and sleep duration.

**Subjects:** Industrial Engineering & Manufacturing; Transport & Vehicle Engineering; Health Conditions

**Keywords:** attention; bus driver; fatigue; fitness for duty; sleepiness

1. **Introduction**

The increasing mobility of the population in Indonesia impacts the improvement of public transportation services. One of the most popular forms of public transportation in Indonesia is the bus (Soehodho, 2017). In PP No. 55 of 2012, a bus is a motorized vehicle for transporting people weighing more than 3500 kg with a seating capacity of more than eight people. An example of a bus service often found in big cities is the Bus Rapid Transit (BRT). BRT is defined as a bus system that provides fast, convenient, and inexpensive service (Deng & Nelson, 2011). Several cities in Indonesia have started to adopt the BRT system as a public transportation service, one of which is the city of Surakarta. The BRT system in Surakarta City is called Batik Solo Trans (BST).

As a mode of public transportation, BST is always required to provide the best service for passengers’ satisfaction. Minimum service standards based on Law no. 22 of 2009 concerning Road Traffic and Transportation covers comfort, safety, security, affordability, equality, and order. The quality, security, and safety that BST is currently implementing are limited to inspections that focus on vehicle readiness but have not considered the driver’s readiness. Irianto and Djoja (2016) explained that the bus driver is one of the essential elements in ensuring driving safety. Drivers on BST operations work with high demands. In addition to the main task of delivering passengers, BST drivers have several strict rules in the form of punctuality for stops at all shelters without exception. These high work demands lead to fatigue, impacting the driver’s health (Purwanto et al., 2018). Fatigue is a pattern that arises from a situation that causes the individual to no longer carry out his activities (Torres-Harding & Jason, 2003). Work fatigue has contributed to 12%-20% of accidents (Dingus et al., 2006). According to Chu (2014), accidents involving high-deck buses caused by driver fatigue were recorded in the police. Another factor that contributes to an accident is sleepiness.

Garbarino et al. (2001) explained that sleepiness is one factor that contributes to the incidence of vehicle accidents. When a person experiences sleepiness, cognitive abilities such as paying attention, alertness, and memory will decrease (Alhola & Polo Kantola, 2007). Referring to the research of Gnardellis et al. (2008), sleepiness can increase the risk of causing an accident increased by 76%. Therefore, checks related to driver readiness are essential factors to consider. The goal is to find out whether the driver’s condition before work is fit or not. Driver readiness checks are known as fitness for duty (Balkin et al., 2011). It is defined as the ability to work on each individual’s physical and mental health to work (STCW, 1995). Fitness for duty research on drivers is generally only applied to special driver populations, such as older drivers (Caragata et al., 2009) and drivers with stroke patients (Unsworth et al., 2019). It is different from research related to fitness for duty on BRT drivers, which is still rarely done. This study aims to develop a predictive model for the Solo Trans Batik Bus driver’s work readiness in physical, mental, and work aspects.

Measurement of physical aspects following the Regulation of the Minister of Manpower and Transmigration Number 02 of 1980 concerning Health and Manpower Examinations in the Implementation of Occupational Safety may include measurements of weight, height, pulse, blood pressure or blood pressure, examination of the senses of sight, hearing, smell, and touch. In comparison, mental aspects can measure mental workload, perception, anticipation, alertness, attention, stress, sleepiness, fatigue, and recovery (Zoer et al., 2014). Dagun (2006) states that attention is a mental aspect that encourages a person to direct and concentrate cognitive activity on a specific object or action. Focused or selective attention can be measured using various
cognitive tests, and the most widely used measuring instrument is the visual reaction time, known as the Psychomotor Vigilance Task (PVT; Krisnanda et al., 2020). One of the subjective indicators that are widely used and quite effective in detecting sleepiness is the Karolinska Sleepiness Scale (KSS; Kaida et al., 2006). Meanwhile, one of the subjective indicators to measure fatigue is the Visual Analogue Scale (VAS). VAS is a valid, reliable fatigue measurement tool and has a good level of strength (Lee et al., 1990).

Research related to fitness for duty involving various aspects has been carried out in recent years. Tan et al. (2013) conducted a study of the driver's fitness for duty using experiments. Aspects noted by Tan et al. only physical aspects in the form of physical and mental aspects in fatigue and sleepiness. Another research on fitness for duty was conducted by Wang et al. (2016) conducted a study of bus drivers in China. The study was conducted to detect cognitive capacity in attention using a tool developed by Anhui Sanlian Applied Traffic Technology. The research shows that the fitness for duty measurement considers cognitive aspects sensitive to accident detection. Onowhakpor et al. (2018) have conducted fitness for duty research on intercity bus drivers in Benin City from the physical aspect, namely alcohol consumption, blood pressure, and eye acuity. The results showed that 49% of drivers were not fit. Another study conducted by Yasobant et al., (2015) analyzed the fitness for duty of bus drivers. The only aspect considered is the physical aspect in fatigue and the risk of Work-related musculoskeletal disorders. Mental aspects have not been considered by Yasobant et al., (2015). In addition, Choi and Seong (2020) conducted research related to fitness for operators by paying attention to physical and mental aspects such as fatigue and sleepiness. There are still many researchers who have not paid attention to other aspects outside of these aspects.

Anund et al. (2018) conducted research related to the driver's work shift. A shift is a characteristic of bus drivers' working hours associated with sleep duration (Diez et al., 2011). A shift is one of the factors that cause an increase in sleepiness, and it can lead to work accidents. Therefore, work shifts need to be investigated as one of the variables in the study. The difference between this study and previous research is that this study was conducted to find out the work readiness of the Batik Solo Trans Bus drivers from various aspects, including physical aspects: age, weight, height, sleep duration, sleep quality, cigarette consumption, caffeine consumption; mental aspects: attention, fatigue, sleepiness; aspects of work in the form of shifts. The age variable was conducted to determine whether age affects the official readiness of a bus driver. This is because according to Owsley et al. (2004), a person's age affects whether or not someone is ready to drive. Variables Weight and height are related to body mass index (BMI). BMI is used to indicate weight category. This body weight is influenced by physical activity. People who have less physical activity tend to be overweight and obese (Herman et al., 2009). Performing routine physical activity is very important for maintaining physical, mental health and maintaining quality of life in order to stay healthy and fit (Cedervall et al., 2015).

The variables of sleep duration and sleep quality are the variables studied because according to Ingram et al. (2019), sleep is one of the important influences in official or work readiness. If someone has a lack of sleep duration and low sleep quality, it will have an impact on drowsiness when driving a vehicle which is also strictly prohibited. Furthermore, the consumption of cigarettes and caffeine is done because based on research conducted by Mahajan et al. (2019) and Smith et al. (2020), consuming cigarettes and caffeine affects a person's readiness to drive. In this study, EEG as a more accurate tool to measure mental workload was not performed. Although EEG is easier and more accurate to measure mental workload, Castor et al. (2003) suggest that the method of measuring workload using EEG is not applied to real activities, but rather to experimental activities in the laboratory because of the difficulty of obtaining accurate data on EEG results in the field directly.

This work readiness model can ensure that BST drivers are in a fit condition seen from various aspects. So that drivers can work effectively and not endanger themselves or the public. Research related to fitness for duty by considering physical, mental, and work aspects have
never before, primarily physical aspects such as age, weight, height, length of sleep, sleep quality, cigarette consumption, caffeine consumption; mental aspects: attention, fatigue, sleepiness; aspects of work in the form of shifts where previous research mainly considers physical and mental aspects with variables that are not widely studied. This study used PVT, VAS, and KSS measuring instruments. This study aims to develop a BST bus driver’s work readiness model, evaluate whether measuring instruments in the form of Psychomotor Vigilance Task (PVT), Visual Analogue Scale (VAS), and Karolinska Sleepiness Scale (KSS) can be used to evaluate driver’s job readiness and determine the effect of job readiness, work and shifts to changes in attention, fatigue, and sleepiness of drivers to reduce the risk of accidents on the highway. In addition, this study also wants to know the influence of the driver’s physical, mental, and work aspects. The work readiness model for bus drivers in Indonesia has never been implemented. This causes traffic accident in Indonesia to be quite high. By implementing this model, it is hoped that traffic accident can be reduced.

2. Research method

This study was undertaken at Palur Terminal as the start-finish place for the Solo Batik Bus Trans Corridor 1. The study was carried out for four months, from January 2021 to April 2021. The research survey was conducted using the probability sampling method through convenience sampling, where the criteria for respondents who will be subjects must be were in the research location and willing to be a participant. The drivers who participated were BST Corridor, one driver, following discussions with the Indonesian Surveyor as the BST supervisor. The selection was based on the timeliness of departing and arriving buses, where this bus had a better Schedule accuracy than other buses so that the variation of the travel duration data was more minor.

Participants are BST Corridor 1 drivers with at least one year of work experience. Participants consisted of 30 male drivers consisting of 18 drivers for the morning shift and 12 drivers for the afternoon shift. The average age of the participants was 41.03 years, height 171.03 cm, and weight 70.03 kg. The driver’s average body mass index is 24.51. All participating drivers are drivers with at least one year of work experience. The following are the research stages, which are shown in Figure 1.

Collecting data in this study was in the form of primary and secondary data. Primary data were obtained directly in the field, such as driver self-data, driver’s PVT, VAS, KSS data, and physical tests in the form of heart rate and blood pressure to support regression analysis. Before work, physical tests were carried out, while PVT, VAS, and KSS measurements were carried out before and after work. PVT measurement was done using a reaction timer where the driver sat quietly and focused on the given stimulus. If the stimulus has appeared, the driver will press the response button as quickly as possible. Then, the results of the measurements will appear on the monitor of the device, and a record will be made.

Secondary data is used to determine when the physical and mental measurements of the driver are carried out. In contrast, the VAS and KSS data were obtained by the driver circling the Likert scale according to the level of sleepiness and fatigue being felt on the questionnaire sheet. The secondary data needed is in the form of BST departure-arrival schedule data.

The following stage was data processing, including data recapitulation of PVT, VAS, and KSS measurement results; normality test, T-test, correlation test, and logistic regression test using IBM SPSS 26 software. A normality test was used to assess whether the distribution of data in a group was normally distributed or not. This normality test was used to determine what T-test will be used next. The T-test was carried out on the PVT, VAS, and KSS measurements before and after work. If the data were normally distributed, it used the Independent Sample T-Test. Meanwhile, if the data was not normally distributed, it used the Mann-Whitney U Test. The T-test was used to determine whether a difference between the morning and afternoon shifts occurs.
A correlation test is used to find out the correlation between variables. These variables included age, weight, height, sleep duration, sleep quality, cigarette consumption, caffeine consumption, shift, PVT value, VAS, KSS, as well as whether the driver was fit or not. The logistic regression test aimed to know whether the dependent variable in the form of driver's job readiness based on physical tests can be predicted using the independent variable. Logistic regression is an approach to making predictive models such as linear regression, commonly referred to as Ordinary Least Squares (OLS) regression (Menard, 2000). Generally, the dependent variable has been marked with the letter Y, while the independent variable was the letter X. Algebraic equation models such as OLS that we usually use are as follows (Hosmer et al., 2013):

\[ Y = B_0 + B_1X + \epsilon \]  
(1)

Where \( \epsilon \) is the error variance or residual model, the equation formed differs from the OLS equation. It does not use the same interpretation as the OLS regression equation with logistic regression. The following is the logistic regression equation:

\[ \ln\left( \frac{\hat{p}}{1 - \hat{p}} \right) = B_0 + B_1X \]  
(2)

Where:

- \( \ln \): Natural Logarithm.
- \( B_0 + B_1X \): Equation commonly known in OLS.
While p accent is the logistic probability obtained by the logistic regression probability formula as follows:

\[
p = \frac{e^{B_0 + B_1X}}{1 + e^{B_0 + B_1X}} \tag{3}\]

Where:

exp or written “e” is an exponential function.

(The exponential is the opposite of the natural logarithm. While the natural logarithm is a logarithmic form but with a constant value of 2.71828182845904 or usually rounded to 2.72).

Based on the equation model above, of course it will be very difficult to interpret the regression coefficient. So introduced a term Odds Ratio or commonly abbreviated as Exp (B) or OR. Exp(B) is the exponent of the regression coefficient. So, suppose the slope/gradient value of the regression is 0.90, then Exp(B) can be predicted/estimated as follows:

\[2.72^{0.9} = 2.226\] \tag{4}

The value of Exp (B) can be interpreted as follows:

For example, the Exp value (B) of the effect of fatigue on understanding the readiness of the bus driver’s office is 2,226, it can be concluded that bus drivers who experience fatigue are more guaranteed to measure the readiness of bus drivers’ services compared to bus drivers whose fatigue is not measured. Another difference is that in logistic regression there is no “R Square” value to measure the magnitude of the simultaneous effect of several independent variables on the dependent variable. In logistic regression, the term Pseudo R Square is known, namely the pseudo R Square value which means the same or identical to R Square in OLS. If the OLS uses the F Anova test to measure the level of significance and how well the equation model is formed, then the logistic regression uses the Chi-Square Value.

The calculation of the Chi-Square value is based on the Maximum Likelihood calculation. In this study there are 11 independent variables namely Age (Years), Weight (Kg), Height (cm), Sleep Duration (Hours), Sleep Quality, Cigarette Consumption (0 = No, 1 = Yes), Caffeine Consumption (0 = No, 1 = Yes), Shift (0 = Morning, 1 = Noon), Change in PVP value, Change in VAS value, Change in KSS value. While the dependent variable, namely Work Readiness or FFD, is divided into 2 categories, namely the category not ready for service (code 0) and the category ready for service (code 1). For the record, the high category is coded 1 and the low category is coded 0. In this study, the binary logistic regression equation is as follows:

\[
\log(Y) = 0 + 1(X1) + 2(X2) + 3(X3) + 4(X4) + 5(X5) + 6(X6) + 7(X7) + \beta_8(X8) + \beta_9(X9) + 10(X10) + 11(X11) + e
\] \tag{5}

With:

\[
Y = \text{Work Readiness or FFD (1 = FIT, 0 = Not FIT)}
\]

\[
X1 = \text{Age (Years)}
\]

\[
X2 = \text{Weight (Kg)}
\]

\[
X3 = \text{Height (cms)}
\]
X4 = Sleep Duration (Hours)
X5 = Sleep Quality
X6 = Cigarette Consumption (0 = No, 1 = Yes)
X7 = Caffeine Consumption (0 = No, 1 = Yes)
X8 = Shift (0 = Morning, 1 = Noon)
X9 = Change in PVT value
X10 = Change in VAS value
X11 = Change in KSS value
e = errors value

Change in PVT, VAS, and KSS value is the value of the change in the PVT, VAS, and KSS due to driving work activities. This data shows changes in the level of alertness, fatigue, and sleepiness of the driver after doing bus driving activities.

3. Results and discussion

3.1. Psychomotor Vigilance Task (PVT)
PVT measurements carried out in this study found that the average PVT value before working on the morning shift and afternoon shift was lower than after work. The minimum value for conditions in the morning before work is 168. The minimum value for conditions in the morning after work is 466. The minimum value for conditions in the afternoon before work is 174. The minimum value for conditions in the afternoon after work is 467. Meanwhile, the maximum values for the morning conditions before and after work are 427 and 833. The average PVT values in the afternoon before and after work are 351 and 721. The graph of the average PVT values is shown in Figure 2 below.

a. Normality Test

The normality test shown in Table 1 was obtained from the Shapiro-Wilk method. This method was chosen because the amount of research data was small, 30. Based on the test results, all the had a normal distribution.

Figure 2. The average of PVT value.
### Table 1. The normality test of PVT

| Category | Statistic  | df  | Sig.  | Criteria | Information |
|----------|------------|-----|-------|----------|-------------|
| PVT      | 0.899      | 18  | 0.055 | 0.05     | Normal      |
| In the morning before work | 0.925 | 18  | 0.161 | Normal |
| At noon before work | 0.885 | 12  | 0.102 | Normal |
| At noon after work | 0.895 | 12  | 0.138 | Normal |
b. Independent Sample T-Test

Independent Sample T-Test was conducted to determine whether there is a difference in the average driver’s attention between the morning and afternoon shifts. The hypotheses in this test are as follows:

| H₀     | the average condition of the attention of the morning shift and afternoon shift drivers is not significantly different |
|--------|---------------------------------------------------------------------------------------------------------------|
| H₁     | the average condition of the attention of the morning shift and afternoon shift drivers is significantly different |

The results obtained in the tests in Table 2 show that the probability value (sig 2-tailed) is 0.826. This value is > 0.05, so it can be said that H₀ is accepted. Based on the probability value, the conclusion is that the change in the driver’s attention while working for the two shifts is relatively the same or not significantly different.

3.2. Visual Analogue Scale (VAS)

Based on the test results, the average VAS value before working on the morning and afternoon shifts was lower than the VAS values after work. The draft of the average of the PVT values is shown in Figure 3 below. The average value indicates that the fatigue level of the morning and afternoon shift drivers has increased after work.

a. Normality Test

| H₀     | average condition of driver fatigue level morning shift and afternoon shift are not significantly different |
|--------|-------------------------------------------------------------------------------------------------------------|
| H₁     | average condition of driver fatigue level morning shift and afternoon shift are different significant |

The tests revealed that the VAS data before work followed a normal distribution. The VAS data after work followed an abnormal distribution.

3.3. Mann Whitney U test

The purpose of the Mann-Whitney U test is to determine whether there is a difference in average driver fatigue between the morning shift and the afternoon shift. The hypotheses proposed in this test are:

- The probability number > 0,05, then H₁ is accepted.
- The probability number ≤ 0,05, then H₀ is rejected.

It can be seen that in the asymptotic (2-tailed)/asymptotic column, the asymptotic significance for the two-tailed test is 0.633. Based on these criteria, the probability number for the driver’s fatigue level on the morning and afternoon shifts is 0.633. This value is > 0.05, indicating that H₀ is accepted. The conclusion is that the driver’s level of sleepiness for the morning shift and afternoon shift is not significantly different.
Table 2. PVT independent sample T-test results on morning and afternoon shifts

|                  | Levene’s Test for Equality of Variances | t-test for Equality of Means |
|------------------|-----------------------------------------|-----------------------------|
|                  | F            | Sig.           | t                | Sig. (2-tailed) |
| PVT Before work | Equal variances assumed                  | 2.576 | 0.120 | −0.222 | 0.826 |
|                  | Equal variances not assumed               |      |      | −0.255 | 0.801 |

Suhardi et al., Cogent Engineering (2022), 9:2143068
https://doi.org/10.1080/23311916.2022.2143068
3.4. Karolinska Sleepiness Scale (KSS)

Based on the measurement results, the average value of KSS before working on the morning and afternoon shifts is lower than after working. The average value shows that the level of sleepiness in driving for the morning and afternoon shifts has increased after work. The following is a graph of the average KSS value shown in Figure 4.

a. Normality Test

Based on the test results, it is known that the KKS data in the afternoon follow the abnormal distribution and other data follow the normal distribution.

| H₀      | average condition of the driver’s level of sleepiness during morning and afternoon shifts are not significantly different |
|---------|-------------------------------------------------------------------------------------------------------------------------------|
| H₁      | average condition of the driver’s level of sleepiness during morning and afternoon shifts are significantly different             |

Figure 3. The average of VAS value.

![Graph showing the average of VAS value](image)

Figure 4. Average of KSS value.

![Graph showing the average of KSS value](image)
### Table 3. VAS normality test

| Category                        | Statistic | df  | Sig.  | Criteria | Information |
|--------------------------------|-----------|-----|-------|----------|-------------|
| In the morning before work     | 0,802     | 18  | 0,002 | 0,05     | Normal      |
| In the morning after work      | 0,919     | 18  | 0,124 |          | Abnormal    |
| At noon before work            | 0,753     | 12  | 0,003 |          | Normal      |
| At noon after work             | 0,903     | 12  | 0,172 |          | Abnormal    |
3.5. Mann Whitney U test
The Mann-Whitney U test was conducted to determine whether there is a difference in the average level of driver sleepiness between the morning shift and the afternoon shift. The hypotheses in this test are:

Decision-making is carried out based on probability values. Therefore, the basis for making decisions is as follows:

The probability number > 0.05, then $H_0$ is accepted.

The probability number ≤ 0.05, then $H_1$ rejected.

It can be seen that in the asymptotic (2-tailed)/asymptotic column, the asymptotic significance for the two-tailed test is 0.397. Based on the probability value, the probability number for the drivers' sleepiness in the morning and afternoon shifts is 0.397. This value is > 0.05, which means that $H_0$ is accepted. Based on these results, it can be concluded that the increase in the sleepiness level of the morning and afternoon shift drivers is not significantly different.

3.6. Correlation test
Correlation test was conducted to determine the relationship between the dependent variable and the independent variable. In this correlation test, the variables tested include:

$Y = \text{Work Readiness or FFD (1 = FIT, 0 = Not FIT)}$

$X_1 = \text{Age (Years)}$

$X_2 = \text{Weight (Kgs)}$

$X_3 = \text{Height (cms)}$

$X_4 = \text{Sleep Duration (Hours)}$

$X_5 = \text{Sleep Quality}$

$X_6 = \text{Cigarette Consumption (0 = No, 1 = Yes)}$

$X_7 = \text{Caffeine Consumption (0 = No, 1 = Yes)}$

$X_8 = \text{Shift (0 = Morning, 1 = Noon)}$

$X_9 = \text{Change in PVT value}$

$X_{10} = \text{Change in VAS value}$

$X_{11} = \text{Change in KSS value}$
| Category                         | Shapiro-Wilk Statistic | df | Sig. | Criteria | Information |
|----------------------------------|------------------------|----|------|----------|-------------|
| KSS In the morning before work  | 0.614                  | 18 | 0.000| 0.05     | Normal      |
| KSS In the morning after work   | 0.856                  | 18 | 0.010|          | Normal      |
| KSS At noon before work         | 0.852                  | 12 | 0.039|          | Normal      |
| KSS At noon after work          | 0.960                  | 12 | 0.777|          | Abnormal    |
Table 6. Results of Mann Whitney U on the KSS test for morning shift and afternoon shift drivers

|                  | KSS Morning Shift—Afternoon Shift |
|------------------|----------------------------------|
| Z                | -0.847                           |
| Asymp. Sig. (2-tailed) | 0.397                           |

Here are the results of the correlation test shown in Table 1.

PVT changes, as well as changes in VAS with changes in KSS. The correlation test results found that the relationship between variables that had significant categories was the relationship between age and sleep duration, age with FFD, body weight with sleep quality, weight with shifts, height with changes in VAS, cigarette consumption with changes in PVT, caffeine consumption with PVT changes. The probability value of 0.05 can be significant if it is greater than or equal to the probability value of sig. SPSS results or (0.05 Sig.). The variable will be very significant if the probability value of 0.01 is greater than or equal to the probability value of sig. SPSS results or (0.01 Sig.). The relationship between variables that have a very significant category based on the tests carried out in this study is the relationship between shifts with sleep duration, shifts with sleep quality, bodyweight with changes in VAS, and changes in VAS and changes in KSS with FFD.

The conclusion indicates that the Psychomotor Vigilance Task (PVT) has no relationship with FFD, so it cannot evaluate the driver’s work readiness. On the other hand, Visual Analogue Scale (VAS) and Karolinska Sleepiness Scale (KSS) can be used to evaluate drivers’ job readiness based on their validity.

3.7. Logistics regression test

The data used for logistic regression testing is the driver’s fitness condition, age, weight, height, sleep duration, sleep quality, cigarette consumption, caffeine consumption, work shift, PVT value, VAS value, and KSS value. The dependent variable of the regression test, in this case, is the driver’s fit or not (FFD). Because the dependent variable is dichotomous (fit and unfit), the test is carried out using a binary logistic regression test.

The output produced in the logistic regression test is an equation model that can predict the driver’s job readiness as the dependent variable on the dependent variable. The model is identified as follows:

a. Coefficient of determination

The coefficient of determination is used to determine the variability of the dependent variable. The coefficient of determination in the logistic regression is shown by the Nagelkerke R Square value, which is presented in Table 8. The VAS normality test is shown in Table 3. The results of Mann Whitney U test VAS driver for morning shift and afternoon shift is shown in Table 4. The KKS normality test is shown in Table 5. The results of Mann Whitney U test KKS driver for morning shift and afternoon shift is shown in Table 6. The results of the correlation test are shown in Table 7.

The value of Nagelkerke R Square in this study is 0.680. This result means that the dependent variable that the independent variable can explain is 68.0%, while other variables outside the research model explain the remaining 32.0%.

b. Hosmer test and lemeshow

The Hosmer and Lemeshow test is used to determine the feasibility of a regression model generated as a whole. This test is also used to determine whether the empirical data fit the model.
|                  | Age    | Weight | Height | Sleep Duration | Sleep Quality | Cigarette Consumption | Caffeine Consumption | Shift | Change in PVT value | Change in VAS value | Change in KSS value | Fit     |
|------------------|--------|--------|--------|----------------|---------------|------------------------|----------------------|-------|---------------------|---------------------|---------------------|---------|
| Spearman's rho   |        |        |        |                |               |                        |                      |       |                     |                     |                     |         |
| Age              | 1,000  | 0,177  | 0,136  | 0,374*         | 0,002         | −0,049                 | 0,347                | −0,095| −0,100              | 0,186              | 0,120               | −0,441* |
| Weight           | 0,177  | 1,000  | 0,277  | −0,295         | −0,293        | 0,187                 | −3,90*               | 0,006 | −4,61*              | 0,385              | 0,131               |         |
| Height           | 0,136  | 0,277  | 1,000  | 0,093          | 0,307         | 0,017                 | 0,047                | 0,087 | 0,060               | −4,60*              | 0,234               | 0,004   |
| Sleep Duration   | 0,374* | −0,295 | 0,093  | 1,000          | −0,335        | 0,220                 | −0,032               | 0,480**| −0,204              | 0,107              | −0,134              | −0,199   |
| Sleep Quality    | 0,002  | −0,442*| 0,307  | −0,335         | 1,000         | −0,205               | −0,037               | −5,28**| 0,272               | −0,170             | −0,016              | 0,138   |
| Cigarette Consumption | −0,049 | −0,299 | 0,017  | 0,220          | −0,205        | 1,000                 | −0,126               | 0,289 | 0,368*              | 0,272              | −0,180              | −0,267   |
| Caffeine Consumption | 0,347  | 0,187  | 0,047  | −0,032         | −0,037        | −0,126                | 1,000                | 0,000 | −3,67*              | 0,281              | −0,016              | 0,067   |
| Shift            | −0,095 | −0,390*| 0,087  | 0,480**        | −5,28**       | 0,289                 | 0,000                | 1,000 | 0,039               | 0,089              | 0,157               | 0,031   |
| Change in PVT value | −0,100 | 0,006  | 0,050  | −0,204         | 0,272         | 3,68*                 | −3,67*               | 0,039 | 1,000               | 0,067              | −0,152              | −0,052   |
| Change in VAS value | 0,186  | −4,61* | 0,107  | −0,120         | −0,272        | −0,016                | −0,089               | 0,067 | 1,000               | −3,88*             | −0,388              | −0,571** |
| Change in KSS value | 0,120  | 0,185  | 0,234  | −0,134         | −0,016        | −0,180                | 0,281                | 0,157 | −0,152              | −3,88*             | 1,000               | 0,541** |
| Fit              | −0,441*| 0,131  | 0,004  | −0,199         | 0,138         | −0,267                | −0,067               | 0,031 | −0,052              | −5,71**            | 0,541**             | 1,000   |
Based on the Hosmer and Lemeshow test results in Table 9, the significance value (p) is 0.760. This result means that the significance value is close to 1. It can be concluded that the model can predict the value of the observation, or the model can be accepted because it matches the observation data (76.0%).

c. Classification Matrix

The classification matrix shows the predictive power of the regression model to predict the possible fit or not of the driver’s condition. The classification matrix is shown in Table 10.

The predictive power of the regression model aims to predict the possibility of a fit driver condition where the value found is 90.9% correct. These results indicate that 20 drivers (90.9%) are predicted to be fit conditions out of a total of 22 drivers who are declared FIT. The model’s predictive power on drivers who are not fit for work is 75% correct. In other words, with the regression model used, there will be as many as two drivers (75%) who are predicted to be in a fit condition. The conclusion obtained is that the predictive power or accuracy of the model in classifying the observations is 86.7%.

d. Logistic regression test results

The logistic regression model formed is shown in Table 11.

Based on the results of the logistic regression test from Table 10, the regression equation obtained is as follows:

\[ p = \frac{e^{FFD}}{1 + e^{FFD}} \]

where:

\[ FFD \]
Table 11. Regression test results

| Variable in The Question | B     |
|--------------------------|-------|
| Step 1^a                  |       |
| X1 Age                   | -0.674|
| X2 Weight                | 0.299 |
| X3 Height                | 0.133 |
| X4 Sleep Duration        | 0.320 |
| X5 Sleep Quality         | -1.699|
| X6 Cigarette Consumption | 5.695 |
| X7 Caffeine Consumption  | -1.735|
| X8 Shift                 | 2.048 |
| X9 PVT Value             | 0.023 |
| X10 VAS Value            | 1.300 |
| X11 KSS Value            | 3.338 |
| Constant                 | -13.991|

$$\text{FFD} = -13.991 - 0.674X_1 + 0.299X_2 + 0.133X_3 + 0.320X_4 - 1.699X_5 + 5.596X_6 - 1.735X_7$$
$$+ 2.048X_8 + 0.023X_9 + 1.300X_{10} + 3.338X_{11}$$

e = 2.71828182845904

4. Conclusion

The model produced in this study is quite good, where 90.9% of the drivers are declared fit where 86.7% of drivers correctly predicted. It means that the model's accuracy in classifying observations was 86.7%. The adjusted R Square value of the model is 68%. This value indicates that factors can explain the driver's fitness for duty in the model of 68%. The ability of the model to predict the value of the observation is 76% (high). VAS and KSS, in this case, are used to evaluate the work readiness of the driver, while PVT cannot be utilized when viewed from the validity point of view. Fatigue and sleepiness affect the driver's work readiness, while attention does not. Fatigue affects the level of sleepiness of the driver as the more tired a driver is, the higher the level of sleepiness felt will be. A shift has no significant effect on the level of attention, fatigue, and sleepiness. On the other hand, shifts can affect a driver’s sleep duration and quality.

Based on the results, this model can be used as a proposal to determine whether a driver is fit to work. However, this model should be more suitable for inter-city or provincial drivers because the route is too short, and congestion is generally high. So that the level of fatigue felt by the driver is also higher. That is different from the BST driver, where the fatigue experienced is only normal so that it does not have much impact on the accident rate and fitness. With the results of this study, it is hoped that it can predict the work readiness of drivers from various aspects. In addition, the study results are expected to predict when and how much the level of fatigue and sleepiness increases while working. This research can indicate that the driver is in sleepiness and fatigue, interfering with driving performance. Thus, the results of future testing can be used to determine the working time that the driver should do.

Funding
The authors received no direct funding for this research.

Author details
Bambang Suhardi^1
E-mail: bambangsuhardi@staff.uns.ac.id
ORCID ID: http://orcid.org/0000-0001-7700-3494
Anisa Rosyidasari^2
Rahmianyah Dwi Astuti^2
Iksan Adiast^2

^1 University Sebelas Maret.
^2 Universitas Sebelas Maret Fakultas Teknik.
^3 Universitas Teknologi Sumbawa.

Disclosure statement
No potential conflict of interest was reported by the author(s).

Citation information
Cite this article as: Fitness for duty prediction model for bus driver of batik solo trans based on physical, mental,
and work aspects, Bambang Suhardi, Anisa Rosyidasari, Rahmanyah Dwi Astuti & Iksan Adiasa, Cogent Engineering (2022), 9: 2143068.

References
Alhola, P., & Polo Kantola, P. (2007). Sleep deprivation: Impact on Cognitive Performance. Neuropsychiatric Disease and Treatment, 3(5), 553–567.
Anund, A., Fors, C., Ihström, J., & Kecklund, G. (2018). An on-road study of sleepiness in split shifts among city bus drivers. Accident Analysis & Prevention, 114, 71–76. https://doi.org/10.1016/j.aap.2017.05.005
Balkin, T. J., Horrey, W. J., Groeber, R. C., Zeisler, C. A., & Dingess, D. F. (2011). The challenges and opportunities of technological approaches to fatigue management. Accident Analysis & Prevention, 43(2), 565–572. https://doi.org/10.1016/j.aap.2009.12.006
Caragol, G. E., Tuokko, H., & Damin, A. (2009). Fit to drive: A pilot study to improve the physical fitness of older drivers. Activities, Adaptation & Aging, 33(4), 240–255. https://doi.org/10.1080/0192478090349080
Castor, M., Macleod, I., Hanson, E., Svensson, E., Nolhander, S., Blaye, P. L., & Hilburn, B. (2003) GARTEUR Handbook of mental workload measurement GARTEUR, Group for Aeronautical Research and Technology in Europe, Flight Mechanics Action Group FM AG13
Cedervall, Y., Torres, S., & Åberg, A. C. (2013). Maintaining well-being and selfhood through physical activity: Experiences of people with mild Alzheimer’s disease. Aging & mental health, 19(8), 679–688. https://doi.org/10.1080/13607863.2014.962004
Choi, M. K., & Seong, P. H. (2020). A methodology for evaluating human operator’s fitness for duty in nuclear power plants. Nuclear Engineering and Technology, 52(5), 984–994. https://doi.org/10.1007/jnet.2019.10.024
Chu, H. C. (2014). Assessing factors causing severe injuries in crashes of high-deck buses in long-distance driving on freeways. Accident Analysis & Prevention, 62, 130–136. https://doi.org/10.1016/j.aap.2013.09.016
Dagun, A. (2006). Save. kamus besar ilmu pengetahuan (save big dictionary of science). Jakarta: Lembaga Pengajian Kebudayaan Nusantara (LPKN).
Deng, T., & Nelson, J. D. (2011). Recent developments in bus rapid transit: A review of the literature. Transport Reviews, 31(1), 69–96. https://doi.org/10.1080/01441640.2011.544167.10.1080/01441640.2011.544167.1
Diez, J. J., Vigo, D. E., Lloret, S. P., Rigters, S., Role, N., Cardinalli, D. P., & Chada, D. P. (2011). Sleep habits, alertness, cortisol levels, and cardiac autonomic activity in short-distance bus drivers: Differences between morning and afternoon shifts. Journal of Occupational and Environmental Medicine, 53(7), 806–811. https://doi.org/10.1097/JOM.0b013e318221c6de
Dingus, T. A., Neale, V. L., Klauer, S. G., Petersen, A. D., & Carroll, J. R. (2006). The development of a naturalistic data collection system to perform critical incident analysis: An investigation of safety and fatigue issues in long-haul trucking. Accident Analysis & Prevention, 38(6), 1127–1136. https://doi.org/10.1016/j.aap.2006.05.001
Garbarino, S., Lino, N., Beelke, M., Carli, F. D., & Ferrillo, F. (2001). The contributing role of sleepiness in highway vehicle accidents. Sleep, 24(2), 201–206. https://doi.org/10.1093/sleep/24.2.201
Gnarra, C., Tzamalouka, G., Papadakaki, M., & Chloukotakis, J. E. (2008). An investigation of the effect of sleepiness, drowsy driving, and lifestyle on vehicle crashes. Transportation Research. Part F, Traffic Psychology and Behaviour, 11(4), 270–281. https://doi.org/10.1016/j.trf.2008.01.002
Herman, K. M., Craig, C. L., Gauvin, L., & Katzmarzyk, P. T. (2009). Tracking of obesity and physical activity from childhood to adulthood: The physical activity longitu-dual study. International Journal of Pediatric Obesity, 4(6), 281–288. https://doi.org/10.3109/17477160802596171
Hosmer, D. W., Jr, Lemeshow, S., & Sturdivant, R. X. (2013). Applied logistic regression (Vol. 398). John Wiley & Sons. https://doi.org/10.1002/9781118548387
Ingram, D. G., Marcicarille, A. M., Ehsan, Z., Perry, G. V., Schneider, T., & Al-Shawawa, B. (2019). Assessing readiness to drive in adolescents with narcolepsy: What are providers doing? Sleep and Breathing, 23(2), 611–617. https://doi.org/10.1007/s11325-019-01799-9
Irianto, J., & Djoja, S. (2016). Status kesehatan penge- mudi dan kelaikan bus menjelang mudik lebaran tahun 2015 (driver’s health status and bus worthi- ness ahead of the 2015 lebaran homecoming). Media Penelitian Dan Pengembangan Kesehatan, 26(3), 378–399.
Kaida, K., Takahashi, M., Akersstedt, T., Nakata, A., Otsuka, Y., Harotani, T., & Fukuwawo, K. (2006). Validation of the Karolinska sleepiness scale against performance and EEG variables. Clinical Neurophysiology, 117(7), 1574–1581. https://doi.org/10.1016/j.clinph.2006.05.011
Krisnanda, M. A., Hasiano, S. T., & Limyati, Y. (2020). Peningkatan fungsional atensi dan memori jangka pan- denk pada wanita dewasa muda dengan ansiestas setelah terapi mewarnai (attention and short-term memory improvement in young adult women with anxiety after coloring therapy). Journal of Medicine and Health, 21(5), 31–39. https://doi.org/10.28932/jmhp.v25.2030
Lee, K. A., Hicks, G., & Murcia, G. N. (1990). Validity and reliability of scale to assess fatigue. Psychiatry Research, 36(3), 291–298. https://doi.org/10.1016/0165-1781(90)90027-m
Mohajan, K., Velago, N. R., Kumar, A., Choudhary, A., & Choudhary, P. (2019). Effects of driver work-rest pat- terns, lifestyle and payment incentives on long-haul truck driver sleepiness. Transportation Research. Part F, Traffic Psychology and Behaviour, 60, 366–382. https://doi.org/10.1016/j.trf.2018.10.028
Menard, S. (2000). Coefficients of determination for multiple logistic regression analysis. The American Statistician, 54(1), 17–24. https://doi.org/10.2307/2685605
Onowhokpor, A. O., Aikorogie, O. L., Esene, H., Efegoma, Y. C., & Okieje, O. H. (2018). Fitness to drive among commercial intercity drivers in Benin-City, Edo State. Journal of Community Medicine and Primary Health Care, 30(1), 77–85.
Owlesy, C., McGwin, G., Jr Phillips, J. M., McNeal, S. F., & Stalvey, B. T. (2004). Impact of an educational pro- gram on the safety of high-risk, visually impaired, older drivers. American Journal of Preventive Medicine, 26(3), 222–229. https://doi.org/10.1016/j.amepre.2003.12.005
Purwanto, E., Hidayat, H., & Pranoto, E. (2018). Tingkat kelelahan (fatigue) pada pengemudi Bus Rapid Transit (BRT) trans semarang dan trans jateng (Fatigue level drivers for bus rapid transit (Brt) trans semarang and trans jateng). Jurnal Keselamatan Transportasi Jalan (Indonesian Journal of Road Safety), 5(2), 53–64. https://doi.org/10.46444/ktj.v5i2.49
Smith, A., McDonald, A. D., & Sasangohar, F. (2020). Night-shift nurses and drowsy driving: A qualitative study. International Journal of Nursing Studies, 112, 103600. https://doi.org/10.1016/j.ijnurstu.2020.103600

Soehodho, S. (2017). Public transportation development and traffic accident prevention in Indonesia. IATSS Research, 40(2), 76–80. https://doi.org/10.1016/j.iatssr.2016.05.001

STCW (1995). Standards of training, certification, and watchkeeping for seafarers 1978, as amended in 1995 and 1997 (STCW convention). London: Albert Embankment.

Tan, Y. Y., Lin, S. T., & Tey, F. (2013, July). Development of fatigue-associated measurement to determine fitness for duty and monitor driving performance. In International Conference on Augmented Cognition (pp. 608–617). Springer, Berlin, Heidelberg.

Torres-Harding, S., & Jason, L. A. (2003). Fatigue as a window to the brain. Chapter: What is fatigue? History and epidemiology. MIT Press

Editors: J. DeLuca.

Unsworth, C. A., Baker, A., Lannin, N., Harries, P., Strahan, J., & Browne, M. (2019). Predicting fitness-to-drive following stroke using the occupational therapy-driver off-road assessment battery. Disability and Rehabilitation, 41(15), 1797–1802. https://doi.org/10.1080/09638288.2018.1445784

Wang, H., Mo, X., Wang, Y., Liu, R., Qiu, P., & Dai, J. (2016). Assessing Chinese coach drivers’ fitness to drive: The development of a toolkit based on cognition measurements. Accident Analysis & Prevention, 95, 395–404. https://doi.org/10.1016/j.aap.2015.09.019

Yasobant, S., Chandran, M., & Reddy, E. M. (2015). Are bus drivers at an increased risk for developing musculoskeletal disorders. An Ergonomic Risk Assessment Study. J Ergonom, 2015. https://doi.org/10.4172/2165-7556.S3-011

Zoer, I., Sluiter, J. K., & Frings-Dresen, M. H. W. (2014). Psychological work characteristics, psychological workload and associated psychological and cognitive requirements of train drivers. Ergonomics, 57(10), 1473–1487. https://doi.org/10.1080/00140139.2014.938130

© 2022 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:
Share — copy and redistribute the material in any medium or format.
Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:
Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
No additional restrictions
You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Cogent Engineering (ISSN: 2331-1916) is published by Cogent OA, part of Taylor & Francis Group.
Publishing with Cogent OA ensures:
• Immediate, universal access to your article on publication
• High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
• Download and citation statistics for your article
• Rapid online publication
• Input from, and dialog with, expert editors and editorial boards
• Retention of full copyright of your article
• Guaranteed legacy preservation of your article
• Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com