PERPUSTAKAAN
SULTAN ABDUL SAMAD
UNIVERSITI PUTRA MALAYSIA

PENERBITAN PEGAWAI

The value of daytime running headlight initiatives on motorcycle crashes in Malaysia

Radin Umar Radin Sohadi.

PFK
1

THE VALUE OF DAYTIME RUNNING HEADLIGHT INITIATIVES ON MOTORCYCLE CRASHES IN MALAYSIA

Radin Umar Radin Sohadi*

ABSTRACT

Motorcycle casualties constitute more than two thirds of road accident victims in Malaysia and as high as 90 per cent in some Asian countries. One of the cost-effective interventions to address this problem is to encourage running headlights during the daytime. This paper presents the value of frontal conspicuity intervention as a low cost safety policy to reduce accidents involving motorcycles in Malaysia. Statistical and non-statistical analyses, the odds ratio, the time series analysis models and a simple graphical technique, were employed in this programme. Data were classified according to daytime and night-time accidents involving conspicuity related, single motorcycle accidents and non-conspicuity related accidents, respectively. The analysis showed that the odds ratio before the intervention is much higher ($p<0.06$) than the odds ratio after the intervention. The daytime conspicuity related accidents dropped significantly by about 29 per cent following the intervention while no significant ($p>0.05$) change was noticed for the non-conspicuity related cases. These results support the hypothesis that the running headlights intervention has been effective in tackling conspicuity related motorcycle accidents in Malaysia.

Keywords: Motorcycle conspicuity, pure visibility, conspicuity related motorcycle accidents, safety evaluation.

INTRODUCTION

Death and serious injuries as a result of motorcycle accidents constitute a large portion of total casualties in Asian countries. This is because most of the vehicle fleets in these countries are motorized two-wheelers. In

* *Road Safety Research Centre, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Selangor Malaysia; e-mail: radinumx@eng.upm.edu.my.*

many ASEAN countries, for example, motorized two-wheel vehicles constitute between 51 and 95 per cent of the total fleet with Malaysia (51 per cent), Cambodia (75 per cent), Lao People's Democratic Republic (79 per cent) and Viet Nam (95 per cent). As such, simple but cost-effective measures should be developed and shared so that casualties among these vulnerable road users can be minimized.

There is a widespread belief that motorcycles are more difficult to detect in traffic than other larger motorized vehicles (Olson, 1989). Earlier studies of collisions involving motorcycles (Hurt et al., 1981, Thomson, 1980) have indicated that drivers who violate motorcyclists' right-of-way often claim not to have seen them before the collision ("looked but failed to see"). This finding is also supported by a local study (Radin et al., 1995) that the majority of multiple motorcycle accidents occurred while motorcycles had the right of way and particularly while they were travelling straight ahead or turning. About two thirds of the motorcyclists tend to be the victims of errors made by other road users.

With the evidence that improving the conspicuity of motorcycles reduces accidents, a nationwide daytime running headlights campaign was launched and was followed by the compulsory use of headlights law three months later. This paper highlights the rationale for the initiative and presents the analyses of the intervention with special reference to the conspicuity related motorcycle accidents (CRMA) and non-conspicuity related motorcycle accidents (NCRMA) in Malaysia. The latter analysis is used as the control analysis.

I. RATIONALE FOR NON-CONSPICUITY OF A MOTORCYCLE

A number of explanations have been put forward for the non-conspicuity of a motorcycle. These explanations have been critically reviewed by Thomson (1980) and a brief summary of factors contributing to the possibility of detection of an object apart from features of the viewers are discussed in the following sections.

A. Luminance contrast

Contrast is a measure of luminance difference between a target and its background (Hills, 1979). Luminance is the amount of light per unit area reflected from or emitted by a surface (Rumar, 1980). The higher the value of contrast, the greater is the probability of detection of a target. Therefore, when ambient illumination levels are lowered, contrast ratio is reduced, and vision is consequently impaired.

In other studies, Monk and Brown (1975) found that increasing the target surround density had a camouflaging effect rather than a noticeability effect. However, in a field experiment on motorcycle noticeability with and without headlight usage, Janoff and Cassel (1970) found that the number of people observing the presence of a motorcycle varies as a function of distance from the motorcycle. The low beam provides a 111 per cent improvement in noticeability over the no-light condition, while the high beam increases noticeability by 142 per cent. In an experiment to determine the effects of motorcycle headlights on noticeability as perceived by oncoming vehicles at various distances, they also illustrated the improvement obtainable by using headlights during the day. In their experiment, the use of headlights indicated an increase in noticeability, which ranged from 46 per cent at 50 feet to 220 per cent at 300 feet.

B. Position in other driver's field of vision

The position that an object occupies in the field of view of an observer has considerable bearing on the probability of its detection. Thomson (1980, 1985) stated that in daylight conditions, visual acuity is considerably less sensitive near the periphery. This means that the object has a higher probability of detection if the observer is looking towards it rather than if the object approaches the observer from an angle. Under night conditions, there is less difference in the sensitivity of central and peripheral vision and both are considerably less sensitive than the central vision in daytime.

Horberg and Rumar (1979) found that a lower light intensity is required for conspicuity increment when the vehicle is in a more central field of vision. They suggested that, although the central visual field is more sensitive to light increment, it is more valuable for the light source to be detected in the periphery. Their study also found that low beam headlights were effective for peripheral viewing angles smaller than 30 degrees. The use of a high beam increased the detection distances considerably where a 60-degree peripheral viewing angle was used.

In a Malaysian study, Radin et al. (1996) investigated the interaction between the position of motorcycle in the driver's visual field, as well as the lighting conditions (table 1). They reported that there was a significant difference between the position of the motorcycle in the driver's visual field and lighting conditions. Accidents in peripheral areas of the visual field were relatively more common compared with the central area during the day than at night. The ratio of peripheral to central vision accidents during the day is 3.91 while at night it is 2.29. This difference is significant at 0.5 per cent significant level ($p<0.005$). This finding supports the notion that day frontal conspicuity is a problem and efforts need to be made to encourage motorcyclist to ride with their lights switched on.

Table 1. Pure visibility motorcycle accidents

Visual field	Day	Night	Total
Peripheral	1 496	108	1 604
Central	383	47	430
Total	1 879	155	2 034
Ratio (peripheral: central)	3.91	2.29	

($\chi^2 = 8.5$, df =1, $p<0.005$)

C. Other factors affecting the perceptual processes

In a typical driving situation, especially at an urban intersection, the driver's attention is often divided into several tasks. This may result in overloading of information processing. Cumming (1972) proposed that if an overload situation is reached, some important visual input may not be processed. This may result in motorcycles not being detected in the driver's peripheral visual field, a situation often known as "looked but failed to see". The possible causes of this phenomenon have also been critically discussed by Hills (1979).

In processing information, the brain generally selects for closer examination those objects that are more conspicuously coloured, brighter, moving or flashing over objects that do not have those characteristics. In this situation, larger objects are often given higher priority while smaller, less conspicuous objects may be overlooked in favour of a larger one. In view of their small physical size, motorcycles may be overlooked by drivers whose attention is naturally drawn to the larger cars and trucks in the traffic stream. One avenue for reducing the information processing load in this "multitasking" situation is to provide positive information to drivers. This can be partly achieved by running headlights since they provide positive information to other drivers.

II. NATIONAL DAYTIME RUNNING HEADLIGHTS INTERVENTION IN MALAYSIA

Since early 1992, a series of multimedia and cross-sectional campaigns have been carried out by the National Road Safety Council of Malaysia. One of the campaigns carried out by the Council was the running headlights campaign. In this campaign, all powered motorcyclists were encouraged to improve their conspicuity by switching on their headlights during the day. The campaign lasted for about two months, beginning from the middle of July to the end of August 1992. The campaign comprised the following:

(a) Advertising on Television Malaysia. A number of television commercials were shown to the public with the message “be seen and not hurt”. A similar message was broadcast through the radio campaign so as to reach people from different walks of life, especially in the rural community;

(b) Posters and leaflets, distributed by the road side and at toll plazas, advising motorcyclists to switch on their headlights during the day;

(c) Giveaway items such as stickers and key chains with a similar message, “be seen”;

(d) Newspaper advertisements. A series of centre-page advertisements were printed in the local newspapers in Malay, Chinese and Tamil.

Rate of compliance to the running headlights campaign

In order to gauge the response of motorcyclists to the publicity campaign conducted by the Government, a series of behavioural observations was carried out at pre-selected sampling points on major routes in the pilot areas, Seremban and Shah Alam. At each of the eight sampling points, samples of about 150 motorcyclists were taken each month starting in June 1992. This approximated 1,200 observations per month. Detailed information was taken during each observation, for example the following:

(a) Number of motorcyclists passing the observation point during the observation period;

(b) Number of motorcyclists riding with their main beam light on;

(c) Number of motorcyclists riding with their dipped light on.

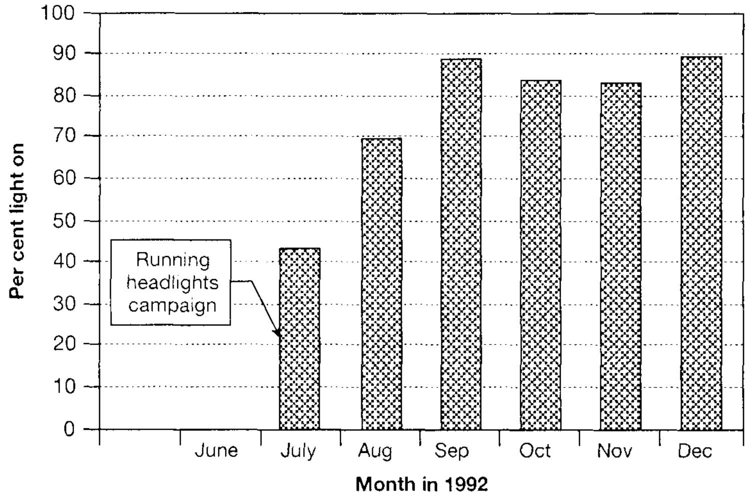

Figure 1. Rate of compliance for running headlights campaign

Figure 1 shows the percentage of motorcycles complying with the running headlights campaign during the day in the districts of Seremban and Shah Alam. It can be seen that the percentage of motorcyclists riding with their lights switched on increased sharply from 0 per cent in June to about 43 per cent just after the beginning of the campaign in mid-July. This figure was maintained at a relatively high level and stood at 82 per cent by the end of December 1992.

The proportion of all riders using their main beam or dipped light was consistently maintained at about 44 and 37 per cent, respectively, throughout the campaign and regulation periods, as seen in figure 2. From the field study, it was noted that motorcyclists riding their bikes with the main beam lights on had better visibility. It is also worth noting that the campaign did not specify which type of light needed to be switched on.

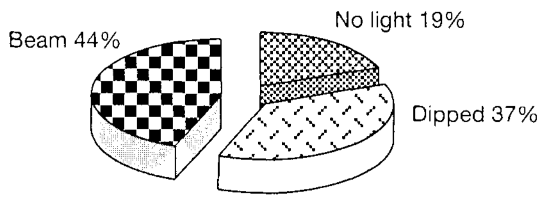

Figure 2. Types of headlights used by riders in Seremban and Shah Alam

III. EVALUATION OF THE SAFETY INTERVENTION

To evaluate the impact of the running headlights initiative, the following analyses were carried out:

- Cumulative plot analysis of CRMA
- Analysis of the odds ratio
- Modelling of CRMA
- Modelling of NCRMA

CRMA is defined as any accident involving motorcycles in which its collision mechanism can be attributed to motorcycle conspicuity. In this analysis, CRMA consists of all accidents involving motorcycles moving straight or turning with the right of way when pedestrians or other vehicles cross their paths. NCRMA, on the other hand, defines all accidents other than CRMA. The above classifications are necessary to differentiate between accident situations in which running headlights could have potentially improved safety and those in which they probably would have been irrelevant.

A. Cumulative plot analysis of conspicuity related motorcycle accidents

The number of conspicuity related motorcycle accidents and the corresponding plot on cumulative accidents 12 months following the intervention are shown in table 2 and figure 3. It can be seen that the number of CRMA deviates slightly only after the fifth month following the campaign. In contrast, a clear separation is observed on the cumulative plot of all motorcycle accidents (control) immediately after the campaign. This upward separation indicates that the number of all motorcycle accidents increases with time after the campaign. Such an increase is expected in view of the high growth of the motorcycle population in Malaysia. Since the number of CRMA remained steady or experienced a slight increase after the fifth month while there was a clear upward toll on all motorcycle accidents, it can be deduced that the campaign and regulation resulted in a reduction in the medium-term CRMA in the study areas.

To analyse further the potential benefit of the intervention, a "before" and "after" analysis was carried out (table 3). Note that the increase in the "after" period data for all motorcycle accidents (control) is about twice the increase of CRMA. The computed χ^2 value for one degree of freedom is 4.03 and therefore it can be concluded that there has been a significant medium-term reduction ($p<0.05$) in CRMA in the study areas.

Table 2. Two-year accident series in Seremban and Shah Alam

Collision type	Before period (July 1991 - June 1992)											
	1991						1992					
	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
All motorcycle accidents	112	105	99	110	94	110	140	124	181	131	130	158
Cumulative accidents	112	217	316	426	520	630	770	894	1 075	1 206	1 336	1 494
Cumulative mean accidents	112	237	362	487	612	737	862	987	1 112	1 237	1 362	1 487
CRMA	33	39	40	30	28	44	68	48	79	44	61	73
Cumulative accidents	33	72	112	142	170	214	282	330	409	453	514	587
Cumulative mean accidents	33	82	131	180	229	278	326	375	424	473	522	571
Collision type	**After period (July 1992 - June 1993)**											
	1992						1993					
	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
All motorcycle accidents	135	149	122	152	129	165	149	178	169	156	181	192
Cumulative accidents	1 629	1 778	1 900	2 052	2 181	2 346	2 495	2 673	2 842	2 998	3 179	3 371
Cumulative mean accidents	1 612	1 737	1 862	1 987	2 112	2 237	2 362	2 487	2 612	2 737	2 862	2 987
CRMA	53	43	38	49	40	68	43	55	85	51	70	50
Cumulative accidents	640	683	721	770	810	878	921	976	1 061	1 112	1 182	1 232
Cumulative mean accidents	620	669	718	767	816	865	914	962	1 011	1 060	1 109	1 158

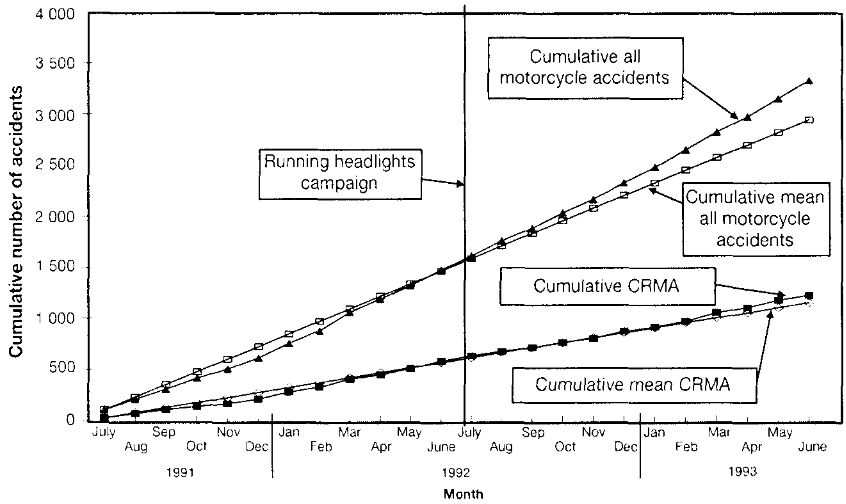

Figure 3. Cumulative plot of CRMA and other motorcycle accidents

Table 3. Chi-squared analysis on conspicuity related accidents

Accident type	Before period (July 1991-June 1992)	After period (July 1992 - June 1993)	Relative increase (per cent)
Conspicuity related motorcycle accidents (CRMA)	610	684	12.1
All motorcycle accidents (control)	1 479	1 855	25.4

($\chi^2 = 4.03$, df = 1, $p < 0.05$)

B. Analysis of the odds ratio

To ensure whether the intervention did reduce CRMA, an analysis on the odds ratio as proposed by Elvik (1993) for the 12 months before and the 12 months after the intervention was carried out. CRMA was classified further into day and night and the odds ratio was computed based on the following equation:

$$\text{Odds ratio } (OR_i) = [\, CRMA_{day} \times SINGLE_{night} \,] / [\, SINGLE_{day} \times CRMA_{night} \,] \quad (1)$$

where, the subscripts$_{day}$ and$_{night}$ denote the daytime and night-time accidents respectively. Single motorcycle accidents (SINGLE) were used as the control in this analysis since they were irrelevant to the conspicuity initiative. The criterion of effectiveness was:

$$OR_{before} > OR_{after}$$

In addition to the above change in the odds ratios, statistical tests of differences on odds ratios can also be carried out. The test of homogeneity of the odds ratios, χ^2, can be calculated using the following formula:

$$\chi^2 = \Sigma \{(\ln OR_i / OR_s) / Sdv\ OR_i \}^2 \quad (2)$$

where OR_i is the odds ratio before and after and OR_s is the summary odds ratio for all periods. The standard deviation Sdv OR_i can be estimated using:

$$Sdv\ OR_i = [\sqrt{}\ CRMA_{day} + 1/\ SINGLE_{day} + 1\ /\ CRMA_{night} + 1/\ SINGLE_{night}] \quad (3)$$

As can be seen in table 4, the odds ratio of 2.4 before the intervention is much higher than the odds ratio of 1.6 after the intervention. The test for homogeneity also revealed that there had been a significant change at 6 per cent level in the odds ratio (P<0.06). This result provides further support that the running headlights intervention had improved the conspicuity of motorcyclists in Malaysia.

Table 4. Before and after analysis on odds ratio

Collision type	Before period (July 1991 - June 1992)	After period (July 1992 - June 1993)	Total (July 1991 - June 1993)
CRMA/day	495	533	1 028
CRMA/night	97	128	225
SINGLE/day	184	268	452
SINGLE/night	87	101	188
Total	863	1 030	1 893
Odds ratio	2.413	1.569	1.900
Standard deviation of odds ratio	0.171	0.153	0.114

$\chi^2 = 3.52$, df = 1, (p<0.06)

C. Modelling of CRMA

The multivariate analysis of the impact of the running headlights intervention to CRMA has been reported by Radin et al. (1996). The explanatory variables used are summarized in table 5. The best-fit model ($p<0.01$) to explain CRMA per week was:

$$CRMA = 6.265\ [e^{0.005\ WEEK}][e^{0.337\ RECSYS}][e^{0.340\ FAST}][e^{-0.341\ RHL}] \qquad (4)$$

Table 5. Explanatory variables used in the best-fit model for CRMA

Explanatory variable	Description	Two-level factors	Coding system
WEEK	Week of the year	NA	1, 2, 3, 4, 5, 6, 7, 8, 9, ... 156
RECSYS	Recording system used	2	(1) Trial form + old form (2) POL27 (Pin 1/91)
FAST	Fasting during Ramadan	2	(1) Not fasting week (2) Fasting week
BLKG	Festive seasons	2	(1) Non-festive seasons (2) Festive seasons
RHL	Running headlights	2	(1) Before intervention (2) After intervention

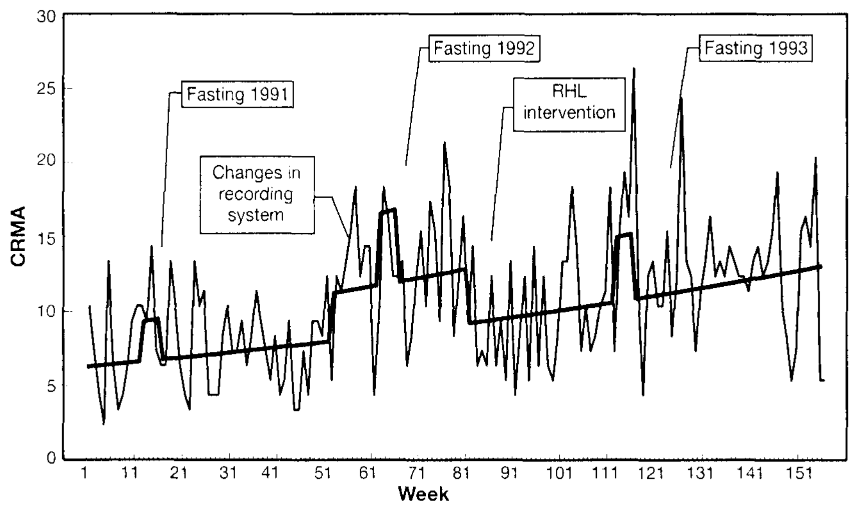

Figure 4. Actual and predicted CRMA accidents in Malaysia

The observed and modelled weekly CRMA accidents are shown graphically in figure 4. This model revealed that the running headlights intervention reduced the conspicuity related motorcycle accidents by about 29 per cent. Therefore, it can be said that the intervention has been successful in improving conspicuity related accidents in Malaysia.

D. Modelling of NCRMA

The above analysis of CRMA strongly suggests that the running headlights intervention (RHL) significantly improves motorcycle visibility and reduces CRMA. To further the value of this initiative, a contrast analysis (Radin, 1999) whereby modelling of NCRMA was carried out. This is because no significant change is expected to the NCRMA following the RHL intervention.

The modelling approach and the explanatory variables used in this analysis were similar to that used for CRMA (Radin et al., 1996). However, the dependent variable used was NCRMA per week, defined as all types of motorcycle accidents other than CRMA. These included all the single vehicle motorcycle accidents, and rear-end accidents with motorcycles. The final model found in this analysis was:

$$NCRMA = 12.037 \{\exp^{0.003\ WEEK}\} \{\exp^{0.251\ RECSYS}\} \quad (5)$$

Note that the RHL term was not significant in the final model, suggesting that there was no significant change in NCRMA following the RHL intervention. This is because the intervention is irrelevant and hence insensitive to these types of accidents.

IV. DISCUSSION AND CONCLUSIONS

The above analyses illustrate the value of running headlights in improving the frontal conspicuity of motorcycles in Malaysia. The reduction in motorcycle accidents as a result of the running headlights intervention concurs with earlier studies (Vaughan et al., 1967; Waller and Griffin, 1977; Zador, 1985), which strongly support the conspicuity problems of motorcyclists. Although extra care must be taken when comparing results from different countries, as definitions, data classifications and traffic situations may differ, the present finding supports the conspicuity hypothesis postulated by earlier researchers and confirms that a running headlights intervention can significantly reduce multi-vehicle motorcycle accidents, particularly the conspicuity related accidents with motorcycles.

Contrary to the above findings, a number of criticisms (Olson, 1989, Cercarelli et al., 1992) have also been made on the effectiveness of this running headlights initiative. The argument is that the conspicuity hypothesis has not been seriously challenged. In an Australian study (Cercarelli et al., 1992), the car-car and car-motorcycle crashes were examined and it was reported that motorcycles and cars did not differ significantly ($p>0.05$) in their relative risks of having multi-vehicle accidents. Olson (1989) also noted that cars and motorcycles are involved in the same types of collisions with about the same relative frequency. Thus the hypothesis that poor motorcycle conspicuity based on multiple-vehicle crashes with single motorcycle crashes during the day was seriously criticized. Comparing groups of crashes for which conspicuity can be posited as a common cause such as the car driver's failure to detect a motorcyclist may be a more enlightening comparison.

In this study, however, it is worth pointing out that the accident series were specially classified into specific groups where conspicuity could be posited as a common cause. The data were stratified into conspicuity related and non-conspicuity related accidents, rather than the general multiple or single vehicle accidents. In addition, a more up-to-date and elaborate multivariate analysis was applied to both the subjects (CRMA) and the control data (NCRMA). As such, both views, that in favour of the conspicuity hypothesis and the criticisms against the hypothesis, were addressed.

It should also be noted that this study was carried out in a country where (a) before the intervention, no motorcyclists used headlights during the day, (b) the motorcycle proportion is extremely high and constitutes about 50 per cent of the traffic population and (c) the use of headlights increased significantly (about 82 per cent compliance) immediately following the intervention. Thus, the running headlights intervention should be able to reveal the full benefit of this road safety measure in terms of collision reduction in Malaysia. In addition, all categories of accidents, including minor injury and damaged-only cases, were included in the analysis. Given the results presented in this article, it is concluded that the running headlights campaign and regulation have been successful in improving motorcycle safety in Malaysia. However, an impact analysis with a larger set of accident data in the "before" and "after" periods could be statistically more meaningful.

REFERENCES

Cercarelli, L.R., P.K. Arnold, D.L. Rosman, D. Sleet and M.L. Thornett, 1992. Travel exposure and choice of comparison crashes for examining motorcycle conspicuity by analysis of crash data, *Accident Analysis and Prevention*, vol. 24, No. 4, pp. 363-368.

Cumming, R.W., 1972. Human factors in relation to intersection accidents, paper presented at the National Road Safety Symposium, Canberra, Australia.

Elvik R., 1993. The effects on accidents of compulsory use of daytime running headlights for cars in Norway, *Accident Analysis and Prevention*, vol. 25, No. 4, pp. 383-398.

Hills, B.L., 1979. Vision, visibility and perception in driving, *Perception,* vol. 9, pp. 183-216.

Horberg U. and K. Rumar, 1979. The effects of running lights on vehicle conspicuity in daylight and twilight, *Ergonomics*, vol. 22, No. 2, pp. 165-173.

Hurt, H.H., J.V. Ouellet and D.R. Thom, 1981. Motorcycle accident cause factors and identification of countermeasures, vol 1: Technical Report, Traffic Safety Center, University of California, Los Angeles, California.

Janoff, M.S. and A. Cassel, 1970. Effects of daytime use of motorcycle headlights and taillights on motorcycle noticeability, paper presented at the 50th Annual Meeting, Highway Research Board, Washington.

Monk, T.H. and B. Brown, 1975. The effect of target surround density on visual search performance, *Human Factors,* vol. 17, No. 4, pp. 356-360.

Olson, P.L., 1989. Motorcycle conspicuity revisited, *Human Factors*, vol. 31, No. 1, pp. 141-146.

Radin Umar, R.S., 1999. The value of frontal conspicuity on motorcycle accidents in Malaysia, Proceedings of the First World Engineering Congress, Kuala Lumpur.

Radin Umar, R.S., G.M. Mackay and B.L. Hills, 1996. Modelling of conspicuity-related motorcycle accidents in Seremban and Shah Alam, Malaysia, *Accident Analysis and Prevention*, vol. 28, No. 3, pp. 325-332.

Radin Umar, R.S., G.M. Mackay and B.L. Hills, 1995. Preliminary analysis of motorcycle accidents: short-term impacts of the running headlights campaign and regulation, *Journal of Traffic Medicine*, vol. 23, No. 1, pp. 17-28.

Rumar, Kåre, 1980. Running lights on – conspicuity, glare and accident reduction, *Accident Analysis and Prevention*, vol. 12, No. 2, pp. 151-157.

Thomson, G.A., 1980. The role frontal motorcycle conspicuity has in road accidents, *Accident Analysis and Prevention*, vol. 12, No. 3, pp. 165-178.

Thomson, G.A., 1985. The value of headlight use for motorcyclists during daylight, Proceedings of the International Conference on Motorcycle Safety, vol. 3, Washington.

Vaughan, R.G., K. Pettigrew and J. Lukin, 1967. Motorcycle crashes: a level two study, Traffic Accident Research Unit, Department of Transport, New South Wales, Australia.

Waller, P.F. and L.I. Griffin, 1977. The impact of a motorcycle lights-on law, *Proceedings of the American Association of Automotive Medicine*, pp. 14-15, Vancouver.

Zador, P.L., 1985. Motorcycle headlight-use laws and fatal motorcycle accident crashes in the US, *American Journal of Public Health*, vol. 75, No. 5, pp. 543-546.