FACTORS AFFECTING PEDESTRIAN VISIBILITY AT NIGHT TIME FOR MOTOR CYCLISTS

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Abstract - In Sri Lanka, most of the motorbike-pedestrian accidents happening in the night time are due to the insufficient visibility of pedestrians. Even though number of researches has been carried out globally regarding improving pedestrian visibility at night for other vehicles, unfortunately few researches have been carried out for motor bikes. In this study, factors affecting the recognition of pedestrians at night such as clothing colour of the pedestrian, rider's age, rider's gender and head light beam condition of the motor bike are considered. For this study white, black, green and red colours were considered as pedestrians clothing colour and four age groups of riders were taken into account. Moreover, head light beam condition of the motor bike was also regarded as head or dim. Experiment was carried out to find the visibility distances in relation to above mentioned factors and data collection method was time duration method and visibility distances were calculated with the help of measured time duration and speed of the motor bike. Experiment was carried out for constant speed of 30 kmph. Findings revealed that the rider's pedestrian recognition distance is affected strongly by the clothing colour of the pedestrian, head light beam condition of the motor bike and rider's age. Rider's gender does not affect pedestrian recognition distance strongly. It was also revealed that Black pedestrian clothing cannot be identified by the rider at a long distance in comparison to other colours. Meanwhile, green and red pedestrian clothing were identified in average distances. Findings showed that white can be identified by the rider at a longer distance than any other selected colours. Furthermore, statistical models were derived for visibility distance in the functions of considered factors.

Keywords- Pedestrian visibility, road safety, motorcyclists

I. INTRODUCTION

Most of the night time motor bike to pedestrian accidents will occur when riders fail to recognize the pedestrian at a reasonable distance. Because rider need some time to apply the brake which is called as 'perception-reaction time'. Within this reaction time period, motor bike moves a certain distance. So that there can be happen a collision. To avoid this situation, rider must have to recognize the pedestrian at a reasonable distance In Sri Lanka, most of the roads are deadlier at night rather than day time. Because in many areas in the country has no enough light condition to recognize a pedestrian at a reasonable distance.

The most efficient way to enhance the pedestrian visibility at night is by increasing the environmental lighting by means of street lights. It will help riders to recognize the pedestrians at a reasonable distance. But when it comes to rural areas where traffic congestion is relatively less, but vehicle speed limit high places, street lights are not common, and it is very much impractical to install. In that context, the aim of this research is to find out the contribution of other factors which affect to the pedestrian visibility at night. This research is going to be carried out to find out the relationship between recognition distance and the affecting factors.

Since there are many factors which affects to pedestrian visibility at night, I have selected only four major factors to this study. They are clothing colour of the pedestrians, age of the rider, gender of the rider and head light beam condition of the motor bike. In this study I have given the priority to the pedestrian's clothing colour in this study.

II. LITERATURE REVIEW

A study conducted by Rachel Rosenberg (2010) to practically examine the hypothesis which was predicted that there would be a main effect for head light intensity such that higher illumination intensities show larger estimated distances compared to lower intensities and also it was predicted that there would be no interaction between clothing and head light intensities on the estimated recognition distance. For this study he had considered 4 different head light beam conditions such as max, high, medium, low and four different pedestrians clothing colours. The considered clothing colours are street, black, white and retro-reflective vest. This study mainly focused on a situation in which a pedestrian is walking along a road way. To increase the accuracy of the results, pedestrians were randomly assigned and walking order of the pedestrians was varied (Rosenberg 2010).

48 participants were taken to this study and a set of questions were given to participants to evaluate their estimation. A mixed model 4 X 4 ANOVA revealed a main effect of clothing, indicating that when averaged across the 4 headlight intensity groups a significant difference in estimated recognition distance among the 4 clothing types was present. Data collection method was direct length measurement using road 4 tracer.

A research which was done by David Shinar in 1984 to examined the relationship between pedestrians' actual night time visibility and their estimated visibility distance with respect to head light beam, reflective tag and glare light. For this research he has taken 19 participants. Methodology of that research is similar to the current research and here he has collected time durations to calculate the visibility distances since vehicle speed was kept constant at 36km/h. His data analysis method was also same as the Rosenberg's study. Data analysing method was two-way analysis of variance of visibility condition i.e. actual vs. estimated visibility distance (Shinar 1984).

Newstead and D'Elia has carried out a study to identify the relationship between vehicle accidents and the vehicle's colour. Their study location was Victoria and West Australia. Here they have considered two independent variables such as vehicle colour and light condition. D'Elia investigated 17 vehicle colours. They are black, brown, blue cream, gold, green, fawn, grey, mauve, maroon, orange, purple, red, pink, silver, yellow, and white. As I above mentioned, they have considered two light conditions, consisting of daylight condition and combined dawn and dusk conditions.

According to the results of his research for the daylight condition, blue, red, silver, gray and black vehicles had the highest crash risks in ascending order. Also, for the dusk and dawn condition, silver and black vehicles had the highest risk in ascending order at 5 percent significance level (AngeloD'Elia 2010).

Another similar research found which was done by Patrick Rosopa about accuracy of drivers' judgments of pedestrian conspicuity while facing varying degrees of headlight glare. He also carried out an experiment using 21 participants. He has selected the participants by considering driving experience and their gender. In this study two independent variables were manipulated within-subjects. Patrick Rosopa has considered about two pedestrian clothing colour and three different glare intensities. The field study was done in an open two-lane roadway with relatively low traffic density. All the Participants in experiment have given a response keypad which connected to a laptop. When the particular response button was pressed, the distance between the test vehicle and the glare vehicle or pedestrian location was calculated with the help of the measured vehicle speed. The test vehicle had maintained a constant speed of 35mph. (Rosapa, et al. 2012).

III. METHODOLOGY

To carry out this study the location was selected by considering the street lights availability and the traffic congestion. Experiment was planned to do in a relatively less traffic congestion area at night. Sitinamaluwa-Aluthwewa-Mulana road was selected for this study since there is no any street lights and have relatively low traffic congestion at night. Moreover, this road is an unlighted road. It was helpful to reduce the disturbance which can be occurred by environment lights. Because study was planned to carry out in dark environment condition and the only lighting condition as motor bike's headlight beam. This road is 3.5m width and there is no any significant building or anything which disturb the experiment and both side of the selected road section were coconut crops.

Here only considered four pedestrian clothing colour for the study. They are black, red, green and white. These colours were selected for this experiment because in Sri

Lanka these colours are widely used as clothing colours. For this study, used that above mentioned four different colour t-shirts and same dark blue colour bottom for every pedestrian as their clothing condition. Same time no any gloving or shining jewelleries or watches worn during the experiment.

For this study only considered two main headlight beam conditions which are called as head and dim. Environment light condition used as dark surrounding, without street lights and any disturbing light source.

The participants were selected by considering their age and their gender. Seven male participants and three female participants were selected for the experiment. Moreover, these participants were divided in to four age categories such as 15-29, 30-44, 45-59 and 60-74 years of age groups. All participants have valid Sri Lankan driving license and all are having minimum four years of driving experience.

This experiment was planned to do with a same motorbike for all the participants. Because there can be different light conditions for different bikes. Because of that reason the visibility distances which measured in the study would be deviate. So, using a same bike for every test ride can avoid that error. Since here considered about the gender of the participants, a common motor bike which can operate by male and female participants had to be selected. Therefore, a scooter was selected as experiment vehicle.

The experiment was carried out and collected the data in above mentioned location by considering previously discussed factors. When it comes to the procedure of this experiment first of all, collected the details of every participants such as age, gender and driving experience. Then randomly selected two participants, one as rider and other one as pedestrian. Next kept the pedestrian with a certain clothing colour at a clear point of the road and the other participant was asked to ride the motor bike at the speed of 30 km/hr and maintain the constant speed as much as possible. And also head light beam condition also kept as head or dim condition. When rider confidently see the pedestrian, he or she may have asked to press the horn and same time the stop watch was started. Stop watch was operated by another person in the motor bike back seat. After motor bike passed the pedestrian, rider again sound the horn and, time duration between two horn sounds was measured by the observer in back seat.

Similarly, the same procedures were carried out for the different pedestrian clothing colour and different head light beam conditions. All participants were involved into the same procedures. Same time the pedestrian's location was changed for every test ride because if the pedestrian placed on an exact location the rider may expect the pedestrian from there for every test ride. So, it will affect to find the real visibility distance. Moreover, pedestrian clothing colour was changed without informing the rider. So, the rider did not know what the pedestrians clothing colour is until he really see the pedestrian. There need to be done eight test rides for each participant and all together 80 test rides were done. The test rides were recorded by a quality video camera and time durations were measured by a stop watch.

IV. RESULTS AND DISCUSSION

To find the relationship between age and the visibility distance I have divided all the test results in to four age categories. The age categories are 15-29 year, 30-44 years, 45-59 years and 60-74 years. All groups have given a representing code number 1 to 4. There was at least one participant for each age group.

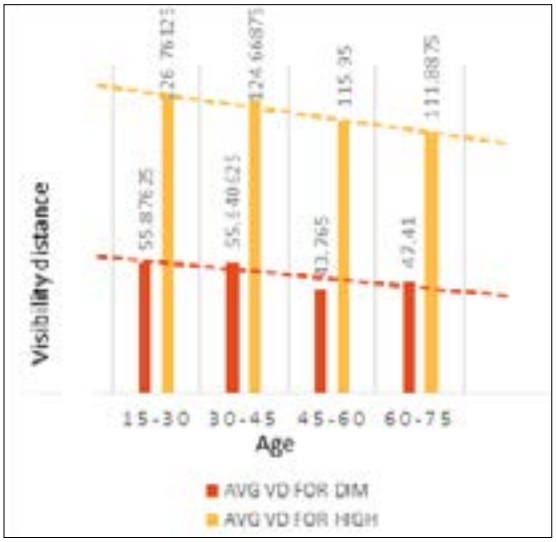

Figure 1. Age Vs Visibility distance graph

To find the relationship between gender and the visibility distance I have separated the test results in to male and female. There were three female participants and seven male participants. Since I wanted only to identify the

relationship between gender and visibility distance I did not considered any other factors except the gender. Here I have given two code values for these two groups, No 1 as female and no 2 as male.

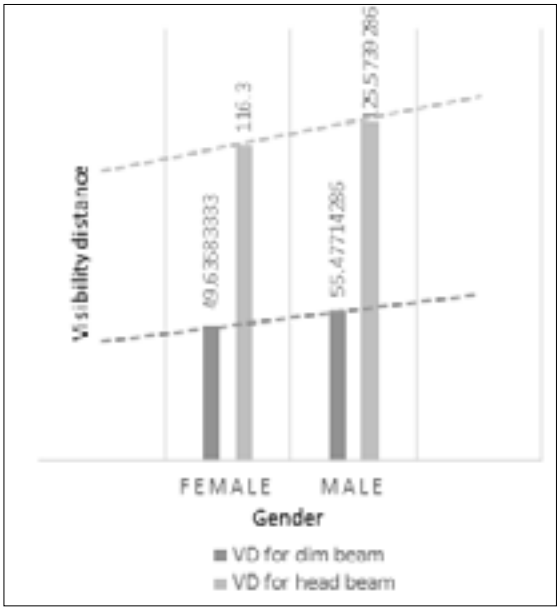

Figure 2. Gender Vs Visibility distance graph

In this research four different types of pedestrian clothing colours were considered. For each colour, average visibility distance was calculated. The colour code values were given in the ascending average visibility distance order. Values were given from 1 to 4. Black, green, red and white respectively 1, 2, 3 an4. These procedures were carried out for high and low beam conditions separately.

After carry out the descriptive analysis it was identified as all four factors have a linear relationship between visibility distances. A function for visibility distance was derived in terms of those four factors using multi regression theory. The multi regression analysis was carried out by using Microsoft office excel software. Visibility distance is selected as the dependent variable and all other four factors (rider's age, rider's gender, head light beam condition of the motor bike and pedestrian clothing colour) selected as independent variables.

Y=(-4.97"X1")+(9.62"X2")+(11.75"X3")+(69.63"X4")-52.17

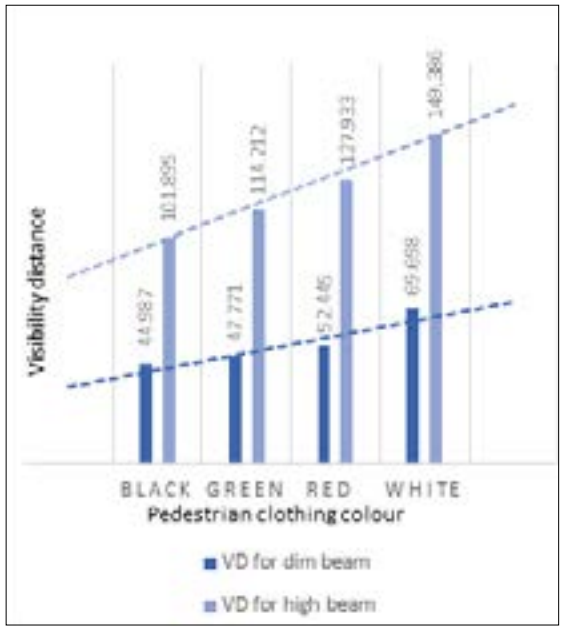

Figure 3. Pedestrian clothing colour Vs Visibility distance graph

In this statistical model Y is representing as the visibility distance in meters." X1", "X2" , "X3" and "X4" the independent variables." X1" Is representing as given value for the age groups. It varies from 1 to 4. Age 15-29 as 1, 30-44 as 2, 45-59 as 3 and 60-74 as 4." X2" Represent a given value for gender groups and it has only two groups which no 1 for female and no 2 for male." X3" Represents the given value for the pedestrian clothing colour. Since I only used four clothing colours for this study its value is varying from 1 to 4 and value 1 for Black colour group, 2 for green colour group, 3 for red colour group and 4 for white colour group. The last independent variable "X4" is representing as the given value for the bike's head light beam condition. Here I only considered two main light conditions which are head light beam and dim light beam. Values given as 1 for dim light beam and 2 for head light beam.

To check the accuracy of the model there selected twenty test results and their estimated visibility distances randomly. When selecting those twenty test results it had taken ten test results for dim light beam and ten test results for head light beam. After that selected actual visibility distances were plotted on a graph against their estimated visibility distances by the developed statistical model.

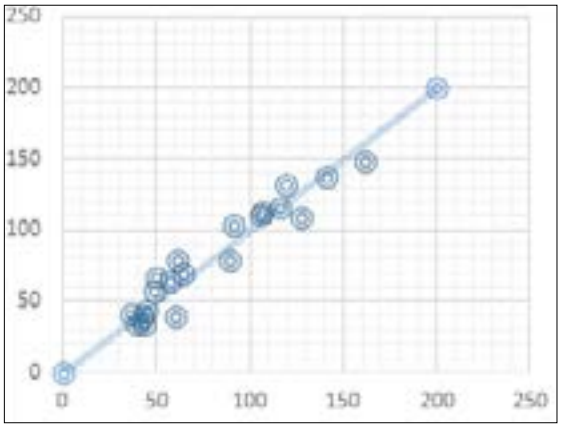

Figure 4. Actual visibility distance Vs Estimated visibility distance graph

Above derived statistical model results show that predicted pedestrian visibility distances have no any significant deviation with actual pedestrian visibility. There were few outlier data and those data were removed from the model to increase the accuracy of the model.

The visibility distance estimating model was derived with the assumption of linear variation between visibility distances with each factor. Also, due to the time limitation a limited number of participants and limited numbers of pedestrian clothing colours were used for this study. It could mainly affect the final output. Because it could have some errors in the assumption of linear variation with limited number of data. There could be some other multi regression variation between each factor. Other than that, experiments were conducted in four different days with same weather condition and same light condition.

This study mainly focused on the factors which affect pedestrian visibility at night for motor cyclists. The results strongly demonstrate that the clothing colour of pedestrian, head light beam condition of the motor bike, age and the gender of the rider significantly affect the visibility distance of pedestrian in night times. Moreover, the graphs which were developed against visibility distance and above considered factors, all the considered factors has a linear relationship between visibility distances.

The clothing colour of the pedestrian is the most significant factor which highly affect to pedestrian visibility at night among all other considered factors. Black colour pedestrian clothes had the lowest recognition distance among the considered four colours. Green colour and red colour had no significant low or high recognition distance. When compared to other colours white colour had a significant recognition distance. Head light beam is also had a significant effect on recognition pedestrians at night. Moreover, pedestrian clothing colour is highly affect visibility distance when using head light beam more instead of using dim light beam. Overall, changing from low beam to high beam improved visibility distances in all cases.

In two head beam conditions, rider's age was a good contributing factor of visibility distance. It could be possible when age increasing means the rider getting older. Normally with the age, people' eye vision decreases. By this effect age may affect the visibility distances significantly. When compared to the age factor, gender factor is not affect to the visibility distance significantly.

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V. CONCLUSIONS

- When considering the results of the regression analysis, Developed statistical model is accurate enough to estimate the pedestrian visibility distance with relevant to considered factors. Since the R square value was 0.91, accuracy of the developed model was ensured.
- Rider's pedestrian recognition distance is affected strongly by the clothing colour of the pedestrian, head light beam condition of the motor bike and rider's age. Rider's gender does not affect pedestrian recognition distance strongly.
- Black colour pedestrian clothing cannot be identified by the rider at a long distance than other colour. Meanwhile green colour and red colour pedestrian clothing can be identified in average distances. White

colour can be identified by the rider at a longer distance than any other selected colours

- White colour dress is safer in night for pedestrians and people who wear black should be aware of their visibility to the vehicles in night. Moreover, not wearing dark colour cloths at night increases pedestrians safety
- In high beam condition, clothing colour was the most highly affecting factor in the recognition of pedestrian in night
- In low beam condition or high beam condition, rider's gender was not a significant factor in recognition of pedestrian in night
- Riders age is also highly affect to the pedestrian's visibility at night. Older age riders should aware about the speed of the motor bike at night time due to low recognition distance
- Overall, changing from low beam to high beam improved visibility distances in all cases

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