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Review article

A review of behavioural issues contribution to motorcycle safety

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ABSTRACT

Motorcycles are considered as one of the extreme modes of conveyance contributing to road accidents. Reports revealed that the number of deaths caused by motorcycles is significantly higher than by any other means of transportation. A large percentage of motorcycle accidents occurred mainly due to human behaviour. The objectives of this paper are to unveil and analyse certain behavioural patterns of riders influencing the motorcycle mishaps through literature reviews on various aspects of riding behaviours including the lack of visibility and alertness, and speeding issues. This is important for a comprehensive and broad understanding of the riders' behavioural and performance traits associated with speeding, visibility, and alertness issues. Thus, collisions due to these issues may be avoided. This study summarizes 104 selected articles published in Springer, Elsevier, Tylor & Francis, IEEE, US Patent, WHO and others, distributed over the year of 1981 to 2019, which were further separated into four classes; 22 articles (21%) on the speeding issues, 25 articles (24%) on the visibility issues, 24 articles (23%) related to alertness issues, and 33 articles (32%) comprising of other studies related to motorcycles. All these research papers highlighted the ways to reduce the risks from speeding and to improve the visibility and alertness of motorcycle riders. As a conclusion, the study found that by applying the Intelligent Transport System (ITS) in motorcycles, road accidents may be reduced. It is also well noticed that the headlight of motorcycle and the use of fluorescent jacket increase the conspicuity of a motorcyclist. Moreover, the Daytime Running Light (DRL) of a motorcycle may also reduce accidents. It is also noted that the use of sensors on steering wheel increases the alertness of drivers. Finally, a framework to gain an improved understanding on the motorcycle riders' behaviour related issues and the ways to handling them were recommended. On top of that, this study had also suggested a new technological utilisation to improve the management of speeding, visibility and alertness issues. Provided that these concerns are addressed, a drop in the number of accident occurrences is possible.

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1. Introduction

Motorcycles are one of the most serious means of transportation contributing to road accidents. Motorcyclists are exposed to a higher risk of crashing compared to car drivers [1]. This is primarily attributed to the inherent vulnerability of motorcycle riders and the greater amount of risks they are exposed to. Across the world, 28% of deaths due to road accidents are caused by motorcycles and the figures are increasing every year [2]. The travel speed, safe distance, longitudinal movement and lateral movement of motorcycles are obviously different from those of other vehicles [3,4]. The growth of motorcycle usage is increasing globally, especially in low and middle-income countries [5]. This is due to its lower cost, better fuel thrift, and compact size convenient for parking in congested zones [6], as well as rapid economic growth of countries, and because of the abundance congestion in roads [7]. In Malaysia, the growth of motorcycle usage has amounted to 47% of all the vehicles registered [8]. This growth is due to the cost-effectiveness and ease of use of motorcycles [9].

The number of deaths caused by motorcycles is significantly higher than by any other modes of transportation, and it is mainly because of the inherent vulnerability and risks exposure of motorcycle riders [10]. Riders are more susceptible to injuries because of lack of protection, where helmet and clothing are the only available gears of protection [11]. Moreover, motorcycle is more prone to accidents due to its build, which makes it much lighter than cars and much faster than most vehicles, while the rider is not enclosed in a box of metal and has only two wheels to balance himself [12].

All over the world, the number of registered motorcycles is about 200 million units [6]. In Malaysia, the current amount of registered motorcycles are 12 million, which represent 45.8% of the total registered vehicles [13]. While in United States, currently approximately 800,000 motorcycles are being registered [14]. In low and middle-income countries, motorcycles constitute a significant percentage of vehicle fleets on road. The percentage of road accident deaths caused by motorcycles in low-income countries is about 39%, and that in middle-income countries is about 34% (refer to Fig. 1) [2]. In South-East Asia, the highest number of accidents has been reported for motorcycles, which amounts to about 34% [15]. Malaysia is one of the Asia countries with high accident rates [16]. The figure reported for road deaths in Malaysia was 62% [17], where 7152 deaths and 521,466 accident cases of road crash were reported in 2016 [18]. The number of road deaths from 2010 to 2016 in Malaysia were increasing by 4.1% [19]. Ang et al., [1] concluded that with increasing age, riders became increasingly regulated. Asia provides the largest percentage of motorcycles usage, making up to 65% of the world share, whereas the number of motorcycles in Europe and the North America constitutes to only 16% [20,21].

The probability of motorcycle accidents is 6–13 times higher than that of other vehicles [22]. A research by the National Highway Traffic Safety Administration (NHTSA 2018) [23] showed that in the USA, motorcycle rider is about 28 times more likely to die per vehicle per mile travelled compared to any other types of vehicle. In Taiwan [24], the probability of death of motorcyclists is about 26 times higher per vehicle per mile of travel, while the probability for them to be injured in a crash compared to car occupants is 5 times higher. In Malaysia [25], the probability of death of motorcycle riders is 17 times higher than that of car drivers. While in Japan, the number of fatalities from road accidents are decreasing every year and most accidents occurred due to the drunkenness of drivers and pedestrians [26].

In an earlier study [27], it was proven that human behaviour is responsible for 95% of traffic accidents. Moreover, majority of motorcycle accidents take place because of human error. Human error, in other words, implies the riders' behaviours including speediness, alcohol drunkenness, fatigue, drowsiness, attentiveness, drug and medicine consumption, seat belt wearing, wearing of fluorescent jacket and helmet use [28,29]. In terms of drivers' illegal behaviour, one of the most popular research topics is the psychological traits influence on the risky driving behaviour [30,31]. [32] revealed that lifestyle provides an important impact on motorcyclists` risky behaviour and traffic accidents

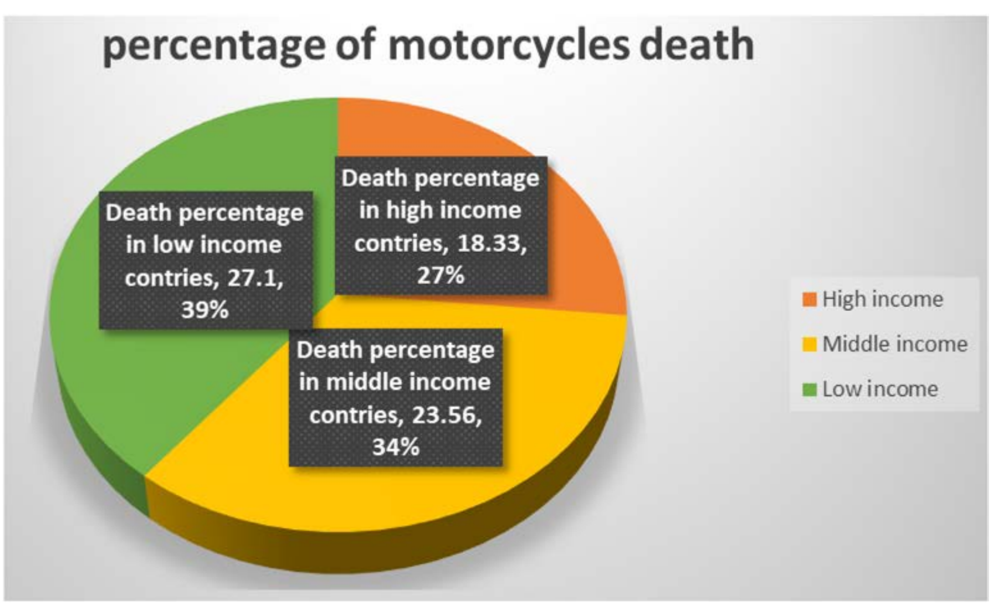

Fig. 1. Percentages of deaths by motorcycle in low, middle and high-income countries [2].

involvement. This paper focuses on the rider's behaviour particularly on speeding, visibility and alertness issues.

Over speeding or speeding issues have been found to be the primary reason behind traffic accidents [33,34]. It is also regarded as the key contributing factor in all road crashes, and is the main reason behind 40% of all severe and fatal accidents [35]. Speeding was reported as a factor in 34% of all fatal motorcycle accidents [36].

Visibility of motorcycle is the major cause behind 65% of crashes between motorcycle and car [37]. The lack of visibility is attributed to precipitation, fog and high winds, which in turn increases the risk and probability of traffic accidents [38,39]. Most of the frontal crashes in motorcycles are due to poor left-turn gap decision by other motorists, or due to an absence of front motorcycle conspicuity [40,41]. Nowadays, study efforts focusing on riders' visual cues in genuine-world traffic have been limited [42]. Davoodi & Hossayni, [43] noticed that the headlight of motorcycle and the use of fluorescent jacket increase the conspicuity of a motorcyclist, whereas the Daytime Running Light (DRL) of motorcycle reduces accidents by 4 to 20%.

Fatigue and drowsiness of riders during a ride is a major cause of road accidents [44]. The National Highway Traffic Safety Administration (NHTSA) estimated that approximately 25% of road crashes are due to the driver's inattention [45]. In Indonesia, motorcyclists fatigue is responsible for the 48% probability of motorcycle accidents [46].

2. Aim

This paper has two key objectives. The first is to assess the articles pertaining to a rise in motorcycle mishaps, particularly in terms of riders' behaviours including speeding, visibility and alertness. The second goal is to recommend a framework for attaining a better comprehension of behaviour related matters pertaining to road safety of bikes. Through the recommended framework from this study, riders' behaviour on roads can be improved if the key goals are achieved.

3. Methods

Literature review was carried out from December 2017 to September 2019. Various adopted publishers were referred, such as Springer, Tylor & Francis, Elsevier, IEEE, US Patent, WHO and others. Fig. 2 shows the number of publications per publisher. In this study, various combinations of keywords were used to conduct the publications search, such as visibility, speeding, vision of motorcycle, alertness, driver alarm, rider behaviour, tired, fatigue, drowsiness, attentiveness and rider's attention. In this evaluation, to be termed fit for modulation, studies have to conform to the following selection benchmarks: (1) focus on the rider's behaviour on motorbike, (2) issues on visibility, speeding and alertness, (3) peer-review by journal articles, books, conference proceedings, or book chapters, and (4) contain at least an abstract.

This study summarizes 104 selected articles from 1981 to 2019 which were separated into four classes. The first class included 22 articles (21%) regarding the speeding issues. The second class included 25 articles (24%) composed of visibility issues. The third class included 24 articles (23%) related to alertness issues while the fourth class included 33 articles (32%) comprising of other studies related to motorcycles (refer to Fig. 3). There are other ways of presenting the articles. For example, Fig. 4 shows the distribution of publications based on the year of publication. The research community selected for this paper were focused on the last 5 years of publications, which represent 67 of 104 articles from the years 2015, 2016, 2017, 2018 and 2019 which highlighted on the ways to reduce the risk of speeding and ways to improve the visibility and alertness of motorcycle riders. Speeding issues focused on the studies concerning the analysis of programs and the developments of ITS and Intelligent Speed Adaptation (ISA), to reduce the risk of speeding. Whereas the visibility issues were concentrated on previous studies related to the improvement of headlight so as to increase the visibility of motorcycles. Concerning the alertness issues, studies on predicted fatigue, drowsiness and distraction were conducted. In addition, studies on the use of sensors on steering wheel to detect fatigue and drowsiness, and the use of alarm to reduce incidents related to lack of alertness were also focused.

4. Rider's behaviour issues in terms of motorcycle safety

This study reviews previous articles regarding speeding, visibility and alertness issues to identify the research contributions, results, methods and gaps pertaining to the articles which are as presented below:

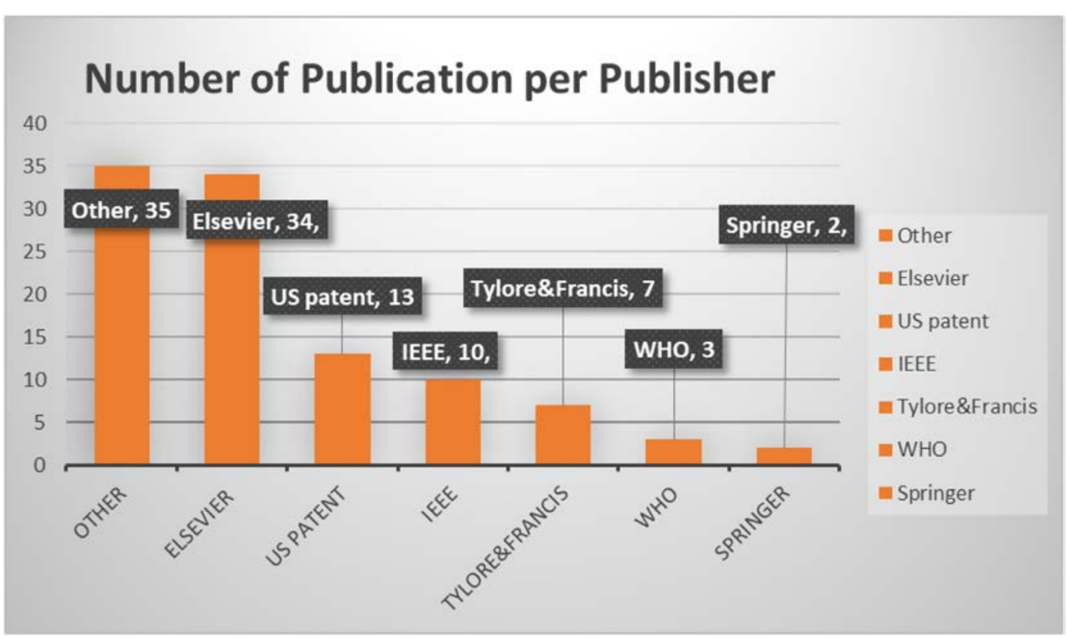

Fig. 2. Number of publications per publisher.

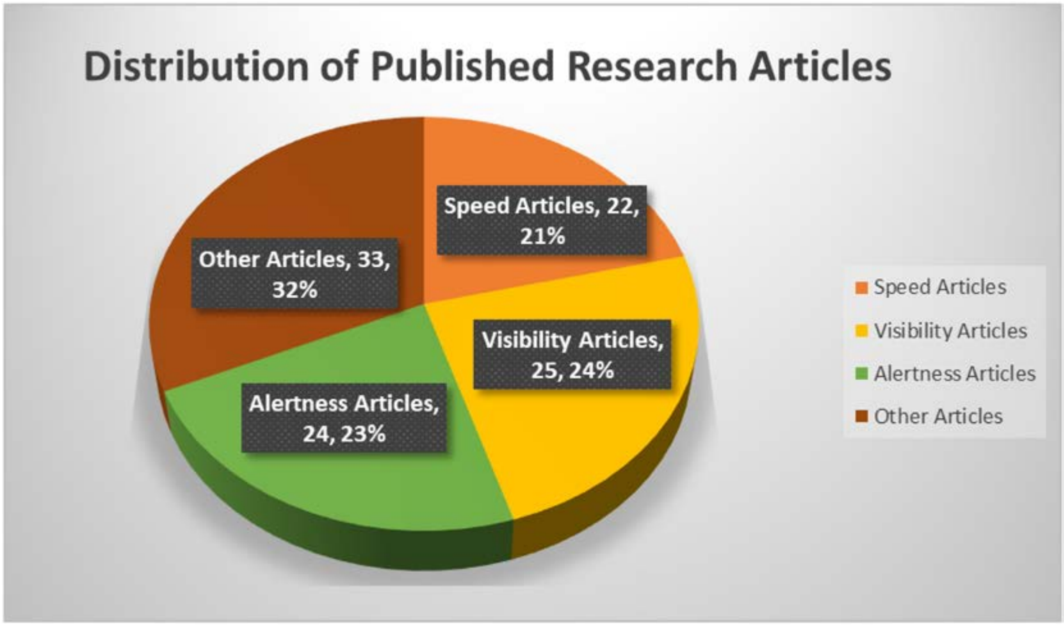

Fig. 3. Distribution of published research articles.

4.1. Impact of speeding on motorcycle safety

4.1.1. Background

Most of the road traffic injury issues can be attributed to speeding. In particular, a key risk factor for most of the road traffic collisions, deaths and injuries is the inappropriate or excessive speeding. In all countries, excessive speeding seems to be a common issue. Based on a study pertaining to the Organisation for Economic Co-operation and Development Countries (OECD), on an average, 40–50%, and reaching up to 80% of drivers drive their vehicles beyond the posted speed limits; it is noticeable that a similar proportion of vehicles driven at excessive speed are common in low and middle-income countries [47,48]. Thi et al., [49] highlighted the casualties due to the high risk of riders' behaviour in Vietnam hospital which showed to be 26% due to speeding.

As per [50], there are various existing ITS technologies that could be integrated in vehicles that allow employing and improving safety for motorcycles, such as brilliant speed adaptation, advanced driver assistance system, driver control system, seat belt/helmet reminder system, lane keeping and lane-change warning system, collision warning and avoidance system, and visibility enhancing system. In the earlier study by Turner & Higgins, [51], various emerging and existing ITS technologies were reviewed that could potentially enhance motorcyclists' safety. Savino et al., [52] predicted that the ITS can be useful in reducing the number of riders deaths due to motorcycle accidents. Thus, researchers

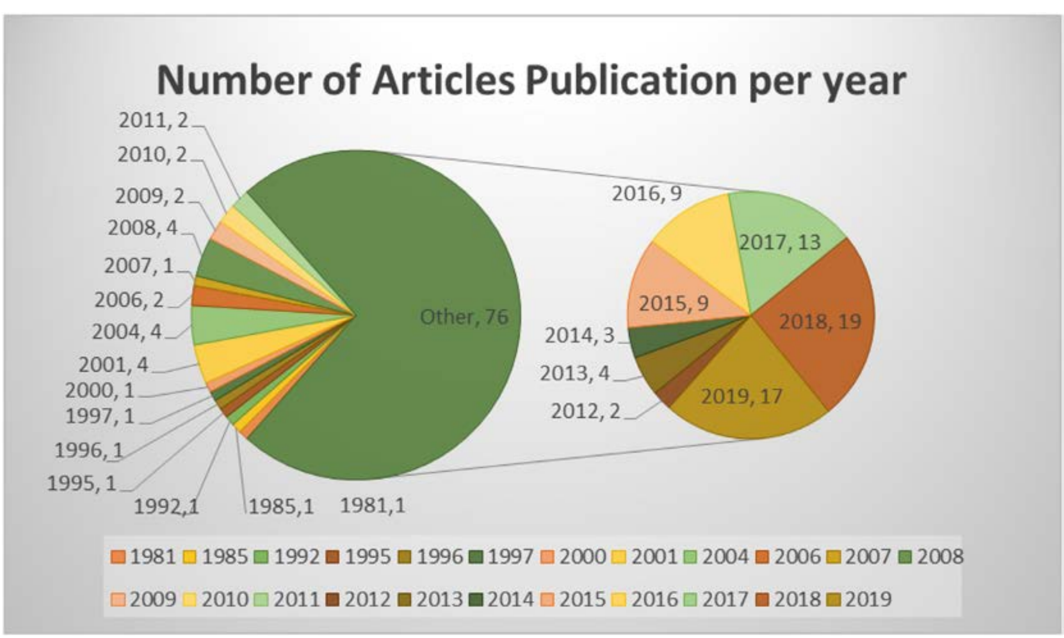

Fig. 4. Number of article publications per year.

in [53] had demonstrated the existing intelligent transport system safety features that are applicable for motorcycles and vehicles which are as presented in Table 1.

Bikers that ride motorcycles of above 250 cc would most likely be tempted to ride at high speeds since these motorcycles provide a remarkably better acceleration seemingly more than even the fastest automobiles (e.g. taking less than 3.0 s to accelerate from 0 to 60 mph) as mentioned in [54,55].

4.1.2. Literature reviews

4.1.2.1. What researchers said on speeding issue. In several articles on speeding [55], it was noted that there exists an excessive speeding factor irrespective of the motorcycle type. In a research by Jevtić et al., [56], for motorcyclists, speed has been considered as a significant risk factor. In another study by Ariffin et al., [57], speed limit was deemed to be crucial. As per [33], speeding has been attributed to maximising the risk as well as severity of accidents, particularly for vulnerable road users. Another researcher in [34] stressed that employing advanced technologies helps to decrease the incidence as well as severity of road crashes due speeding. Furthermore, as per [58], a major cause of traffic accidents is the inappropriate speeding. According to [36], 34% of all fatal motorcycle crashes stated speeding to be a contributing factor. In other articles by Ghadiri et al., [35], for road authorities globally, a key concern is to improve the adherence to speed limits. Besides, Joy et al., [59] had noted that there is a rise in the number of accidents by two-wheelers at an alarming rate. As per [60], over-speeding was found to be a key reason for the occurrence of accidents. Furthermore, according to [51], employing the Curve-Speed Warning (CSW) technology that warns the riders on crossing the speed limit could help in preventing a crash.

4.1.2.2. Contribution of researchers regarding speeding issues. Amini et al., [61] had contributed ideas to increase the safe distance between car and motorcycle. Abdul Manan et al., [55] evaluated the impacts of riding with excessive speed related to the characteristics of road, riding behaviour of motorcyclists, and the characteristics of both motorcycles and motorcyclists. Jevtić et al., [56] investigated the difference in the velocity distribution pertaining to various motorcycle styles as well as the variation in the delivery of speeds for specific motorcycle styles and cars. In addition, the relationship existing between motorcycle styles and travel speed with regards to Belgrade, Serbia, was stressed upon. Other researchers Ariffin et al., [57] had focussed on minimising pedestrian as well as motorcycle collisions. Thus, this helps to identify associated issues and implement suggestions on motorcycle safety technology pertaining to clashing with a pedestrian. In addition, Agerholm et al., [33] had worked on minimising the impact cast by speeding on road. Another article by Abu et al., [34] was focussed on minimising accidents as well as the severity of road crashes due speeding. Moreover, a work by Jiménez et al., [58] was focussed on controlling the traffic speed.

Table 1
ITS safety features between four-wheeled vehicles vs. Powered Two Wheelers (PTW) [53].

ITS features	Four-wheeled	PTW
Anti-lock braking system (ABS)	√	√
Adaptive cruise control	√	R
Airbags	√	√
Autonomous braking	√	R
Combined braking system (CBS)	√	√
Curve warning	-	R
Electronic stability control	√	HR/R
Lane keeping assistant system	√	R
Obstacle detection	√	R
Pre-crash system	√	R
Seat-belt/helmet reminder	√	-
Traction control system	√	√

R = under research.
HR = mainly high-performance motorcycles.

Dodge et al., [36] contributed by evaluating the technologies that possess strong potential to enhance the safety of motorcycles. Besides, Ghadiri et al., [35] also contributed towards examining the impacts of Intelligent Speed Adaptation (ISA) on the driving speed. Furthermore, another researcher Joy et al., [59] worked on minimising road accidents with regards to speeding. Another article by researchers in [60] had contributed ideas on evading a crash due to speed humps on roads. Other researchers Ariffin et al., [62] had focused on improving the motorcycles' stability on road during manoeuvring and speeding. Moreover, Turner & Higgins, [51] contributed towards minimising the role of excessive speeding in motorcycle crashes.

4.1.2.3. Proposed methods to tackle speeding issues. Abdul Manan et al., [55] had put forward a new software called MECHROM for data analysis and collection, in which data were employed based on the controls over 8277 motorcyclists on various kinds of roads pertaining to the road hierarchy in Malaysia in 2015. Other researchers Jevtić et al., [56] put forward a study that involved a sample size of 1080 motorcycles. The measurement of speed was done at six different locations on the main roads in Belgrade, Serbia. Thus, the styles pertaining to motorcycles were segmented into three different groups based on their average speeds. Another article Ariffin et al., [57] includes data analysis derived from 1626 associated road crashes pertaining to reports by the Royal Malaysia Police (RMP) in 2009–2013, which were retrospectively gathered via Malaysian Institute of Road Safety Research (MIROS) Road Accident Analysis and Database System (M-ROADS). Agerholm et al., [33] put forward a speed-calming measure regarding a new technique to determine speeds with regards to Global Navigation Satellite System (GNSS) data through floating, and the analyses included car data along with 3216 trips passing one/more Speed-Calming measures (SCs). In addition, Abu et al., [34] suggested using ITS for instance the Anti-lock Braking System (ABS). Jiménez et al., [58] focused on employing the ISA systems, in which these systems are set with known speed limits so as to increase compliance. Dodge et al., [36] suggested employing ITS for motorcycles, for example the Curve Speed Warning and ABS. However, other researchers Ghadiri et al., [35] had suggested employing ISA on driving speed by considering 11 private cars in Penang, Malaysia, along with an advisory system. A novel security enabled speed monitoring system had been put forward in another article by Joy et al., [59] pertaining to two-wheelers, employing wireless technology. This technology becomes functional and warns the driver if the speed limit goes beyond the permissible level. Yuen et al., [60] suggested installing sensor apparatus on-board camera for a motorcycle that allows reading change in speed. In addition, Ariffin et al., [62] recommended employing technologies such as the Automated Emergency Braking (AEB), ABS and Combined Brake System (CBS) that involves the proportional as well as simultaneous activation of both rear and front brakes. Furthermore, Turner & Higgins, [51] suggested employing the speed alert systems technology for motorcycle operators.

4.1.2.4. Results obtained by researchers on speeding issues. Amini et al., [61] deduced that through the use of ITS, a warning message to the driver of a car can be sent to keep a safe distance between him and the motorcycle. The results obtained by Abdul Manan et al., [55] with regards to the speed test demonstrated that motorcyclists drive faster when compared with other transports pertaining to dual carriageway major roads that include three lanes and second collector ways that include four lanes. In general, of the surveyed motorcycles, it was found that 42.2% exceeded the speed limit, while 28.6% were found to cross the 85th percentile of the traffic speed. The factors pertaining to riding by motorcyclists on expressway at excessive speed were determined. Based on the results from Jevtić et al., [56], motorcyclists were found to drive faster than car drivers, with an extreme speeding found to be 2.3 times higher for motorcyclists versus car drivers. Based on the results from other researchers [57], five factors were found to be considerably associated to the severity of injury, which included the location of the bodily injury, age, road geometry, speed limit and lighting condition pertaining to the collision location. Another article by Agerholm et al., [33] showed results of the minimisation of the impact on speed variation due to hump. Compared with bumps, chicanes lead to increased variation in speed before arriving at Speed Calming (SC). Furthermore, as per Abu et al., [34], the results suggested stopping the motorcycle and vehicle without sliding it. Other studies by Jiménez et al., [58] found that when the warning parameters were redefined, acceptance by drivers increased considerably. Researchers in Dodge et al., [36] demonstrated that by employing Vehicle-To-Infrastructure (V2I) communications, drivers can be notified regarding the posted speed for an upcoming curve. Also, Ghadiri et al., [35] achieved a considerable decrease in the mean, maximum and 85th percentile speed, with an estimated reduction in injury accidents by 13–18% and decrease in fatal accidents by 17–23%. Other studies by Joy et al., [59] had demonstrated results that helped in decreasing the road accidents with appropriate monitoring of vehicle by the authority and also providing additional security to car from theft. Besides, the results in a work by Yuen et al., [60] from statistical analysis demonstrated that the riding characteristics such as throttle force and speed brake force would get influenced with regards to the distance from the hump, in which an increase was observed from the initial point (−100 m) reaching to a peak (47.074 km/h) at a distance point of −70 m but a gradual reduction was seen at a distance point of −60 m further from the speed table. In addition, the results in Ariffin et al., [62] suggested ways to achieve greater brake efficiency without affecting the controllability and stability of a motorcycle.

4.1.2.5. Gaps identified by researchers on speeding issues. In various studies, the exact relationship between various behavioural traits such as motorcycle style, speed and inclination towards risky behaviour has not been addressed Jevtić et al., [56]. Moreover according to Jiménez et al., [58], the discrepancies in the findings imply that the effect of speed homogenisation was not decreased. In other researches [35], it was revealed that a practical and beneficial method was not identified in relation to the psychological measures that make use of ISA in the region (Penang).

4.2. Impact of visibility on motorcycle safety

4.2.1. Background

Visibility is found to be one of the major causes behind motorcycle related road accidents as the size of motorcycle is small, which makes it less visible to big vehicles [38,39]. The visibility of motorcycle is a few [63]. In this context, it was further realised that the size of motorcycle is a significant factor that impacts conspicuity [64,65]. Objects are identified by human based on their shape, size, motion and colour. A motorcycle's face-on area can be imagined to be 30–40% of that of a car. Poor conspicuity of Powered Two-Wheelers (PTW) is one of the primary factors that lead to their involvement in accidents. Conspicuity refers to the ability of other road users to perceive and be aware of the presence of a motorcycle in the proximity [41].

As stated in [65], there are three fundamental selections to be made with respect to recommendations that can increase the motorcycle conspicuity: increase in size, brighter colours, and the use of daytime running lights. It is observed that fluorescence and bright colours improve the visibility of an object as it enables light to be reflected or remitted around it. The visibility of a motorcycle is further dependent on its reflective traits and the background against which they are seen. Colour perception is almost non-existent at night. There is a common agreement that white, yellow and red colours, and fluorescence are most likely to improve motorcycle visibility. The practice of wearing fluorescent clothing can lead to enhanced visibility and thereby decrease the risk of accidents by almost 37% compared to other drivers. On the other hand, wearing a white helmet lowers the risk by 24% as compared to a dark helmet [66,67].

4.2.2. Literature reviews

4.2.2.1. What researchers said on visibility issue. Risks to riders injuries are interrelated with the visibility of the motorcyclists [68,69]. As discussed in a research by Rogé et al., [29], numerous instances of collision between Vulnerable Road Users (VRU) and cars reveal that car drivers fail to identify VRUs in time to avoid a collision, mainly due to poor conspicuity. According to [70], several cases of collisions between cars and cyclists indicate that car drivers, due to low visibility or sensory conspicuity, fail to see the latter in time. In another study by Ranchet et al., [71], it was stated that in most motorcycle collisions, there is an involvement of another vehicle that disrupted or violated the motorcycle's right-of-way at an intersection. Other studies Al-Awar Smither & Torrez, [40] indicated that low conspicuity is usually to be blamed for the recurring collisions and fatalities encountered by motorcycle riders. In a different article [41], it was stated that a lack of conspicuity of motorcycles by other road users is one of the major factors that results in a large number of motorcycle crashes, particularly during day time traffic. On the basis of earlier researches [66], it can be said that road fatalities and accidents that involve motorcycle riders is an alarming matter and a cause of significant concern in Malaysia as well as other ASEAN countries, where low conspicuity is one of the key accountable factors. As mentioned in a study by Gershon & Shinar, [72], low conspicuity of PTW is a significant factor in the occurrence of accidents. In other studies by Zlsur et al., [73], it was indicated that Light Emitting Diode (LED) when used as the primary source of light for different applications in motorcycles leads to improvement in visibility.

Additionally, as stated by Kheawhorm, [74], inclusion of a LED headlight renders a modern or stylish look to the structure, that increases the visual interest of the observer. In an earlier study [75], it was observed that when more than one headlamp is added to a motorcycle, the total width between the headlights requires to be considerably less than the diameter of an automobile, which is very critical for the conspicuity of the vehicle at night. In other researches [76], it was stated that in the frequently occurring motorcycle accidents, there is usually an involvement of another vehicle that violates or disrupts the motorcycle's right-of-way at some junctures. Additionally, as highlighted by [77], lighting device is a necessary constituent of a car, involving a motorcycle or any other two-wheeler because it heightens the visibility for riding during daytime, or during low visibility conditions or night time. Yet, in another study done by Villa et al., [78], night driving was considered to be a challenge, particularly when trying to overtake. At night, there are more constraints pertaining to computer graphics performance, since most of the relevant details are associated with low luminance and low contrast values. The overall difference has been found to be considerably high because of light sources stemming from vehicle headlamps and road lighting. While in the USA [79], it was seen that a low beam would help motorcyclists when more light is added or if the motorists have integrated reflectors with its vest and helmet. In addition, as per [64], it was suggested that motorcycle riders should wear clothing that are white, red, yellow and fluorescent and similar colours apply for the motorcycles, since all these help in enhancing conspicuousness. However, the effectiveness also relies on the level of contrast between the motorcycle and its background. For instance, standard yellow and fluorescent yellow-orange materials can be identified quicker from a distance when compared with other colours, subject to weather condition. Another article by Turner & Higgins, [51] stressed on the Adaptive Front Lighting System (AFS) as an emerging technology that employs a certain angle for the steering wheel as well as the vehicle speed to ensure that the headlight is luminous for the driver to see the front-side of the roadway. Calculation of the speed and angular velocity of a motorcycle can be done to send a signal so as to rotate the light in tandem with the motorcycle's movement.

4.2.2.2. Contribution of researchers regarding visibility issues. The authors in [29] examined the chances of improving the visibility of motorcyclists and pedestrians. In addition, Rogé et al., [70] had also worked to enhance the visibility of motorcycles. Ranchet et al., [71] examined the impact of various headlight configurations pertaining to motorcycle detectability. Other studies conducted by Al-Awar Smither & Torrez, [40] evaluated variables that could help in improving conspicuity of motorcycles exposed to a high-fidelity simulated environment.

Furthermore, Davoodi & Hossayni, [41] reviewed the effect of Daytime Running Light (DRL) usage pertaining to motorcyclists on multivehicle motorcycle crash. Another article by Solah et al., [66] helped to deal with conspicuity. Gershon & Shinar, [72] evaluated the effect of various outfits of riders on the detectability of PTWs as well as determining the chances that a unique Alternating-Blinking Lights System (ABLS) would improve rider's conspicuity. With regards to the earlier study by Zlsur et al., [73], they worked on decreasing the impact of LED headlight performance by solving the issue of heat dissipation. Other researchers Kheawhorm, [74] had worked on minimising the occurrences of accidents by improving the visibility of motorcycles. Similarly, Neale et al., [75] also worked on minimising the occurrences of accidents by applying the same mean of improvement. ESPIE et al., [76] worked on enhancing the perception of car drivers towards motorcycles. Another article by SRIVIRAT, [77] put forward an alternative lighting device structure that does not interfere with the illumination of lighting sources, while in the meantime offering an auxiliary illumination that has improved aesthetic appearance. Other studies Sun, [80] helped to address the issues pertaining to motorcycle's headlamp. Villa et al., [78] worked on enhancing the realism of motion cues through night driving simulators of motorcycles.

4.2.2.3. Proposed methods to tackle visibility issues. The authors in Rogé et al., [29] employed safety messages to increase awareness on the vulnerability of road users with the help of two groups of 17 motorists by allowing them to watch a film presenting safety messages regarding the fragility of road users. Rogé et al., [70] investigated the use of yellow cyclist jacket by evaluating 43 motorists who were asked to performed a vulnerable road user exposure task pertaining to a car-driving poser. In an urban setting, they were asked to expose pedestrians and cyclists in order to locate them as well as to determine the toughness in identifying them. Other studies Ranchet et al., [71] had suggested employing and testing three creator headlight orders: (1) upright white (two white lights on the branch alongside the central white headlight and one white light on the helmet of motorcyclist), (2) regular yellow (middle yellow headlight) and (3) upright yellow (similar configuration as that of (2) with yellow lights in place of white) through (1) low emissions, (2) Daytime Running Lights (DRL) or (3) DRLs and low beams. Thus, video clips pertaining to computer-generated traffic situations were presented briefly (250 ms duration) to 57 drivers. Furthermore, Al-Awar Smither & Torrez, [40] employed the DRL, in relation to the age of drivers pertaining to other vehicles. A total of 75 entrants participated in this study, who were made to watch a sequence of video clips regarding road traffic, after which they were asked to specify if they foresee any hazardous situation. In another article by Davoodi & Hossayni, [41], databases and internet were employed to evaluate the impact of DRLs. In the literature, three major classes were recognised assessing value studies as well as other significant reports pertaining to the impact of motorcycle DRL. Solah et al., [66] analysed 950 samples by conducting a survey for a month, which included four areas in Selangor state. Collection of information was done from four regions (Bangi, Kajang, Dengkil and Semenyih) pertaining to functionality of brake light and DRL, motorcyclist attire, availability of third brake light, and the inclusion of helmet reflector for a selected area. Other researchers Gershon & Shinar, [72] recommended employing Alternating-Blinking Lights System (ABLS) via two experiments. The first experiment involved attention conspicuity pertaining to PTWs, while the second one examined search conspicuity of PTWs. Another article by Zlsur et al., [73] recommended employing a heat pipe in LED for a motorcycle headlight. Thus, Kheawhorm, [74] recommended installing two LED headlights in the right and left sides, wherein both include inner high beam and outer low headlight. While Neale et al., [75] put forward the employment of a headlamp on a motorcycle pertaining to two groups; one group included headlamps possessing the shortest distance, when measurement is done for a 3-lx level on the ground; the second set included the other half with the farthest distance, when measurement is done to a 3-lx level on the ground. Mapping was done for a total of 9 headlamps; of these, 4 headlamps were included for the bikes, while 5 were mounted on rigs. This light value pertaining to the headlamp between the shoulder and the roadway was measured. Also, as a short-term solution, ESPIE et al., [76] put forward an innovative headlight design to minimise the occurrence of accidents by employing 4 MC headlight configurations (horizontal, standard, vertical and combined) and carried out testing in a left-turn situation for three groups of 23 volunteers participated in the experiment. A lighting device structure was evaluated by other researchers [77], which included a configuration of lighting sources for lighting illumination, a reflector that has been configured to reflect lighting via lighting sources as LED elements and an inner lens fixed to the reflector. In addition, another article by Sun, [80] recommended employing low and high beam lens of LED via a white LED module, a parabolic reflector, an elliptical reflector and a toric lens mounted on motorcycles. With regard to an earlier study [78], two experiments on 33 participants were carried out. As a proxy for motion perception, Time-to-Collision (TTC) was employed. According to the first test, the visibility pertaining to the motorcycle's outline is considered to be the primary visual cue for estimating TTC in night-time conditions (but the same cannot be applied to cars). The second test evaluates this thesis, which demonstrated enhancement of visibility pertaining to the motorcycle, giving rise to biases during estimation of TTC, while taking it off did not seem to impact the estimation of TTC—at the cost of realism troubles.

4.2.2.4. Results obtained by researchers on visibility issues. As per the results by Rogé et al., [29], watching safety-related movie led to the improvement of visibility pertaining to VRU, which resulted in a safer driving behaviour. In addition, Rogé et al., [70] found that motorists would detect even at a greater distance those cyclists who were wearing jackets. While, as per [71], the visual of a motorcycle is seen to improve when a yellow headlight is employed. Other studies by Al-Awar Smither & Torrez, [40] demonstrated a link among DRLs as well as effective detection of motorcycles, which signified that age-related changes could impact the ability to effectively identify as well as respond to a motorcycle. Another article by Davoodi & Hossayni, [41] suggested that motorcycle crash risk decreased by 4% to 20%. While for a study by Solah et al., [66], the results demonstrated that ~96% of motorcycles did not have a third brake light, whereas dark attires were worn by ~44% of motorcyclists (refer to Fig. 5). With regard to an earlier study [72], in both experiments, the results demonstrated that PTWs disclosure rates increased with the ABLS application and the difference in terms of detection rates between the search conspicuity experiment and attention was mitigated. While as per [73], increasing illuminance value was seen pertaining to LED and reliability of headlight. In addition, Kheawhorm, [74] demonstrated an enhancement in the motorcycle's visibility by increasing the lighting along roads.

Besides, Neale et al., [75] had also confirmed that the high headlight was not able to provide any extra illumination, and the high beam's land level was surprisingly less than that of the low beam. It is clear that the beam pattern's angle was noticeably high, and therefore illuminating directly towards the ground. Other studies by ESPIE et al., [76] suggested that the headlight arrangement which produces more yellow colour light on the fork and the helmet substantially increases the visibility of a vehicle. Thus, SRIVIRAT, [77] confirmed the increase in the light intensity of a headlight. Other investigations by Sun, [80] showed that the average lighting effect of a high beam reaches up to 21.56 lx, optical efficiency reaches to 66.45%, while the average deviation amounts to 14.17%. Furthermore, for low beam, its average luminosity is 21.55 lx,

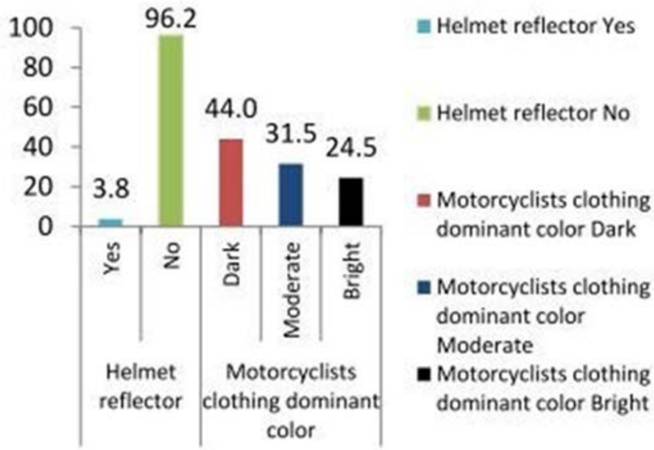

Fig. 5. Helmet and attire wearing among motorcyclists [66].

optical efficiency is 66.43%, whereas the average deviation is 13.96%. Also, the results observed by Villa et al., [78] suggested that the motion signals at night-time are more realistic with the application of a High Dynamic Range (HDR) and also that these display devices may be effective in conditions where there is a need of realistic views in the presence of less visible contrasts.

4.2.2.5. Gaps identified by researchers on visibility issues. As per [29], this researcher did not focus on the impact of the extent of anger intensity among car drivers when facing other weak drivers to measure the intensity threshold value beyond which they tend to get annoyed by the weak drivers. Rogé et al., [70] confirmed that luminous cyclist jacket is not sufficient to improve visibility. In other studies by Ranchet et al., [71], holes are efficient if yellow lights are less in the street. Another study by Ichiro Nakao & Tatara, [26] was conducted under real-world situations like adverse atmosphere or high-density traffic region. Davoodi & Hossayni, [41] observed that motorcycle DRLs were not used worldwide, specifically in nations where there is a high amount of motorcycle accidents. Based on an earlier study [66], it was shown that the use of LED lamps for all vehicles reduces the risk of lamp failure. Another investigation by Gershon & Shinar, [72] confirmed that drivers are required to consider the visual attributes of the surroundings and must be provided with an aid for visibility that makes them less vulnerable to the changing atmosphere and assists the drivers with a specific visual signal. Previous studies by Zlsur et al., ([73]; Kheawhorm, [74]; SRIVIRAT, [77]; Sun, [80]) confirmed that LED is presently too expensive to be used universally. Other investigations by Neale et al., [75] showed that there is an irregularity and inconsistency in the performance of the low and high beams of headlights. ESPIE et al., [76] highlighted that these defects must be found and corrected by implementing novel motorcycle headlamp configurations. Another study by Villa et al., [78] did not consider other cars and pedestrians in its evaluation.

4.3. Impact of alertness (fatigue) on motorcycle safety

4.3.1. Background

The fatigue and drowsiness in vehicle drivers are a major cause of accidents on road. Majority of people considered driving under alcohol influence as a significant cause of accidents, yet the drowsiness in a driver is just as fatal. It also diminishes alertness, concentration and vigilance in such a way that the capability to carry out various consciousness-based actions (driving) is weakened, awareness is reduced, judgement gets decreased and the risk of accident is increased. The accidents on road due to fatigue are more serious and fatal rather than rash or drunk driving. Fatigue in drivers is more severe as they tend to lose consciousness which causes critical injuries or even deaths. Unfortunately, people travelling in other vehicles as well as pedestrians become the victims [44]. Certain aspects affecting the extent of driver's drowsiness and behaviour are the job of the driver, long driving duration, working routines, night driving, consumption of stimulants, working times as well as driving speed [46].

The NHTSA (National Highway Traffic Safety Administration) assessment mentioned that about 25% of police-reported accidents involved some sort of driver's lack of concentration [45,81]. As per [82,83], driver's fatigue was defined in 2 ways: firstly, "weakened performance (reaction time when decelarating, wastage of concentration, poor judgement, high probability of getting asleep, bad performance regarding control tasks) and specific feelings about exhaustion or drowsiness". The second is "long awake duration, lack of quality sleep over long interval, continual physical or mental work, disturbances in the curcadian rhythms, inadequate breaks and environmental factors (like noise, heat and vibration)".

In [83,84], it was found that 40% of drivers reported to suffer from fatigue at the lower half of long trips. This individual feeling is described as being drowsy, tired, sleepy, bored, lethargic, lack in concentration, not able to be aware, or being mentally slow. This individual attribute of drowsiness is in harmony with the measures of the fatigue of a driver. Nevertheless, there may be qualitative differences among drivers and fatigue with respect to physical requirements or the perceptual/cognitive demands related to driving. So far, not much is known regarding the exact aspects that lead to riders fatigue. For instance, in a hospital in Vietnam, 9% of cases due to phone usage causes collisions [49].

4.3.2. Literature reviews

4.3.2.1. What researchers said on alertness issue. Truong et al., [85] demonstrated that in Vietnam, when riders are on mobile phones while riding, they are more exposed to the risk of accidents. In a research by Truong et al., [86], they demonstrated that disruption in driving because of mobile phone usage is extremely dangerous. In other investigations by Chen et al., [87], they mentioned that the DFD (drowsiness-fatigue-detection) system can be used for improving the safety on road. Moreover, Effendi & Syadiah, [88] stated that fatigue is a major cause of accidents of motorcycles. In another study by Fung, [89], it was reported that innovative technology and integrated environment of vehicles are the primary means of distraction for drivers. In a research by Kim, [90], they observed that the drowsiness of drivers is more serious as it leads to fatal accidents. Based on an earlier study [91], it was found that the increase in stress from workplaces and insufficient sleep plays an important role in the increasing level of fatigue and drowsiness in drivers. In this context, it is noticeable that in reality, drivers get too sleepy or even fall asleep while driving and it is a serious issue for which the consequences are well-known. Other studies by Gold, [92] mentioned that one of the most serious driving problems of the country is the dozing off of drivers while driving on highways at night at a high speed. In a study by Tristan, [93], it was observed that vehicle accidents and distracted driving are the major causes of injuries and deaths on road. Moreover, in a research by Turner & Higgins, [51], it was mentioned that the use of advanced driver assistance systems provides additional information to prevent accidents due alcohol consumption or fatigue and acts as a mean to prevent driving by unlicensed drivers.

4.3.2.2. Contribution of researchers regarding alertness issues. Relying on a study conducted by Truong et al., [85], they contributed to the understanding on the effect of using a mobile phone while riding on motorcycle crash involvement. As per [86], the researchers contributed towards the decreasing of motorcycle accidents due to behavioural changes by examining the association between mobile phone usage and accidents occurrences. Chen et al., [87] demonstrated that the DFD system played a significant role in attaining the objective of improvement of road safety. An earlier investigation by Effendi & Syadiah, [88] was committed which focusing on the issue of the fatigue of motorcycle riders.

Fung, [89] contributed by suggesting boosting techniques on the concentration of drivers. Another study by Kim, [90] was committed with aim of decreasing the accidents frequency caused by drivers' drowsiness. Other investigations by [94] executed a plan to increase the alerts in a motorcycle if it meets with an accident. In addition, as per [92,93,95–99], they contributed to the increasing driver's attention using alarms. Gold, [92] committed in avoiding accidents caused by inattentiveness. Other studies by Henn, [100] suggested to create alertness in the riders of vehicles. Moreover, Muzammel et al., [101] contributed by examining the physiological reactions of riders to the collision warning system at the rear end when audio warnings are activated.

4.3.2.3. Proposed methods to tackle alertness issues. Truong et al., [85] recommended that in the data acquisition in Vietnam from an online survey on university students (741 survey participants), the survey was distributed among the riders of motorcycle of two campuses; Hanoi and Ho Chi Minh city campuses. Truong et al., [86] recommended a web-based survey on university students in Vietnam. The survey covered 741 people comprising of 665 motorcycle riders and 76 non-riders. Chen et al., [87] recommended the donning of a wearable smart glass that runs on a cloud-based platform for detecting drowsiness and exhaustion. Other investigations by Effendi & Syadiah, [88] were carried out in Bekasi in the year 2017 through quantitative techniques and cross-sectional research methods in which 106 participants were selected by random sampling to assess several parameters related to a particular fatigue survey among motorcycle riders for online ojek. In a study by Kim, [90], there was a test for the equipment and a way to determine the driver's drowsiness extent specifically when the persistent closure time of the driver's eyelid is more than First Threshold (DTH), that is, an early warning has been entered and maintained until the persistent closure time of the driver's eyelid is below 1 DTH which is lower than the initial outset for warning the driver regarding drowsiness. On the basis of the earlier investigation by Holt, [94], it was recommended that the tipping sensor should have a V-shaped casing with a pre-set quantity of contained mercury and a pair of probes of sensor wire positioned on the opposite edges of the casing. A time-delay element allows small crashes from occurring in which the safety warning of the motorcycle will not be initiated for a pre-set amount of time, thus providing time for the driver to balance the motorcycle. In case the vehicle is not balanced within the pre-set duration, there will at least be an activation of a visual or an audible alarm. The alarm may include a visible or audible signal such as a flashing tail-lamp, a flashing front lamp, flashing blinkers, a Global Positioning System (GPS) device or a blaring horn. Other experts Ramesh, [91] suggested using intelligent network of wireless sensors to observe and sense the drowsiness of riders in real-time events by a device consisting of several embedded Infrared sensors to track the pulse rate of the driver and determine the extent of the driver's drowsiness. Another investigation by Gold, [92] suggested using a box positioned on the car's dashboard which has a circuit connected to the car's electrical devices. This circuit triggers two signals in sequence, initially a visual warning, and then an audible warning. As per [93], it was suggested to monitor the position of the driver's hands on the steering wheel through a set of sensors located on the periphery of the wheel to create contact between both hands of the driver and the wheel. Other investigations by Jerome, [98] proposed using a pressure sensor around the steering wheel and signal operation which avoids accidental issues with prior delay alarm mechanisms and repositioning of the hands without pausing or rotating the device off. In a study by Rieth et al., [99], it was suggested to use a steer-by-wire in the periphery of the steering wheel to detect the contact between a single hand and the steering wheel of the vehicle. Moreover, according to [97], the researcher proposed using a couple of conducting plates connected to the opposing parts of the circular steering wheel in an arrangement where these plates are located apart from each other. On the basis of an earlier investigation by Gwin, [96], the researcher suggested using a pressure sensor along the steering wheel where a pressure detector is connected to the periphery of the steering wheel, which determines the overall pressure of the hand grip on the wheel. In a research by Gerger, [95], the researcher suggested using a hand grip sensor in the circumference of the steering wheel in which there is a monitor for measuring the alertness of drivers, and it includes a sensor which is connected to the vehicle's system responsible for controlling the vehicle. This sensor senses the fatigue of the driver by measuring the changes in the pressure exerted by the driver on the steering wheel and the control devices. Other studies by Henn, [100] suggested using a protective helmet and a camera which is located on the helmet. This protective helmet has a transparent facial region through where the driver can have visibility and the camera is also located on this helmet.

4.3.2.4. Results obtained by researchers on alertness issues. Truong et al., [85] proved that in Vietnam, 10% of riders use mobile phones for calling while riding on a daily basis. As per [86], the observations indicated that making phone calls while riding a motorcycle was the highest prevalence (74%) whereas irresponsible overtaking was the lowest (33.2%). Other investigations by Chen et al., [87] showed from their outcomes the active capability of processing the related fatigue and drowsiness events to improve road safety. In another research by Effendi & Syadiah, [88], the results showed that the subjective fatigue level had values as follows: high level at 6.6%, medium at 42.5% and low level at 50.9%. Fung, [89] confirmed that when there is an increase in the utilisation of new technology in the vehicle, the driver tends to ignore the main driving task and gets distracted. On the basis of earlier research by Kim, [90], the results were used to determine the drivers' drowsiness. According to [94], the result suggested an increase in the alarm of motorcycle in the occurrences of accidents and upsetting situations. Other experts Ramesh, [91] had presented outcomes with sensing ability of the heart rate and alertness on the driver dynamically or informing of the rescue squad regarding the drowsiness of the driver to prevent accidents. Moreover, in a study by Gold, [92], the results showed an increase in the driver's attention due to alarm. In another investigations by Tristan, [93], the results showed that it is necessary to avoid the uses of cellular phones and other mobile devices. In other reports by Gerger, ([95]; Gwin, [96]; Ronald, [97]; Jerome, [98]; Rieth et al., [99]), the outcomes showed that there is an alarm for drivers which increases the focus of the drivers and also decreases their drowsiness and fatigue. In another study by Henn, [100], the results confirmed that by observing the face of driver using a camera, a dangerous situation can be recognised and a warning can be provided if the situation is hazardous. Lumba et al., [46] confirmed that in the outcome of the Bayesian network model's structure, the probability of exhaustion-related mishaps was 48%.

4.3.2.5. Gaps identified by researchers on alertness issues. Truong et al., [85] had conducted a survey which is dependent on students and only for small analysis sample size. As per [86], the scope of the survey can be improved by covering more university campuses at different locations, unlike the earlier researches that covered only one university. Another research by Chen et al., [87] confirmed that the system gap is dependent on Long-Term Evolution (LTE) or Wireless Local Area Networking (Wi-Fi) which is not applicable for a motorcycle. Moreover, Effendi & Syadiah, [88] do not proceed with the on-going study related to the prevention of accidents at workplace and monitoring of diseases at workplace which might have maintained and increased the health and safety of the motorcycle and cab drivers. On the basis of past researches, Gwin, [96] showed that equipment are likely to have an unforeseen effect for the cause of backbone and neck damages since drivers hold their heads firmly to avoid triggering the alarm accidentally. Furthermore, several drivers do not want to make themselves uncomfortable by putting on the devices. Other studies by Gold, ([92]; Tristan, [93]; Gerger, [95]; Ronald, [97]; Jerome, [98]; Rieth et al., [99]) showed that the system turns on the sounds of the alarm when the indicator or the wiper are used or when the steering wheel is manoeuvred right or left. In a research conducted in Indonesia's Bekasi City, samples encompassed of 238 respondents took part in the interviews [46]. Attributes which affect the likelihood of fatigue-related mishaps are: age factor, long duration of driving, road geometry, road condition, roadside variability and riding time, which were determined using the Bayesian Network Model.

5. Framework of factors impacting rider's behaviour

In this framework, the study classifies and recommends the framework of the injury type of crashes into four sections as follows:

Section 1: According to [102,103], the injuries taken by riders in a crash can be classified into five categories which are known as KABCO, consisting of: fatal (K), serious (A), moderate (B), minor (C) and damage only (O) (refer to Fig. 6, Section 1). The use of KABCO in police crash reports provides a simple and intuitive classification of injuries, however, with significant limitations as well. For example, the injury severity information provided in police reports typically relates to the most severe injury sustained by the rider. In other words, the severity information of the police-reported injury does not typically account for the possibility of multiple injuries on different body parts of a rider. A major police-reported crash injury is different from two major injuries sustained by the rider in a crash. Nonetheless, both crashes will be classified as major injury crashes in police crash reports with no sensitivity to the possibility of multiple injuries to the rider. Even though most motorcycle (or motor-vehicle) crashes involve injuries to more than one body part, the use of scales for describing multiple riders' injuries is still lacking.

Section 2: According to previous researches [104], they developed several models to identify the variables influencing the severity of two-vehicle crashes, and to quantify their effects. These variables are illustrated in Fig. 6, Section 2, and can be classified into three major groups: variables associated with the driving environment and the crash characteristics, demographic or behavioural variables, and variables related to the vehicle attributes.

This study focuses on the behavioural variables group since it represents 95% of traffic accidents [27]. The behavioural variables group includes speeding, alcohol drunkenness, fatigue, drowsiness, attentiveness, drug and medicine consumption, seat belt wearing, wearing of

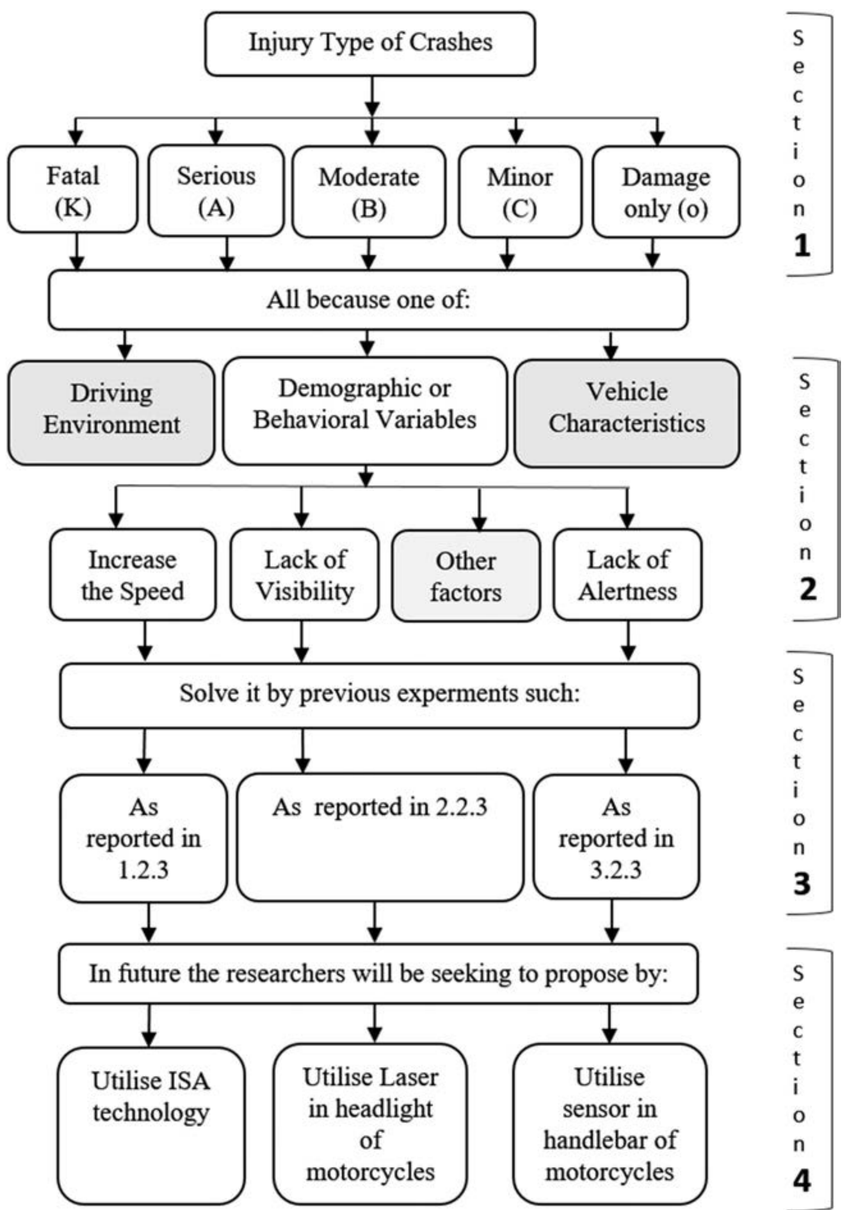

Fig. 6. Framework for the injury type of crashes.

fluorescent jacket and helmet usage [28,29]. In Fig. 6, Section 2, the behavioural variables group is further categorized into four classes; increase speeding, lack of visibility, other factors and finally lack of alertness. This study focuses on the speed, visibility and alertness classes only and not on the other factors class as shown in Section 2 of Fig. 6.

Section 3: In this section, the study demonstrates the works from previous studies and proposes suggestions related to speeding, visibility and alertness issues which are as explained and reported in 4.1.2.3, 4.2.2.3 and 4.3.2.3 of this paper.

Section 4: This section proposes some ideas related to speeding, visibility and alertness issues and ways to solve them and thus are addressed in the future works to reduce accidents. These ideas are illustrated as the future directions as presented below.

6. Conclusion and future directions

The review paper focuses on the riders' behaviour variables related to speeding, visibility and alertness issues as shown in Fig. 6, Section 2. This paper summarizes 104 articles related to speeding issues (22 articles), visibility issues (25 articles), alertness issues (24 articles), and others (33 articles). Most of them were published in the last five years. The riders' behaviour has seen to be enhanced in various places and through different ways as mentioned by previous studies related to speeding, visibility and alertness issues which are as follows:

Speeding issues: The author in Dodge et al., [36] observed that speeding represents 34% of all fatal motorcycle accidents. Whilst Jiménez et al., [58] suggested that by employing the Intelligent Transport System (ITS), a system set with known speed limit, compliance may be increased and road accidents due to speeding can be reduced. However, the use of ITS is not yet fully implemented on motorcycles.

Visibility issues: The author in Davoodi & Hossayni, [41] had proven that the Daytime Running Light (DRL) of motorcycle reduces accidents by 4 to 20%, and the headlight of motorcycle and the use of fluorescent jacket increase the conspicuity of a motorcyclist. Whilst Ranchet et al., [71] had proven that the utilisation of yellow headlight increases the visibility of a motorcycle. However, the efficiency of yellow light is less in the street.

Alertness issues: The author in Lumba et al., [46] had proven that in Indonesia, the probability of fatigue-related accidents was represented to be 48%. Besides, Thi et al., [49] revealed that accidents caused by the distraction due to mobile phone usage to be 9%. While in a study by Tristan, [93], it was suggested to monitor the position of the driver's hands on the steering wheel using a set of sensors located on the periphery of the steering wheel through the contact between both hands of a driver and the steering wheel. This is to reduce the distraction and fatigue of a driver and thus increasing alertness through the produced alarm sound. However, this alarm is only activated once the wiper or signals are turned on.

In Section 3 of Fig. 6, most proposals highlighted on the minimisation of accidents related to speeding, visibility and alertness issues and are explained in this review paper as reported in 4.1.2.3, 4.2.2.3 and 4.3.2.3 respectively.

For future directions, the framework of this study (Fig. 6, Section 4) suggested the increase in the utilisation of intelligent speed adaptation (ISA) on motorcycles to avoid accidents caused by high speed. It was also suggested to apply laser in headlights to increase the visibility of motorcycles. Besides, the use of sensors in the handlebar of motorcycles to increase the alertness of bikers was also proposed. If these concerns are addressed, there will be a drop in the number of accidents related to speeding, visibility and alertness issues, and thus saving riders' lives.

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