Impact on Driver Behavior, Performance, Fatigue, Over Speed and Infrastructure as A Factor of Road Accident: A Review

W Suprihatiningsih¹,², A.M Leman¹, D Feriyanto², H Pranoto² and Norshah Afizi Shuaib

¹Occupational Safety, Health and Working Environment (OSH-WE) Research Group, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM), Pagoh Higher Education Hub, KM 1 84600, Muar, Johor, Malaysia
²Faculty of Mechanical Engineering, University Mercu Buana, Jakarta, Indonesia
³School of Manufacturing Engineering, Universiti Malaysia Perlis (UniMAP), Kampus Tetap Ulu Pauh, Jalan Arau-Changlun, 02600 Arau, Perlis, Malaysia.
⁴Green Design and Manufacture Research Group, Center of Excellence Geopolymer and Green Technology (CEGeoGTech), Universiti Malaysia Perlis, 01000 Kangar, Perlis, Malaysia.

E-mail: wiwit.suprihatiningsih@mercubuana.ac.id

Abstract. Road safety is become an interesting field to be investigated due to high road accident that still occurred in the world and it increased every year. Second highest accident rate in the world signed by South-east Asia with 20.7 per 100.000 population. That rate include the road accident that occurred in Indonesia. There are several parameters in road accident such as infrastructure, driver behaviour, environment, driver performance, driver fatigue, over speed, vehicle and safety device. Therefore, this study approach a model to interconnect the variables in order to achieve a pattern of road accident factors. This study believe will be improve the awareness of the related agency to increase their responsibility in improving and applying road safety. Moreover, this study output will be comprehensive discuss and critical discussion in terms of road safety plan that may applied in order to reduce the road accident.

1. Introduction
Road safety is become an interesting field to be investigated due to high road accident that still occurred in the world and it increased every year. Second highest accident rate in the world signed by South-east Asia with 20.7 per 100.000 population. That rate include the road accident that occurred in Indonesia. There are several parameters in road accident such as infrastructure, driver behaviour, environment, driver performance, driver fatigue, over speed, vehicle and safety device. Therefore, this study approach a model to interconnect the variables in order to achieve a pattern of road accident factors. This study believe will be improve the awareness of the related agency to increase their responsibility in improving and applying road safety. Moreover, this study output will be comprehensive discuss and critical discussion in terms of road safety plan that may applied in order to reduce road accident. Figure 1 show the population, road traffics deaths, and registered motor vehicle by the country.

The accident rate in South-East Asia that dominated by developing country like Indonesia that show the road accident that consists of pedestrian, motorcyclist, passenger car, bus and truck. In 2019 there were 107.500 cases, which increased 3% as compared to road accident in 2018. However, the road traffic
death in 2019 was decreased for 6% as compared to road traffic death in 2018 for 23,530 road fatalities. The road fatalities majority caused by three main factors which are human factor for 61%, environment and infrastructure factor for 30% as well as vehicle factor for 9% [2].

Figure 1. Proportion of population, road traffic deaths, and registered motor vehicles by country 2016 [1]

There are several factors that influence on road accident such as driver behaviour, driver performance, driver fatigue, infrastructure, environment and over speed. Figure 2 show the Rates of road traffic death per 100,000 population by WHO regions: 2013, 2016 [1].

Figure 2. Rates of road traffic death per 100,000 population by WHO regions: 2013, 2016 [1].
2. Review on Factor of Road Accident

2.1. Driver Behaviour
Driving behaviour was consists of errors and violations as shown in table 1. Errors means that the driver unable to achieve their intended consequences that divided into three major categories which are slips, mistakes and lapses. Meanwhile violation is more complex than errors due to involved the operating procedure, codes, norm and rules [3]. Driver behaviour can be a significant factor to control the road accident [4]. The driver behaviour was influenced by several factors such as vehicle, environment factor, demographic characteristic and roadway-related features [5]. In case of truck and bus driver manly caused by driver distraction that included on the driver task that action the activity exclude a driving task such as interaction with passenger, non-driving related device such as ticket machine, radio headset and radio [6], location, traffic sign, driver age, gender, and experience [7, 8].

| Driver behaviour | Influenced Factor                                                                 | Reference |
|------------------|-----------------------------------------------------------------------------------|-----------|
| Errors           | Vehicle, slips, mistakes, lapses, location, traffic sign, driver age, gender, experience, environment factor, demographic characteristic and roadway-related features | [3, 5, 7, 8] |
| Violation        | Operating procedure, codes, norm, rules, interaction with passenger and non-driving related device | [3, 6] |

2.2. Driving performance
Driving performance was influenced by several factors such as ages [9], roadside advertisements [10], weather condition such as fog, rain, snow, ground blizzards, slush, and strong winds [11] and driver fatigue that caused by driving distance, temperature, an ergonomic seat etc [12]. Regarding to age factor, the previous study shows that crash rates were highest for drivers between the age of 16-17, decreased until ages 60-69 but increased after age of 70 [13]. According to [14] that drivers 65 years and older were slowest to change lanes in a lane changing task, followed by first year drivers under 25 years.

There are several indicator of good driving performances which are speed consistency, maximum deceleration and low lane deviation [15]. That performance will be achieved by eliminating driver distraction from external parameters such as reaction time on other vehicle or roadside sign, acceleration, driver focus, steering reversal rate (SRR), headway, standard deviation of lane positioning (SDLP) and situation awareness [16]. That parameters will be effect on the driver by different visual and cognitive distraction. Driving distraction also effected by age and driving experience. According to [17] younger drivers are found to be more inclined (than older drivers) to engage in phone tasks during driving, their performance is found to be less affected by the phone use.

2.3. Driver fatigue and over speed related road accident
Road accident mainly caused by driver fatigue and over speed based on [18] mention that Driver fatigue and over speed contribute to the 32% and 15% of road accident, respectively. In order to reduce the number of crashes caused by fatigued driving, active safety systems that monitor driver states have been developed to provide driver alerts and/or control intervention [19]. The existing fatigue monitoring system was provided the alarm when the driver close to fatigue condition in real time and that condition not adequate in the system. Fatigue will be effected on driving performance and low reaction time of driver. drivers often perform non-driving related tasks or even doze off when they over-rely on automation that effect to the takeover performance due to delayed takeover reaction time [20]. Therefore, it is very important to develop a system that can detect the driver condition in real time either fatigue, close fatigue or not.
In addition, driver fatigue and over speed may influence by various factors such as travel time, driver achievement, weather condition, driving behaviour or driving attitude and physiological factor. In previous study that conducted by [21] that they develop fatigue detector by several parameters such as mouth aspect ratio, temperature, heart rate, eye aspect ratio and integrated with speed limiter with fuel cut off system. The speed limit has been regulated by The Ministry of Transportation in Indonesia in order to reduce the number of traffic accidents. Therefore, the ministry has issued the regulation of speed limit for commercial buses based on area which consists of maximum speed of 100 km/h in highway, 80 km/h in urban area, 50 km/h in centre of urban area, and 30 km/h in the residential area [22].

2.4. Infrastructure effected to road accident

One of the most critical factors that effecting to the road accident is road infrastructure and environment such as geometrical design, lighting, road type, road quality, weather conditions and traffic control [23]. The 10 infrastructure elements that are included are as Exposure (e.g. traffic flow, traffic composition), Road surface, Road environment (e.g. weather, lighting), Road type, Alignment – road segments, Traffic control – road segments, Presence of work zones, Cross-section - road segments, Traffic control – junctions and Alignment – junctions.

Environment refers to human-road interaction such as road infrastructure, traffic sign, traffic light and any circumstance that affected the driving condition, described in the percentage of accident occurrences consisting of accident type same direction, pedestrian, fixed object, direction and hit animal and than risk factor consist of three things that are very important in reducing the potential for accident on the road human, environment, vehicle, some factors are considered very important to be agreed in every ride made by a driver. Contribution of environment factor to the road traffic accident is listed in table 2.

| Accident type          | Human | Environment | Vehicle | Statistically significant relationships                                                                 |
|------------------------|-------|-------------|---------|--------------------------------------------------------------------------------------------------------|
| Sideswipe: same direction | 75    | 20          | 5       | Negligence, dangerous overtaking, sight distance, faulty indicators, cars                                |
| Pedestrian             | 75    | 25          | 0       | Driving on the shoulder of the road, pedestrian visibility, speed, alcohol, pedestrian facilities, cars |
| Fixed object           | 80    | 15          | 5       | Negligence, losing control, speed, alcohol, fatigue, road signs, steering, brakes, cars                 |
| Sideswipe: opposite direction | 90    | 10          | 0       | Dangerous overtaking, speed, males, sight distance                                                     |
| Hit animal             | 10    | 90          | 0       | Speed, fencing, lighting                                                                              |

Today, roads are undoubtedly safer than a few decades ago, and road transport performance has improved considerably. Majority of the fatalities occur in accidents outside built-up areas, whereas motorways appear to be the safest [25]. Major highways, including motorways and freeways, are designed for safer high-speed operation and generally have lower levels of injury per vehicle km than other roads, highways that require high security to the user, so some signs and some lighting to provide the effect of driving safety at night becomes very important. Motorways are the safest road environment for fast-moving traffic and, except for measures to ease congestion such as ramp metering and variable speed limits, they are not usually subject to additional infrastructure measures for speed management purposes [26].
By contrast, in most industrialised countries, rural roads carry the greatest risk of fatalities and injury. Drivers running off the road and colliding with roadside objects in single-vehicle accidents are a major problem in the rural network in many countries, infrastructure of the highway becomes the main polemic in the level of risk of accidents on the highway, this is in the presence of some things that is not understand the driver on the road being passed, thus increasing the speed can not be used in anticipation faster and also because it causes other. It is expensive and impractical to apply infrastructure-based speed management measures to the entire network to prevent these accidents [27]. However, local improvements to rural roads can be made by removing roadside obstacles such as trees, utility and sign poles, to make the road safer and more forgiving in the most dangerous locations. A highly effective solution for rural roads – which requires long-term planning would be to separate traffic travelling in opposite directions, using for example, median barriers. Some countries, such as Sweden, are progressively improving their highest risk rural roads to this standard. However, it is evident that for most countries, resource constraints prevent this measure being carried out on a large scale [28].

3. Road Safety Model and Approached Model

Road safety model were developed in order to simulate the road safety application with closed-real time condition in order to reduce the road accident when the system is applied. There are various technique to develop a model such as by mathematical model [29] such as Generalised Linear Model (GLM) using a Poisson or a Negative Binomial Distribution [30], multilevel modelling, macroscopic model for speed limit by using system dynamics of METANET model that expresses the conservation of vehicles while the second equation expresses the mean speed as a sum of the previous mean speed, a relaxation term, a convection term, and an anticipation term [31]. According to [8] given the number of components and causal mechanisms theoretically described in the TCI model, a systematic classification scheme (SCS) was developed to guide and assist in synthesising the available literature as shown in figure 3.

![Figure 3. Task capability interface model [8]](attachment:image)
The system approach will be correlate with several variables of road safety in terms of vehicle, infrastructure, driver behaviour, driver performance and safety device that installed in the vehicle. This approach model as in figure 4 was developed to investigate the effect of that variable on road accident. This model will be investigated by the survey and questionnaire analysis that involve the transportation company and it will levelled by likert scale. This model believe will be achieved a better knowledge in terms of road accident factor and relation between variables that contribute to the road accident that occurred every time. This model achievement will be recommend to related agency to apply this result in order to reduce the road accident and road fatalities.

Figure 4. Approached road accident model

4. Conclusion
Road accident was influenced by several factors such as driver behaviour, driver performance, infrastructure, environment, driver fatigue, over speed, vehicle and safety device. However, the connection of each factors is become an interesting area to be investigated and it cannot separate each other. This study with approach model will be obtained the critical factor that influence to the road accident in order to take an action to solve or minimize the issues.

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References
[1] World Health Organizations (WHO) 2018 2018 Global status report on road safety (Geneva: WHO)
[2] Ministry of Communication and Information Technology Republic of Indonesia
[3] Huey-Kuo C, Huey-Wen C, Jin-wei S and Fur-Hsing W 2019 Transport. Res. A-Pol. 130 118-133
[4] Singh S 2015 Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey Traffic Safety Facts Crash Stats. Report No. DOTHS812115 (Washington DC: National Highway Traffic Safety Administration)

[5] Salar S G, Mansour H H and Alireza J A 2018 Saf. Sci. 110 142-151

[6] D’Souza K A, Siegfeltd D V and Hollinshead A 2013 Manag. Prod. Eng. Rev. 4 10–19

[7] Young K L, Regan M A and Lee J D 2008 Factors Moderating the Impact of Distraction on Driving Performance and Safety Driver Distraction: Theory, Effects, and Mitigation vol 1, ed Regan M A, Lee J D and Young K L (Florida: CRC Press) p 335

[8] Oviedo-trespalacios O, Verity T, Watson B and Hinton J A 2019 Transport. Res. A-Pol. 122 85-98

[9] Mehmert B, Eren E, Ren M, Thobias S, Walter B, Abdelrazig Y and John O 2019 J. Traffic Transp. Eng. 6 455-469

[10] Walker H E K and Trick L M 2019 Saf. Sci. 115 121-130

[11] Anik D, Ghasemzadeh A and Mohamed A 2019 J. Safety Res. 68 71-80

[12] Young-ching L and Tsun-ju W 2009 Saf. Sci. 47 1083-89

[13] Tefft B C 2012 Motor Vehicle Crashes, Injuries, and Deaths in Relation to Driver Age: United States, 1995-2010 Project Summary Report (Washington DC: AAA Foundation for Traffic Safety)

[14] Edquist J, Horberry T, Hosking S and Johnston I 2011 Appl. Ergon. 42 619-626

[15] Maryam Z, Patricia M, Mei, Y, Yulin D, Carl P, Joseph H R, Kaber W and David B 2017 Appl. Ergon. 65 70-80

[16] Choudhary, Pushpa and Velaga, Nagendra R 2019 Saf. Sci. 111 179-187

[17] Oviedo-Trespalacios O, Haque M, King M and Washington S 2016 Transp. Res. Part C Emerg. Technol 72 360–380

[18] National General Safety Plan (RUNK) 2011-2022 Republic Indonesia. (Constitution No : 22, Pasal 203 Republic Indonesia, 2010

[19] Feng Z, Areen A, Mike B, Reates C, Swaminathan R, Dev K, Walter T, Tijerina L and Baying L 2020 Driver fatigue transition prediction in highly automated driving using physiological features Expert Sys. Appl. 147 113204

[20] Neubauer C, Matthews G and Saxby D 2014 Proc. Hum. Factors Ergon. Soc. Annu. Meet. 58 2053–57

[21] Pranoto H, Leman A M, Sebayang D and Feriyanto D 2016 MATEC Web Conf. 78 01053

[22] Ministry of Transportation, Republic of Indonesia 2015 Procedures for Determining Vehicle Speed Limit PP No. 111 (Jakarta)

[23] Eleonora P, Ashleigh F, Athanasios T, Apostolos Z, Claire Q and George Y 2019 Accid. Anal. Prev. 125 85-97

[24] S. Hwanga and S. Lee 2017 J. Constr. Eng. M. ASCE 83 330-340

[25] Abdullah D M N A and Von H L 2011 Int. Conf. on Innovation, Management and Service IPEDR vol 14 (Singapore: IACSIT Press)

[26] Meng F, Li S, Cao L, Peng Q, Li M and Wang C 2016 Appl. Ergon. 53 122-130

[27] Meng F, Li S, Cao L, Li M, Peng Q, Wang C and Zhang W 2015 Traffic Inj. Prev. 16 474-483

[28] Hussein M, Salman M C K, Baharin K, Supriyo B and Ariyono S 2010 Proc. of the World Congress on Engineering vol 2 (London)

[29] Pathivada B K and Perumal V 2017 Transp. Res. Procedia 27 961-968

[30] George Y, Dragomanovits A, Laiou A, Richter T, Ruhl S, Francesca L T, Lorenzo D, G. Daniel G, Karathodorou N and Haojie L 2016 Transp. Res. Procedia 14 4257-66

[31] Frejo D B, Bart D D, Papageorgiou M and Schutter B D 2018 IFAC-Papers OnLine 51 343-348