Research on BRT Driver Jakarta Fatigue Evaluation

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Abstract—Driving in Jakarta as capital of Indonesia can be very exhausting due to high traffic density. The burden of public vehicle drivers such bus driver is heavier, since they are dealing with the traffic during their work. Nowday, Bus Rapid Transport (BRT) becomes one of highly demanded transportation system for Jakartans and worker from urban area. In this background, research on fatigue from driving addressing BRT’s driver becomes a critical issue in ensuring safe operation. In this study a workload evaluation, sleepiness, motivation level, self-rated fatigue and salivary amylase test was established to evaluate fatigue level of BRT driver from 2 different shifts (45 participants). Data collected directly during BRT’s driver was on duty, before and after their services. Based on anova analysis, it reveals that different shift could affect fatigue levels (p<0.05) based on SOFI result, although workload each shift is similar. The study also show that 27% more driver are in stress condition before starting their task in morning-shift. Suprisingly, driver’s motivation level among shift is not differ. As a conclusion, early shift had a larger influence on stress and sleepiness level on BRT driver, a rotation schedule may help to overcome the problem.

Keywords— Driver fatigue, time-of-day, shift, stress

I. INTRODUCTION

Bus Rapid Transit (BRT)- Jakarta known as TransJakarta in Indonesia, has been available since 2004 which aims to improve the quality of transport services for Jakartans. There are 12 route services provided, and each route has different service route length, dedicated road space available to be passed through by BRT buses, different traffic and passanger density. Number of passengers it self keeps increasing for each route specifically when route pass through the Jakarta’s main roads. So this day, BRT become one of important affordable public transportation for Jakartans and other city near to Jakarta[1].

Working as a public transport driver such as BRT driver is very challenging sometimes. The driver has to deal with unbelievable traffic in a certain time, and at the same time they required to maintain its safety during the trip. An increasing traffic flow from urban areas in weekdays is one of contributor to the traffic density, in addition of traffic flow from the city. Higher traffic density could increase driver workload during weekdays. This study is focusing on the BRT driver condition, and how a workload affects to their fatigue level. Understanding about the BRT driver work condition is crucial to create a conducive working system for the drivers.

As an illustration, BRT drivers work schedule is available in two shifts. Drivers who work in morning shift has to wake up very early, while afternoon-shift driver has finished their duty after 9 pm and back home late. During their duty, morning-shift driver has to deal with a heavy traffic at 7-9 am and around lunch time, while afternoon shift usually has to face it after office hour at 4.30-7.00 pm and sometime until 9 pm. In addition, BRT driver have number of cycle route to fulfill, and when heavy traffic density occur, a driver has difficulty to achieve the target. This condition can induced the increasing of driver’s workload and can lead them to stressful situations.

It should be noted, drivers get additional workload when they distract or have secondary task such as phoning, talking to passanger, listening to the music, etc. The brain translates driving as main task and the secondary tasks or distractions as a stimulus that requires a specific response. Receiving stimulus and giving a response will use resources such as visual, auditory, cognitive and psychomotor resources (VACP).
VACP concept [2] divides information processing in human into four dimensions of the resource. This concept is later used by Bierbaum et al (1989) [3] to approximate the weight of a task based on the utilization of resources during task execution. Driver’s workload can be assessed from visual, auditory, cognitive and psychomotor resource utilization [4].

Driving job is categorized as multitasking job, and this kind of job needs extra resources utilization [5]. However, there is a limit of the total amount of resources and the amount that can be allocated to specific activities. This resource concept is closely related to workload, performance level, work attention, and safety. Work performance tends to decline when some resources are used simultaneously; this also influences the person’s ability to process information. Excess workload triggers an increasing work risk, induced slower performance [5], and affected worker fatigue level [6].

Model fatigue and safety relation mention task related factors as contributors to occupational fatigue [6]. Time-of-day and time- awake are also mention as fatigue’s influence factors. Sufficient time to recover (short break or sleep), will help overcome the problem, and conversely, rest deficiency inhibits the recovery and lead to impaired performance capabilities. Working condition faced by BRT drivers could lead to this rest deficiency especially for morning-shift driver who work in very early shift [7].

Morning shift pushes the driver to work while human biological clock is in sleeping period, and thus increase the urge to sleep [8] [9]. From fatigue point of view, sleepiness is one of fatigue indicators and it’s hard to be apart from the human circadian rhythm [8] [9] [10] [11] [12] [13]. Working hours not only can disrupt biological clock, but also influence work stress [14]. And work stress analysis suggested as one of indicator to investigate to complete fatigue evaluation [15][16][17][18].

The combination of an objective and a subjective measurement is also suggested in fatigue evaluation, and an practical objective measurement is available with technologies nowadays. Stress assessment, for example, can be evaluated through salivary amylase use a technology called Nipro Cocorometer [19]. Salivary amylase level on kU/L is used to determine when someone is in stress mode or not [19] [20].

This paper discusses of BRT driver fatigue evaluation. Current research on BRT drivers working condition measurement such as workload, stress level or work motivation aspect is very limited. Finding on this research can give new perspective on driving job fatigue. In this study BRT driver condition was analysis by comparing subjective fatigue level, workload, stress and motivation level between morning-shift and afternoon-shift driver.

II. METHOD

A. Participants

A total of forty five BRT drivers involved in the study, 37 male (age 26-51) and 8 female (age 37-44), 23 worked in the 1st shift and the rest is in the 2nd shift. They joined BRT at least a year ago up to 4 year. All participant have an experience as public transport driver at least 2 years before they joined BRT.

B. Data collection

This research is a naturalistic study, and data collected during BRT drivers on duty for both shift. Collection data started before drivers starting their job, it took place in the bus garage before bus head to first stop. Before data collected, driver was brief about the collection data process, and they signed inform consent. Salivary amylase each drivers who participate in the study took by researcher, and tested using cocorometer nipro. The result recorded along with driver’s personal data. Sleepiness level also asked, based on Karolinska Sleepiness Scale (KSS) that has been used in literatur [7][17].

Researcher observed and recorded all activities of driver since bus was started until the driver finishes their shift. After they finish their services, salivary amylase test carried out, and researcher help them to fill in motivation questionnaire consist of 24 question. After reallibility and validity test, questionnaire result for each driver categorized into high, good, sufficient, low and very low as indicating motivation level. Sleepiness level also asked, and recorded.

In the morning shift, data collection was conducted from 4.00 am and done at 01.30 pm. The afternoon shift started at 11.00 am and complete at 8.00 pm.

Observation on drivers’ work condition was conducted via direct observation on the drivers’ activities during duties and was noted manually based on predetermined activity list. The list was based on the concept developed by Yee et al (2006) [4]. Then, the proportion of resource utilization, i.e. visual, auditory, cognitive and psychomotor resources was determined. After
data was collected, frequency of each activity was multiplied with the proportion of resource utilization to obtain information of which resource is the most utilized and is the biggest burden for the driver.

Level fatigue of driver was also measured using a Swedish Occupational Fatigue Index (SOFI) [21]. SOFI is one of fatigue subjective measurement tools. SOFI has been used to assess perceived fatigue related to work [22] [23] and translated into several languages with good reliability and validity [24] [25]. SOFI questionnaire consist of 25 item tests (questions) which grouped in 5 dimensions as follows: (1) Physical Exertion/PE, (2) Physical Discomfort/PD, (3) Lack of Energy/LE (4) Lack of Motivation /LM, (5) Sleepiness/SL; as SOFI original proposed.

Salivary amylase test was conducted to determine whether the driver was in a good condition (non-stress) before and after duty [18][19], based on the saliva amylase level. Saliva is took using disposable tip and it test using Nipro Cocorometer. This research used > 60kU/L as the limit to determine driver on stress condition [19]. Assessment was conducted to find out whether there are fatigue differences experienced by driver shift 1 and shift 2

C. Analysis method

Fatigue condition data of BRT’s driver was analysed using two-way ANOVA to see whether the differences is exist between morning and afternoon task. On analysis of fatigue level that indicated by workload, two-way Anova was conducted to see whether workload of each resource is different. This analysis also was conducted to see whether workload morning-shift and afternoon-shift are different.

Stress level data is analysis using descriptive analysis to find out how many morning-shift driver in good condition compare to afternoon-shift driver, indicate by salivary amylase value < 60kU/L. The same analysis is conducted on motivation data among driver. In addition, one-way anova is also performed to find out whether the differences was exist.

III. RESULT

A. Workload and fatigue level

Driver’s workload assessed through estimation of resource utilization, it assess based on examination of activities carried out by driver during their duty. Each activity has different resources weight. For instance when a driver has to slow down the car, usage of psychomotor resources is higher than visual, cognitive, and auditory resources.

Examination of activities is refers to certain activities list and frequency of each activity is recorded. Total frequency of activities multiplied by weight of each resources usage to determine estimation of resource utilization.

Resource utilization for each shift analysis using two-way Anova to see whether there are differences between the shift. Analysis of the workload revealed a significant main effect of each resource (F3, 8) =8, 887, p value=0, 0063, and but not for the interaction and differences for each shift (p>0.05). This indicates that the workload of each resources is different significant, and as data showed, visual workload is the highest compare to other. Further more, analysis result revealed that workload for each resources in the morning-shift driver is similar with afternoon-shift driver.

The workload perceived differently by driver based on Swedish Occupational Fatigue Index (SOFI) result. Although driver perceived their job is not a fatigued, but increasing level of fatigue consisten for each 5 dimension after 8 hour services (see Fig. 2). Anova analysis showed significant difference fatigue level before and after driver services for both shift. This result can be conclude that although estimation of workload between shift is similar, starting working early is more fatigued perceived by drivers compare to working in the afternoon shift.
Sleepiness level assessment (KSS) has given similar results with SL in SOFI. KSS after duty is higher compared to before duty, and level of sleepiness on shift 1 is higher than shift 2.

B. Stress level

Salivary amylase level testing using nipro cocorometer is conducted to determine stress levels of drivers before and after their duty. Measurement is applied for both shifts. Salivary amylase level > 60kU/l is the limit to determine stress level. There are 87% of shift 1 drivers who categorized post-stress, whereas only 60% of shift 2 drivers fall into this category. We can conclude that working in early shifts tends to create higher stress compared to working in normal time.

The result of salivary amylase test after duty showed that the percentage of post-stress drivers does not differ much for each shift (54% for shift 1 and 60% for shift 2). However, we can say that the percentage before duty is higher compared to data after duty. This indicates that drivers feel relatively after finishing their job. The phenomenon doesn’t result in significant differences between shift 1 and shift 2. Analysis of variance (ANOVA) analysis shows that stress levels among morning-shift drivers and afternoon-shift drivers are similar statistically.

C. Motivation level

Measurements of work motivation were conducted using a 24-question questionnaire. Validity test shows that questions 1, 3, 7, and 19 must be omitted, and the level of instrument reliability of the 20-item test is 0.667, meaning that the reliability of this instrument is accepted or > 0.6. Work motivation level determined based on the total value answer of each respondent, and categorized into high, good, sufficient, low, and very low. Results of work motivation for morning-shift and afternoon-shift can be seen below:

<table>
<thead>
<tr>
<th>Work Motivation Level</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>87%</td>
</tr>
<tr>
<td>Good</td>
<td>21%</td>
</tr>
<tr>
<td>Sufficient</td>
<td>9%</td>
</tr>
<tr>
<td>Low</td>
<td>0%</td>
</tr>
<tr>
<td>Very Low</td>
<td>0%</td>
</tr>
</tbody>
</table>

A work motivation questionnaire result between drivers in shift 1 and 2 is analyzed to confirm the presence of differences. Using one-way ANOVA, test results of p value were >0.05, thus concluding that there is no difference in the work motivation level between drivers in shift 1 and 2. It can be concluded that work condition and workload do not influence the drivers’ work motivation. Other compounding factors such as work environment should be considered for further investigation.
IV. DISCUSSION

The aim of this study was to investigate a workload, sleepiness and motivation level, self-rated fatigue and stress level to evaluate fatigue level BRT’s driver from 3 services route and 2 different shifts. This study demonstrated that fatigue level of driver in both shifts increasing after 8 hours duty, although the increasing perceived very small. Based on workload analysis, resource utilization of visual is the highest among other 3 resources (psychomotor, cognitive and auditory) for both shifts. In driving job capability to give respond after visual stimulus given can give significant effect to safety.

Increasing fatigue level after the duty is consistent with an increasing of sleep and stress level after duty. This condition is experienced by 80% drivers after their services for both shifts. The literature also suggests that sleepiness and stress level measurement is largely used in fatigue assessment [6] [10].

Although salivary amylase showed that drivers who work early shift have higher stress levels, the result of motivation level for both shifts is not statistically different. It seems that workload, stress and sleepiness level doesn’t affect the driver’s motivation level.

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