A Comparative Analysis of Mental Workload between Train and Bus Drivers

Hartomo Soewardi [1] and *Perdana Suteja* Putra [1*]

[1] Industrial Engineering Department, Islamic University of Indonesia, Yogyakarta, Indonesia

Abstract. Human error is one of the crucial problems in land transport, sea transport, and air transport that inflicting some undesirable occurrence such as delay, cancellation, or accident. This incident causes inconvenience and apprehension for passengers. Hence, drivers should avoid some errors in driving by improving alertness and reducing the excessive workload. This study presents a comparative study about mental workload between train and bus drivers based on subjective and objective criteria. NASA-TLX method is used to measure subjective variables by distributing questionnaires. While the content of a drivers' Salivary α-amylase (SAA) is measured as an objective parameter before and after driving. 30 drivers are participated in this study who have experience for more than 3 years. Statistical analysis is conducted to test the hypothesis for a difference. The result of this study shows that bus drivers' SAA level is significantly higher (Asymp. Sig. 0.49) than train drivers for both before (91.99 kU/l) and after (83.19 kU/l) driving activity. Similarly, weighted workload subjectively of bus drivers' mental workload (1051) is higher than train drivers (1031) insignificantly (Asymp. Sig. 0.561).

1 Introduction

Human error is one of the causes of an accident in modes of transportation [1-5]. Risyapudin in [5], a traffic director of Polda Metro Jaya, stated that the main factor in an accident on land transportation such as bus, car, motorcycle, and a train is human error. This condition is an undesirable incident for all passengers because it can cause delay, cancellation, rescheduling, unclear information even accident particularly in public transportation such as bus and train [6].

The fact, accident level of train transportation is still in the high ratio [7]. Indonesian Ministry of Transportation stated that there are 42 accidents of train in 2010 (i.e. 3 crashing accidents, 25 fallen trains, 4 rolled trains, 6 floods and erosion cause, and 4 other reasons). In 2011, there are 33 accidents as if 1 crashing accidents, 23 fallen trains, 2 rolled trains, 1 floods and erosion cause, and 6 other reasons. While 33 accidents have occurred in 2012 i.e. 2 crashing accidents, 21 fallen trains, 2 rolled trains, 4 floods and erosion cause, and 2 other reasons. Most of the accidents take place in 2013 including 25 fallen trains, 1 rolled trains, 7 floods and erosion cause, 6 other reason. Moreover, [8] and [9] found that as much as 394 people have died that was caused by 23 bus accidents in 2012 and 14 bus accident in

* Corresponding author: perdanasuteja@gmail.com

2014. Refers to traffic corps of Indonesia's data, Bus accidents have happened in 2013 as many as 13 incidents. It brings out passengers into apprehend public transportation usage.

Based on the result of investigation by the transportation department of Indonesia in 2013 and also the result of study in 2002 found that some causes of these accidents are mostly a lack of concentration, a lack of anticipation, an internal condition by drivers, and the mileage of a public transportation [10-11]. Other studies identified that such causes of accidents were produced by the excessive mental and physical workload of drivers in driving [12-15]. These study conducted was based on the subjective considerations only. As for the objective consideration are still a few of study investigated. Thus, it is significant to investigate the mental workload of drivers with considering both subjective and objective criteria. The objective is to investigate the comparison of mental workload between train and bus drivers by using two criteria that are NASA-TLX and Salivary Alpha-Amylase.

2 Research Method

2.1 Subject

Thirty respondents were recruited for this study which consists of fifteen bus drivers and fifteen machinists. Their age is in range between 27 to 47 years old where all of them has no physic or mental health problem. Drivers and machinist worked for 8 hours/day in route of Yogyakarta-Jakarta and they have experience for more than three years respectively.

2.2 Apparatus

Cocorometer and disposable test strips by Nipro Inc. were used to measure salivary alpha-amylase (SAA) level. And a National Aeronautics and Space Administration-Task Load Index (NASA-TLX) questionnaire implemented to assess mental workload level subjectively. While IBM SPSS software version 21 and Microsoft Excel software to count up statistical data for analysis.

2.3 Procedures

2.3.1 Objective measurement
Disposable test strips inserted into the mouth (for 20 seconds under the tongue), and later were attached back into the instrument. It is assessed for before and after driving. After a few minutes, the display would read the value (in kU/l), with moderate and highly stressful conditions were indicated by a value of greater than 45 and 60 KU/l, respectively [16].

2.3.2 Subjective measurement
NASA-TLX assess six indicators influence on mental workload which is Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Effort (EF), Own Performance (OP) and Frustration Level (FR). Unlike the SAA measurement, the NASA-TLX was administered after a driver had just finished a trip by fulfilling pair-wise comparisons and rating scale from 0 (Low) to 100 (High), Unless OP is 100 (Low)to 0 (High).

2.4 Statistical Analysis

The statistical analysis used is non-parametric Wilcoxon Signed-Rank and Mann-Whitney U test. Wilcoxon Signed Rank in the significant level of 5% takes account to differentiate

the SAA level between before and after driving and 5% significant level of Mann-Whitney U test differentiate the SAA level and weighted workload between train and bus Drivers.

3 Result and Discussion

3.1 Objective Analysis

In prior to driving bus activity, the SAA result is 63.78-139.29 kU/l (mean: 91.99 kU/l; SD ± 30.25) which is classified in high stress. It produced by constrained time to complete preparation and bus check that leads to drivers' anxious on time departure [17]. Moreover, the high level also gained for after driving which is 83.19 kU/l (SD ± 15.96). It identified that 93.3% of respondents are in high stress that influenced by driving effects such as high focus, boredom, traffic jam and fatigue [18].

Moreover, the high SAA average also obtained by machinists (70.33 kU/l; SD±23.46). Mostly 53% of respondents are at high-stress level. A complex of standard operational procedures causes the drivers' apprehensive in missing stages that lead to human error, absenteeism, complaint, and sickness [18]. A large percentage of the drivers had fairly long commuting time (one to two hours) that could have introduced a source of stress since they had to deal with traffic jams and uncertainty [15]. Meanwhile, after driving stress of machinist classified at a high level which is 72.28 kU/l (SD±12.39). A total of 73.3% of respondents is at the high stress that produced by after driving impact such as boredom and high concentration, occurrence report and overview the next task. [15] stated that deal with many level train crossings, a large percentage of which were unguarded and illegal could create additional mental burden since the drivers had to watch the traffic and made difficult decision to cross safely. It was exacerbated by the fact that many houses and local activities were very close (often done on) the railway track.

In statistical analysis demonstrates insignificant difference on stress felt by bus drivers (Asymp. Sig. 0.256) as well as train drivers (Asymp. Sig. 0.733) between prior to driving and after driving activity as shown in Figure 1.

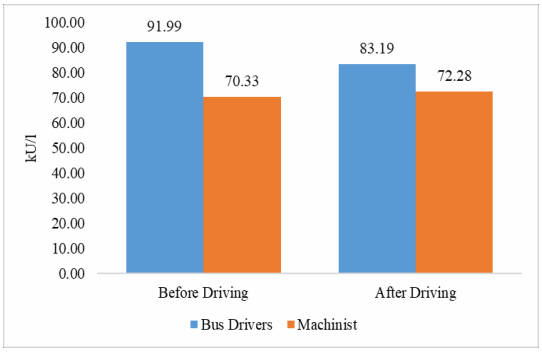

Fig. 1. Comparison of SAA Average between Before and After Driving.

When examined bus drivers individually, changes in SAA level demonstrates that mostly respondent (57%) are decreasing from before to after driving. This condition influenced by their satisfaction to usher passengers safely [19]. Besides, the change of salivary level from before to after driving found that 53% of respondents are rising. Generally, it affected by some after procedures that have to be finished in fatigue condition [20]. Then, drivers' anxious increased for missing procedures.

Thence, Figure 1 describes the SAA average of bus drivers (91.99 kU/l) is higher than machinists (70.33 kU/l) significantly (Asymp. Sig. is 0.049) in prior to driving activity. The

higher uncertainty and complexity is main factor influenced on this condition. Moreover, in after driving described SAA level of bus drivers (83.19 kU/l) is higher than machinists (72.28 kU/l) significantly (Asymp. Sig. is 0.049). It mostly affected that bus driving activity needs more focus, boredom, concentration and uncertainty traffic jam.

3.2 Subjective Analysis

In deeper analysis, subjective assessment of bus drivers evinces temporal demand gains the highest level (203.933) whereupon followed by mental demand which is 199.87. Then, physical demand, effort and frustration product is 192.733, 185.133, and 185.1 respectively. Lastly, the lowest product is performance indicator which is 83.13. Hence, total WWL obtained is 1051. Furthermore, the frustration level is the most dominant indicator of subjective criteria which is 211.067. Secondly, temporal demand (203.9) and effort (182.3) indicator dominates the result of stress assessment. It is followed by mental demand, physical demand and performance indicator whereas the product is 182.3, 179, and 77 respectively.

Bus drivers commonly worked overtime since the job rotation is changed based on their own will that leads to the lack of resting time and produce human error [20]. Unpredicted complexity (e.g. traffic jam, trouble machine) also leads the pressure in time management [22-23]. Drivers need to estimate a traffic jam, distance, fuel, and budget. Hence, improvisation, thinking and deciding to solve the problem are needed by drivers [24]. [25] and [18] has supported that drivers need to focus to operate the vehicle and concentrate on the road such as a sign, lamp, announcement, etc. In addition, the brake is not lightly handled and traffic jam rises fatigue and physical demand [14, 18, 23]. Additionally, drivers' frustration originates from feelings of uncertainty which stems from a sense of inability to fulfill the need. [26] has explained when these needs are constantly ignored or unsatisfied, anger, depression, loss of self-confidence, annoyance, and sometimes violence in relation to the partner, passengers, manager, etc. However, Management has offered assurance for drivers and bus to decrease an insecure condition. Lastly, performance is the lowest indicator due to the perspective that tasks as a responsibility that leads to the stable satisfaction on work performance [27-28]. Moreover, [29] stated compensation, reward, and facilities provided would improve drivers' satisfaction.

On the other result, machinist often disguises occurrence such as driving for more than a certain speed and did not take a regular break induce anxious for work communication among workers thereupon increase frustration level indicator [11]. Meanwhile, the time pressure is influenced by the arrival on time schedule but drivers are not allowed to drive for more than a certain speed in uncertainty condition. They also need to carry out 21 slogans, point and mention it. Moreover, the daily routine such as dynamic braking (every 30 m) and locomotive examination (if stops more than 5 m) have to be remembered by drivers cause mental and physical demand. It is relevant to study conducted by [19] and [30] in mental workload influence. Lastly, performance indicator is the lowest level since the management implement bonus, reward and facilitate them satisfactorily [29].

Furthermore, subjective assessment asserts that weighted-workload of bus drivers is higher than machinist insignificantly (Asym. Sig. is 0.561) as described in Figure 2. In indicator analysis, bus drivers dominate on temporal demand (199.87), physical demand (192.73), temporal demand (203.93), own performance (186.3), and effort (83.13) rather than machinists' product. Moreover, the machinist has higher product once on frustration level (211.067) as described in Figure 3.

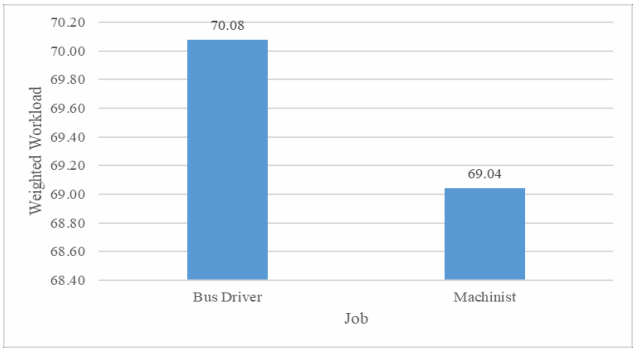

Fig. 2. Comparison of Weighted-workload between Bus Drivers and Machinists.

As explained that bus drivers involve higher uncertainty, complexity, focus, time management skills, mentally and physically effort, and unsatisfactorily work performance. Meanwhile, machinists involve higher frustration to disguise occurrence that produces high level of frustration and inconvenience in communication both drivers and management.

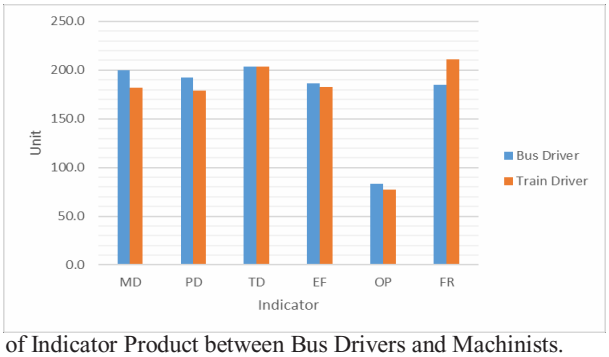

Fig. 3. Comparison of Indicator Product between Bus Drivers and Machinists.

Hence, the result and analysis evince that bus drivers' mental workload is higher than machinist in both objective criteria and subjective criteria. Nonetheless, it significantly differences in salivary-alpha amylase and insignificant difference in weighted-workload result. It happened due to the higher mentally factors felt by bus drivers.

4 Conclusion

It concluded as follow:

1. Based on the objective analysis (Salivary alpha-amylase level), bus drivers and machinist have high stress before and after driving. They are 91.99 kU/l and 83.19 kU/l for before and after driving of bus drivers. Meanwhile, machinists' mental workload is 70.33 kU/l and 72.28 kU/l in prior to and after driving activity.
2. On the subjective analysis, bus drivers have average weighted-workload in 70.08 level while machinists have 69.04 level of weighted-workload mean.
3. The result evinces on both objective and subjective parameters; it is valid that bus drivers have higher mental workload than the machinist at 5% significance level.

References

1. A. Smiley, K.A.Brookhuis, *Road Users and Traffic Safety*. 83–105(1987)
2. P. C Cacciabue, Gui.App.Hum.Fac.Meth, **1**(2004)
3. D. Woods, Dekker,R.I.Cook,L.Johannesen,N.B.Sarter, *Behind human error,* (2010).
4. A. Noroozi,N.Khakzad,F.Khan,S.Mackinnon,R.Abbassi,Rel.Eng.Sys.Saf **119**, (2013)
5. G. Lazuardi,Hum.Err.Fak.Dom.Pen.Kec.Lal.Lin, (2015)
6. J.A. Michon, Hum.Beh.and.Traf.Saf 485–520, (1985)
7. Biro Komunikasi dan Informasi Publik, Dal.Lim.Tah.Ter.Kes.Per.Men, (2014)
8. E.S. Budi, Lag.Kec.Bus, *Kompasiana*, (2012)
9. E. Rusyanto, Cat.Dar.Kec.Bus.Mem, (2014)
10. Dirjen Perhubungan Darat, Pet.Tek.Pem.Aw.Ken.Um.Tel.Ting.Nas.Th.2013, (2013)
11. G. Matthews, *Issues in Ergonomics Science*, 195 (2002)
12. K. Brookhuis, D. Waard, *Virtual Reality*, 191–205 (2003)
13. Tarwaka, S.H. Bakri, Sudiajeng, *Ergonomi Untuk Keselamatan, Kesehatan Kerja dan Produktivitas,* (2004)
14. E.T. Solovey, Zec, Garcia, Reimer, Mehler, Cla.dri.wo.usg.phy.dri.perf.d**, 4057** (2014)
15. C.H. Moerti, Iridiastadi, Sutalaksana, *International Journal of Science and Research (IJSR)*, 2014–2017 (2016)
16. M. Yamaguchi, Kanemori, Kanemaru, Takai, Mizuno, Yoshida, *Biosensors and Bioelectronics*, 491–497 (2004)
17. M. A. J. Kompier, Martino, Rev.bu.dri.occ.st.st.pre, 253–262 (1995)
18. M. A. J. Kompier, *Bus drivers: Occupational stress and stress prevention*, (1996)
19. S.G.Hart,L.E.Staveland, Dev.NAS.Res.Emp.The.Res, 139–183 (1988)
20. R.Schlegel, *Automotive Ergonomics*, 359–382 (1989)
21. J.L.M. Tse, R.Flin, K.Mearns, Bu.dr.wel.rev.50.y.res, (2006)
22. H. Soewardi, E.B.Wibowo, An.Men.Wor.Pub.Bus.Dri, 335–339 (2014)
23. V. Faure, R. Lobjois, Benguigui, *Traffic Psychology and Behaviour*, **40**, 78–90 (2016)
24. J.Paxion, E.Galy, C.Berthelon, Men.wor.driving. *Frontiers in Psychology*,**5,** 1–11 (2014)
25. T.Heine, Lenis, Reichensperger, Beran, Doessel, Deml, *Applied Ergonomics*, **61**, 31(2017)
26. A. De Botton, The consolations of philosophy, (2000)
27. M.S.P.Hasibuan, *Manajemen sumber daya manusia*, (2005)
28. S.Martoyo, *Manajemen sumber daya manusia (5th ed.)*, (2000)
29. A.Kinicki, Kreitner, *Organizational Behavior: Keyconceptsskillsandbest Practice*, (2008)
30. S.G.Hill, Lavecchia, Byers, Bittner, Zaklad, Christ, *Human Factors*, **34**, 429–439. (1992)