DEVELOPMENT OF SERVICE PERFORMANCE MODEL FOR EXCLUSIVE MOTORCYCLE LANES

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ABSTRACT: *One of the challenges to the planning of transportation is the development of road performance that properly reflects the level of service. The road performance measure or level-of-service scale currently used in the HCM 2010 has basic calculations for motor vehicle, pedestrians and bicycle, but there is no method to use for motorcycle, so this paper assessed rider perception of performance of exclusive motorcycle lane to objective measures of service performance model. Data for the model using field data and video surveys were collected in three exclusive motorcycle lanes in Malaysia. The video surveys data consist of participants' perceptions of comfort, convenience, safety, manoeuvrability, and operational characteristics of exclusive motorcycle lanes. For this reason fifty video clips from a viewpoint of a motorcyclist riding were used. Total 261 participants who were randomly selected contributed in this study and filled out survey forms. Each participant saw ten video clips and ranked them on a scale from 'Excellent to 'Very Poor'. The data were analyzed using a logistic regression model. The result show model is good reliable and has a good correlation coefficient (COX=0.72). Also the important factors to rider perceived road performance were motorcycle speed, total lane width, motorcycle volume and pavement surface quality.*

The outcome provides guideline for engineers and transportation planners to evaluate different design options by changing the independent variables to find the best combination of factors to achieve the desired road performance. Also existing roadways can be evaluated to determine the present performance level or level-of-service on all segments. On the other hand, this study is also seen as filling the existing knowledge gap between the various types of land transportation amenities and facilities such as pedestrians, bicycles, and vehicles which provides the state service performance index or level-of-service (LOS) of motorcycle facilities.

KEYWORDS: Road performance, Exclusive motorcycle lane, Level of service, Video survey, Logistic regression

1. INTRODUCTION

The level-of-service (LOS) is an important measure of performance in analyses of transportation facilities. The concept of level-of-service (LOS) is widely recognized worldwide and popular in traffic and transportation engineering operations as a service performance [1]. It is used in the Highway Capacity Manual (HCM) to represent the quality of service (QOS) and or corresponding satisfaction indices provided by a transportation facility as perceived by the users or customers [2]. It is used to evaluate the performance of road, identify the existence of traffic problems, evaluate traffic improvement, and communicate with decision makers and citizens.

The standard calculation of measure of performance or level-of-service is based on a methodology in the Highway Capacity Manual 2010 (HCM) [3]. The HCM describes level-of-service (LOS) as "A qualitative measure describing operational conditions within a traffic stream, based on service measures such as speed and travel time, freedom to maneuver, traffic interruptions, safety, comfort, convenience and the driver's perception of those conditions." LOS is divided into six categories, A through F in the 2010 HCM. LOS A indicates excellent service and LOS F indicates extremely poor service. The HCM 2010 provides methodologies for estimating the level-of-service and capacity for both uninterrupted and interrupted transportation facilities. For each facility there are one or more performance measures, which characterize the user's perception of the operating conditions of that facility.

In recent years, several studies have been undertaken to develop users' perception of performance or level-of-service for automobiles, bicyclists and pedestrians. These efforts have included the development of models based on the geometrics of roadway segments and other variables. Some researchers have focused on auto driver perceptions of quality of service for urban streets, signalized intersections, and rural roads. Researchers have used field surveys and video survey and have interviews to identify key factors affecting perceived performance or level-of-service for different field conditions [4-7].

Also previous studies have shown various methods to describe the level-of-service provided to bicyclists and pedestrians. The majority base their methods on either the separate or combined works of Landis, Sorton, Harkey, Jensen, and Petritsch [8-12]. The one missing element in each of these studies is the lack of recognition of the motorcyclists' perception of performance.

Motorcycle is an important and popular transportation tool that is unique in comparing to other areas of the world. In many Asian countries, motorcycle is as a main vehicle for transportation mode. This transportation system will have significantly reduced delays, and congestion, but the motorcycles due to other vehicles are one of the most dangerous one in accidents. This problem severe when high proportion of motorcycles is in the mixed vehicle population. Studies have proven that segregation is the best engineering method to safe motorcyclists [13].

At present, there are no specified standards available for assess motorcycle service performance or level of service of an exclusive motorcycle lane. Also very little empirical research has been conducted regarding the traffic operation of motorcycles up to now. The result of this paper provides a valuable tool for assessing motorcyclist service performance and approach to level-of-service (LOS) for motorcyclist in exclusive motorcycle lanes. This paper details the research design, data analysis and model development performed.

2. Research Objective

The main objective of this study is to develop the model of service performance for exclusive motorcycle lane that describe the motorcyclists perception of their riding experience along the exclusive motorcycle lanes. This study addressed that question by asking motorcycle riders to rate the quality of segments of exclusive motorcycle lanes. The following tasks were carried out in supporting the above research objective.

1) To determine factors affecting motorcyclist perception of exclusive motorcycle lanes
2) To determine the impact of age, experience and gender of participants on road performance

3. METHODOLOGY

A review and assessment of alternative methods result to select of video surveys method as methodology. The use of video surveys methodology to obtain ratings from bicyclists, vehicles and pedestrians has been found to produce consistent results in previous studies [4,5,8,9]. The results of the survey were then analyzed using regression equation to determine the service performance model. This is unique approach that enable direct from the motorcycle riding to be used to establish the characteristics that most influence perceived performance. Video survey provides the ability to control and allows for repeated survey to different groups. It also provides a safe testing environment, and is reducing the unit cost of data collection.

Two hundred sixty one motorcyclist as a participants in a classroom setting viewed rated video clips of exclusive motorcycle lanes. Videos were projected on a large screen and participants were asked to rate each clip on a scale from one to six (excellent to very poor) immediately after viewing it. Computer speakers were used to provide sound.

This research evaluated motorcycle service performance or level of service under ideal condition along the exclusive motorcycle lanes. Therefore, in order to reduce the variation in the analysis for this basic research, the sites only considered the straight and level basic segments along the exclusive motorcycle lanes in state of Selangor, Malaysia. The choice of the study sites along the motorcycle lane were governed by the availability of high positions or concealed locations such as the pedestrian overhead bridges of high grounds. All observations are conducted good day time weather conditions.

3.1 Data Collection

As the methodology used for this study was heavily dependent on data, the sites need to be selected carefully and able to collect the relevant data for analysis. On the other hand, in consideration for a basic study in motorcycle traffic sciences, the study began with focusing on the ideal condition. This was done to help the population sample focus on the geometric and operational conditions while reducing their focus on additional physical discomfort or comfort that might be caused by visible uphill or downhill roadway segments. Considering the site selection criteria, only the straight and level segments along the exclusive motorcycle lanes have been selected.

Federal Highway F02, Subang Jaya and Putrajaya-Cyberjaya Expressway in Malaysia were the best sites for data collection. These sites have high volume traffic, different lane widths (3m ..., 3.85m), different motorcyclists speed, long stretch, and different surface pavement quality (Fig. 1).

Fig. 1. Study Site at F02 Highway, Selangor (W= 3m)

In the first stage, only low traffic volume conditions were observed, since there weren't high traffic volumes even during the peak hours. However, it is presumed that high traffic flow conditions might occur if the motorcycle's lane widths were made narrower than 3 metres (normal total exclusive motorcycle lane width in Federal highway in Malaysia), and coupled with significantly higher motorcycle traffic flow.

In order to get such situation with considerably high motorcycle traffic flow, and motorcycle lane widths narrower than 3m, new experimental studies were conducted. These studies involved motorcyclists riding along the level and straight basic segments of a road which were narrowed down on the left-side by using safety cones over a length of 500m, while the right-side were obstructed by the road kerbs. Eight different lane widths were reduced from three metres width on the federal highway. These new experimental studies were carried out on a 500 m segment motorcycle lane along the Federal highway F02, Selangor near Seri Setia plaza with the assistance of staff from Highway Maintenance Company.

There were eight different experimental lane widths in total namely, 1.5m, 1.6m, 1.8m, 2m, 2.2m, 2.4m, 2.6m and 2.7m (Fig. 2). Motorcyclists considered width less than 1.5 m as dangerous and hesitate to ride there. The steps were chosen as increments of 20 cm, as increments less than 20 cm were not noticeable enough to motorcyclists. Similar to the first experiment, the motorcyclists riding behaviour and traffic flow were digitally captured; meanwhile the motorcycles' speeds were recorded by a laser speed detector. Then additional video clips, which made a total of 50 video clips with a wider range of different conditions, were prepared and developed to be shown to participants.

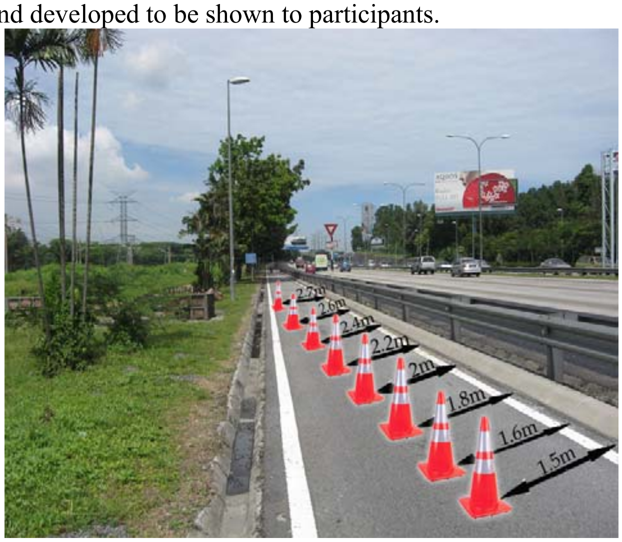

Fig. 2. Eight Lane Widths

Data collection effort was the conduct of two steps: field data and video survey data. Field data involved gathering motorcycle volume (mc/hr), total lane width (m), motorcycle speed (km/hr), and Pavement Condition Rating (PCR). To measured speed, used portable laser speed detector that installed on top of the pedestrian bridges nearby the study site and one camera recorded the speedometer (Fig. 3). The total paved width of motorcycle lanes were measured in metres by using a horizontal distance measurer (Trumeter). Pavement quality evaluate base on PCR standard [14].

Fig. 3. Volume and Speed Collection

3.2 Creation and Develop of the Video Clips

The next step of the data collection effort was the conduct of the video survey. The video survey was used to find how road users perceive performance at exclusive motorcycle lanes. Before the video survey, many video clips prepared. In this method, the video camera was mounted on shoulder of recorder assistance in the back seat of the motorcycle that riding along the exclusive lane and was used to provide a video and audio. Recorder assistance captured from eye level of motorcycle rider position (Fig. 4).

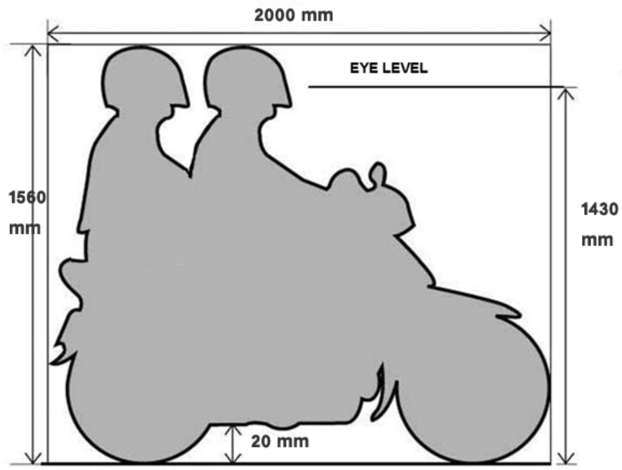

Fig. 4. Captured on Videotape from Eye Level

After the capturing & videotaping from eye level of motorcycle rider position, the video edited and prepared short video clips for survey. The clips were replayed and motorcycles volumes counted. For each video clips, speed and volume of motorcyclist measured the same time. The manual tally-counter was used to count the number of motorcycles passing across the lane as observed on the computer screen. The video clips depicted the road in approximately 500 metre segments, with a presentation length 30 seconds. In all, fifty video clips provide for this research.

3.3 Video Survey Data

The survey began with some background information for each participant regarding the study, including the objectives of the research effort and factors to be significant in influencing perceived trip quality. Also, instructions for completing the video survey were read to them, and questions were answered to further define or clarify the process.

The first stage of the survey included personal information, such as experience level, age, type of motorcycle they use. Also, the participants were asked to make a listing of all the factors that considerably affected their ranking. The second stage the participants were shown the ten video clips from a rider's view that projected onto a large screen. Each participant was asked to rate on a scale from 1 to 6 where 1 represents "Excellent" and 6 represents "Very poor" in terms of overall performance with respect to the motorcycle volume, total lane width, motorcycle speed and pavement surface quality plus any other measures that they considered important in determining their overall performance level as a motorcyclist (Table 1). A practice clip was shown first to familiarize participants with the task at hand.

Table. 1. Rating Scale

Rating	Road Performance
1	Excellent
2	Very Good
3	Good
4	Fair
5	Poor
6	Very poor

3.4 Selection of Participants

This research was used simple random sampling. With simple random sampling, each sampling unit in a frame has an equal probability to be sample. This study consist two hundred sixty one participants. Participants ranged in age from 18 to 42 and were composed of 42 percent females and 58 percent males.

The average age of the participants was 24 years. None of the subject who participated was under the age of 18. Seventy four percent of the subjects in the 21 to 25 age group. The remaining 26 percent of the subjects were distributed among the 18s to 45s age groups. Normally, a motorcycle is considered to be more appealing to the young people. The age distribution is shown in figure 5.

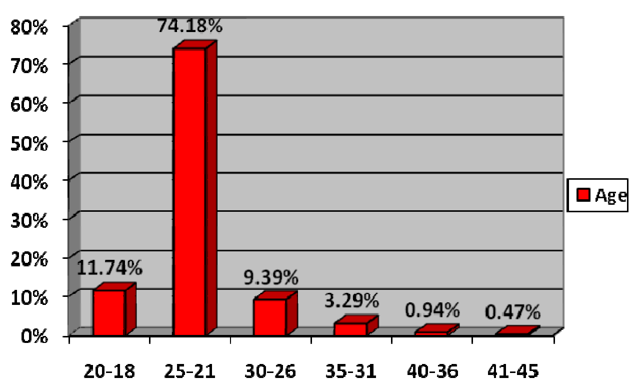

Fig. 5 Age Distribution of Participants

3.5 Multinomial Logistic Regression Model

Data collected on overall user perceptions (dependent variable) from the video surveys are typically ratings on a scale from 1 through 6. Such ratings are not continuous but discrete and ordinal. The best model that appropriate for modelling discrete, ordered response variables is multinomial logistic regression. Multinomial logistic regression has ability to predict the probability of responses in each LOS based on combination of explanatory variables. Logistic regression analysis is proper way to predict model when the dependent variable is qualitative rather than quantitative.

Multinomial logistic regression with J categories and I explanatory variables cab be expressed directly in terms of the response probabilities, π_j as shown in equation 1 [15].

$$\pi_j = \frac{\exp(\alpha_j + \beta_{j,i} X_i)}{\sum_h \exp(\alpha_h \mid \beta_{hi} X_i)} \qquad (1)$$

j = 1,…, J-1 , h = 1,…, J-1 and i = 1,…,I

Where h is the total number of response categories. In this study, the response categories are1,2,...,6 correspond to level of service A, B, C, D, E, F. The explanatory variable used in the model are motorcycle speed, motorcycle volume, total lane width and pavement surface quality.

As in Multinomial logistic regression, π_j represent the probability of an event that depends on I or independent variables. To obtain the corresponding logit function from this, we calculate (*j* represent the whole set of covariates ($X_1, X_2, \ldots, X_I$):

$$\text{Logit}[\pi_j] = \text{Ln}\left[\frac{\pi(j)}{1-\sum \pi(j)}\right]$$

$$= \text{Ln}\left[e^{\beta 0 + \beta 1 X1 + \beta 2 X2 + \cdots + \beta i Xi}\right] =$$

$$\beta 0 + \beta 1 X1 + \beta 2 X2 + \cdots + \beta i Xi \qquad (2)$$

So, that the logit of the probability of an event given *j* is a simple linear function. To summarize, the basic equations of multivariate logistic regression are:

$$\pi_{(j)} = \frac{e^{\beta 0 + \beta 1 X1 + \beta 2 X2 + \cdots + \beta i Xi}}{1 + \sum e^{\beta 0 + \beta 1 X1 + \beta 2 X2 + \cdots + \beta i Xi}} \qquad (3)$$

Where π_j represent the probability of an event, β_i are regression coefficients, and X_I are a set of predictors. Which gives the probabilities of outcome events given the covariate values $X_1, X_2, \ldots, X_I$, and

$$\text{Logit}[\pi_j] = \beta 0 + \beta 1 X1 + \beta 2 X2 + \cdots + \beta i Xi \qquad (4)$$

4. RESULTS

4.1 Significant Factors that Affect on Motorcyclists Perception

The focus of the study was to predict a model that described overall rider perception of service quality on exclusive motorcycle lanes, and the extent to which factors present on it influence rider ratings. As explained before, a survey of participants was used to determine what factors to be significant in performance of exclusive motorcycle lanes.

A wide variety of factors were tested and analysis. Based on findings, the most influential factors to rider perceived service performance were motorcycle speed, total lane width, motorcycle volume and pavement surface quality.

4.1.1 Speed

The most important factor to riders was revealed to be able to maintain their desired speed. Speed or rate of motion is defined as travelling distance per unit time. Each motorcycle moves at a different speed in a moving traffic stream. Therefore, the traffic stream involves a distribution of individual motorcycle speeds and does not have a single characteristic speed to characterise the traffic stream. The 85th percentile speed is often used as the principal criterion and engineering judgment and the consideration of other factors often results in the establishment of arbitrary speed limits that do not reflect travel speeds.

Result show 74.5% of participants mentioned that motorcycle speed is an important factor that affects road performance ($p< 0.05$) and for 95 percent confidence level, the proportion of participants that mentioned speed is an important factor was between 87% and 62%. Also Figure 6 shows there is a relationship between the score speed and the value speed. Based on the results, if speed decreases the score of speed is an increase.

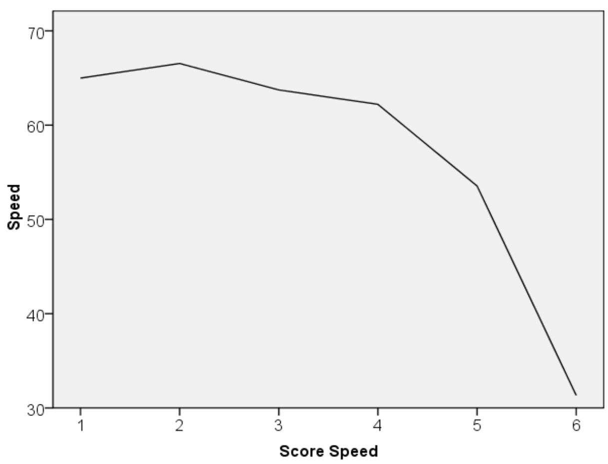

Fig. 6. Relationship between Motorcycle Speed and Score Speed

4.1.2 Volume

Participants also indicated that the motorcycle volume is the important factor to riders. The number of vehicles that passed during a specified time interval at a point on a highway or a given lane in a direction of a highway was designated as the traffic volume [3]. In terms of traffic volume, the general consensus for traffic design and analysis is the hourly volume.

Result shows 78.7% of participants mentioned volume is an important factor that affects road performance ($p< 0.05$) or for 95 percent confidence level, the proportion of participants that mentioned volume is an important factor was between 90% and 67%.

Figure 7 shows the relationship between the measure of volume and the score volume of the survey participants. Based on the results, if volume increases the score of volume is an increase. Logically, a low volume was indicated a better performance ranking and an increase in traffic volume, increased the performance index, and resulted in a worse performance ranking, suggesting less comfort for the motorcyclist. Participants said that they had felt having more options to manoeuvre in different traffic situations.

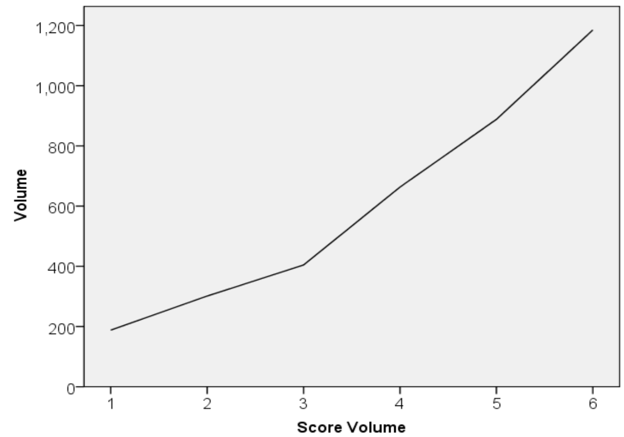

Fig. 7. Relationship between Motorcycle Volume and Score Volume

4.1.3 Pavement Quality

The third important factor to riders was the pavement quality. The smoothness of the road surface affects different factors such as the comfort, safety and speed of motorcyclists. Pavement surface irregularities can do more than just make a ride unpleasant. Pavement surfaces should be smooth, and the pavement should be uniform in width. Result show 80.9% of participants mentioned pavement quality is an important factor that affect on road performance ($p< 0.05$) also for 95 percent confidence level, ratio of person that mentioned pavement quality is an important factor was between 92% and 69%.

Figure 8 shows the relationship between the measure of pavement quality and the score pavement quality of the survey participants. Based on the results, if pavement quality increases the score of pavement quality is an increase. Obviously, the low pavement quality was indicated as a worse road performance by participants. In other word, if pavement condition rating increases the performance index is an increase.

4.1.4 Lane Width

Lane width played a factor in determining how much space was available to make passing manoeuvres and also affects the lateral spacing between two motorcycles, and it was also affects the motorcyclist's sense of freedom to manoeuvre. Result show 65.9% of participants mentioned motorcycle volume is an important factor that affect on performance ($p< 0.05$) or for 95 percent confidence level, the proportion of participants that mentioned lane width is an important factor was between 79% and 52%.

Figure 9 shows the relationship between the measure of lane width and the score lane width of the survey participants.

Based on the results, if lane width decreases the score of lane width is an increase.

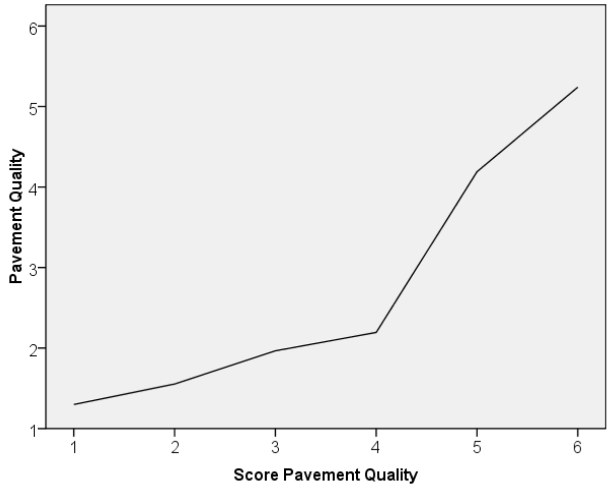

Fig. 8. Relationship between Pavement and Score Pavement

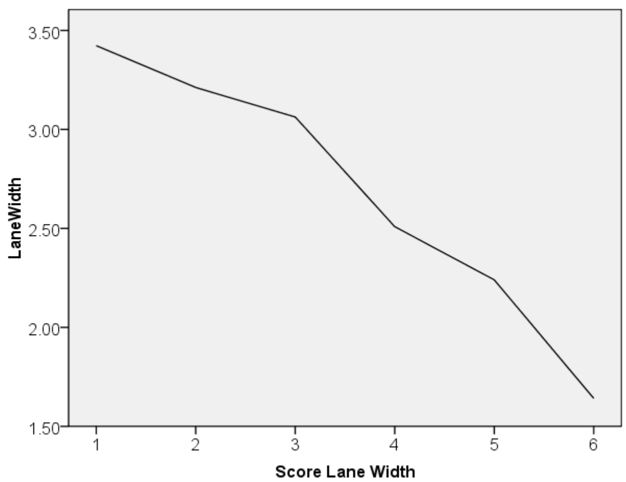

Fig. 9. Relationship between Lane Width and Score Lane Width

4.2 Impact of Demographic on Perception of Road Performance

By viewing exactly the same video clip, the difference between two groups also rider characteristics, including age, experience and gender can compared. For example, expert riders may emphasize comfort more so than low expert riders. To determine whether the age or gender or experience of the rider in this study affected overall performance, three tests have been performed.

First, a statistical comparison was made between the mean motorcycle scores for females versus that of males. The means and standard deviation were respectively, 5.77 and 0.43 for female motorcyclists and 5.32 and 0.77 for male motorcyclists. The computed t-test (2.57) was significant at a = 0.05 (Table 2). At the 0.05 significance level, females graded worse (more severely) overall than males (5.77 vs. 5.32, p=0.01). The 0.05 level of significance (i.e., 95% confidence level) was used throughout the paper for statistical analysis. Table 2 shows male and female respondents differed significantly in their perceptions of overall.

Table. 2. Independent Samples Test (Impact of Gender)

		Levene's Test for Equality of Variances		t	df	Sig. (2-tailed)
		F	Sig.			
overall	Equal variances assumed	12.798	0.001	2.286	44	0.027
	Equal variances not assumed			2.572	43.268	0.014

The second test was for perception differences associated with motorcycle experience level (as determined by number of years travelled as a measure of experience). There was a significant difference in grading between those who less than 2 years experience as a casual rider and those who 2 years or longer as an expert rider (Fig. 10). Also the results show participants who were 30 years or younger graded same like older participants (Table 3). So the only gender and experience had statistically significant effect on subjects' ratings and rankings.

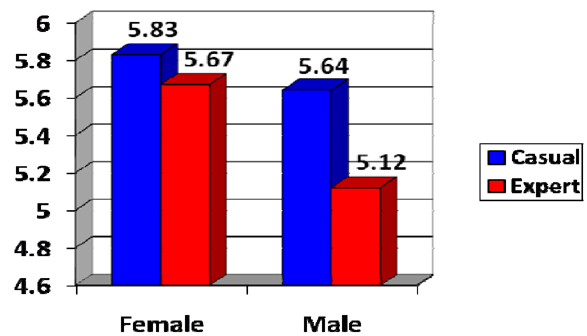

Fig. 10. Effect of Experience on Overall Perception

Table. 3. Independent Samples Test (Impact of Age)

		Levene's Test for Equality of Variances		t	df	Sig. (2-tailed)
		F	Sig.			
overall	Equal variances assumed	3.722	0.060	1.047	44	0.301
	Equal variances not assumed			0.520	1.020	0.693

4.3 Ranges of Variables Included in the Model

The study design yielded 13050 (261*10*5) scores coincident with a myriad of roadway conditions and traffic throughout this research. The resulting data was compiled into both spreadsheet and SPSS program databases for extensive analyses.

Two hundred sixty one motorcyclists were surveyed as subjects for this study. Using a 1 to 6 rating scale, each subject provided separate ratings of the motorcycle speed, motorcycle volume, total lane width and surface pavement quality characteristics of 50 different clip conditions. These clips representing twelve levels of traffic volume, twenty six levels of traffic speed, six levels of pavement quality, and fifteen lane width configurations. A rating of '6' indicated a high level of perceived discomfort able; a rating of '1' indicated high level of perceived comfort. Ratings were based upon the view of a motorcyclist riding through the scene. All scenarios took place on a simulated straight, daylight conditions and all traffic laws were obeyed during the filming of the motorcycle clips.

The sites selected also represented an extensive range of combinations of these variables, from low-volume, low-speed, and narrow-lane locations to high volume, high-speed, wide-lane locations. The geometric and operational characteristics ranged as shown in Table 4.

Table. 4. Ranges of Variables Included in the Model

		Speed	Lane Width	Volume	Pavement Quality
N	Valid	2610	2610	2610	2610
	Missing	0	0	0	0
Minimum		20	1.50	60	1
Maximum		81	3.85	1440	6

4.4 Test of the Overall Model

Test of the overall model is done by the likelihood ratio test, also called the model chi-square test. The likelihood ratio test tests the significance of the researcher's model as a whole when the reduced model is the baseline model with the constant only. Null hypothesis is rejected that knowing the independents makes no difference in predicting the dependent in logistic regression when probability (model chi-square) is less than 0.05. Therefore, significance value less than 0.05 ($p < 0.05$) results in rejection of the null hypothesis that all of the predictor effects are zero. In this case study, significance of the test was zero ($p < 0.05$) so it confirms that the effects of all variable contribute to the model (Table 5).

Table. 5. Likelihood Ratio Test

Effect	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Speed	1368	97.490	5	0.00
Lane Width	1298	27.390	5	0.00
Volume	1620	350.221	5	0.00
Pavement Quality	1986	716.126	25	0.00

4.5 Regression Coefficient Evaluations

The values for the logistic regression equation for predicting the dependent variable from the independent variable are called regression coefficients. In this study, the response variables are score overalls with category of 1 to 6. The explanatory (independent) variables used in the model are motorcycle speed, total lane width, motorcycle volume and pavement surface quality. The explanatory variables have been chosen to maximize model fit. Coefficients with significance value of less than 0.05 are statistically significant.

The effect of each predictor is summarized in the parameter estimate table. The signs of the coefficients for covariates and relative values of the coefficients for factor levels can give important insights into the effects of the predictors in the model, although, interpretation of the coefficients in this model is difficult due to the nature of the link function. The likelihood of a response category is decreased with respect to the reference category by respective parameters with significant negative coefficients. The likelihood of a response category is increased by the respective parameters with positive coefficients. The mathematical expression for logistic regression model by equation 4 is as follow:

$$1^{st}\text{ Logit: } Ln\left[\frac{\pi_j}{1-\sum\pi_j}\right] = 4.732L - .01V + P\alpha \begin{bmatrix} \text{if } P = 1 \rightarrow \alpha = 10.86 \\ \text{if } P = 2 \rightarrow \alpha = -8.08 \\ \text{if } P = 3 \rightarrow \alpha = 4.51 \end{bmatrix} \quad (5)$$

$$2^{nd}\text{ Logit: } Ln\left[\frac{\pi_j}{1-\sum\pi_j}\right] = .101S + 3.275L - .008V + P\beta \begin{bmatrix} \text{if } P = 1 \rightarrow \beta = 12.11 \\ \text{if } P = 2 \rightarrow \beta = -6.93 \\ \text{if } P = 3 \rightarrow \beta = 6.66 \\ \text{if } P = 4 \rightarrow \beta = -12.83 \end{bmatrix} \quad (6)$$

$$3^{rd}\text{ Logit: } Ln\left[\frac{\pi_j}{1-\sum\pi_j}\right] = .101S - .005V + P\gamma \begin{bmatrix} \text{if } P = 1 \rightarrow \gamma = 12.84 \\ \text{if } P = 2 \rightarrow \gamma = -5.43 \\ \text{if } P = 3 \rightarrow \gamma = 9.13 \\ \text{if } P = 4 \rightarrow \gamma = -10.18 \\ \text{if } P = 6 \rightarrow \gamma = -7.52 \end{bmatrix} \quad (7)$$

$$4^{th}\text{ Logit: } \left[\frac{\pi_j}{1-\sum\pi_j}\right] = 3.498L - .005V + P\delta \begin{bmatrix} \text{if } P = 1 \rightarrow \delta = 12.81 \\ \text{if } P = 2 \rightarrow \delta = -3.67 \\ \text{if } P = 4 \rightarrow \delta = -7.49 \\ \text{if } P = 5 \rightarrow \delta = -11.64 \end{bmatrix} \quad (8)$$

$$5^{th}\text{ Logit: } \left[\frac{\pi_j}{1-\sum\pi_j}\right] = 3.273L - .003V + P\theta \begin{bmatrix} \text{if } P = 4 \rightarrow \theta = -4.32 \\ \text{if } P = 5 \rightarrow \theta = -7.36 \\ \text{if } P = 6 \rightarrow \theta = -6.95 \end{bmatrix} \quad (9)$$

Where:
S= Motorcycle Speed (Km/hr)
L= Total Lane Width (m)

V= Motorcycle volume (Motorcycle/hr)
P= Pavement Condition Rating (PCR)
Equation 3 is used for calculating the probabilities for each category and the category with the highest probability was selected as the predicted category of the model.

$$\text{Probabilities Category 1: } p_1 = \frac{e^{1^{st}\,Logit}}{1+e^{1^{st}\,Logit}+e^{2^{nd}\,Logit}+e^{3^{rd}\,Logit}+e^{4^{th}\,Logit}+e^{5^{th}\,Logit}} \quad (10)$$

$$\text{Probabilities Category 2: } p_2 = \frac{e^{2^{nd}\,Logit}}{1+e^{1^{st}\,Logit}+e^{2^{nd}\,Logit}+e^{3^{rd}\,Logit}+e^{4^{th}\,Logit}+e^{5^{th}\,Logit}} \quad (11)$$

$$\text{Probabilities Category 3: } p_3 = \frac{e^{3^{rd}\,Logit}}{1+e^{1^{st}\,Logit}+e^{2^{nd}\,Logit}+e^{3^{rd}\,Logit}+e^{4^{th}\,Logit}+e^{5^{th}\,Logit}} \quad (12)$$

$$\text{Probabilities Category 4: } p_4 = \frac{e^{4^{th}\,Logit}}{1+e^{1^{st}\,Logit}+e^{2^{nd}\,Logit}+e^{3^{rd}\,Logit}+e^{4^{th}\,Logit}+e^{5^{th}\,Logit}} \quad (13)$$

$$\text{Probabilities Category 5: } p_5 = \frac{e^{5^{th}\,Logit}}{1+e^{1^{st}\,Logit}+e^{2^{nd}\,Logit}+e^{3^{rd}\,Logit}+e^{4^{th}\,Logit}+e^{5^{th}\,Logit}} \quad (14)$$

$$\text{Probabilities Category 6: } p_6 = 1-(p_1+p_2+p_3+p_4+p_5) \quad (15)$$

To summarize the strength of the relationship, pseudo R^2 statistic is employed. Effect strength of the relationship with goodness of fit is reflected by the pseudo-R^2 measures. Cox and Snell's, Nagelkerke's, and McFadden's are the three pseudo R^2 values. According to this measure, the model with the largest Pseudo R^2 statistic is "best". In this case study with the pseudo R^2 value equal to 0.72 is a good fit model (Table 6).

Table. 6. Pseudo R-Square

Cox and Snell	0.716
Nagelkerke	0.736
McFadden	0.351

5. CONCLUSION AND DISCUSSION

This paper developed of a model that assess to user perception of performance at exclusive motorcycle lanes and the factors affecting them. Participants saw video clips and rate those segments with respect to how comfortable they would be riding on that segment under the geometric and traffic operations conditions. A number of independent variables influencing motorcycle perception was identified and tested in chi square analysis. In this case, the most influential factors to rider perceived performance was found to be total lane width, motorcycle volume, motorcycle speed, and pavement surface quality. Using these variables as independent variables and the overall rating for each roadway segment as the response variable, a model was developed to predict the overall performance level of motorcycles ($p< 0.05$). Also the study revealed that the gender and experience of participants had statistically significant effect on subjects' ratings and rankings.

By using this model, existing roadways can be evaluated to determine the present motorcycle performance or level-of-service on all segments. These evaluations can be useful in several different ways. Firstly the option of being able to evaluate existing roads in a balanced manner will help transportation authorities to determine whether existing roads might need an upgrade or not. Secondly, weak links in the network can be pinpointed, and sites needing enhancement can be prioritized based on the index values. This model can also assist an organization to design motorcycle lanes. It could as well be a helpful tool to evaluate different design options by forecasting the expected level-of-service of these design alternatives. For instance, engineers and transportation planners can ascertain a target motorcycle level-of-service by iteratively changing the independent variables to find the best combination of factors to achieve the desired performance or level-of-service and use the model to test different alternative roadway cross-section designs.

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