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Automated Awareness Safety System (AwAS) for Red Light Running in Malaysia: An Analysis of Four-year Data on Its Effectiveness

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ABSTRACT – *This paper discusses the trend of red light running (RLR) due to the implementation of the Automated Awareness Safety System (AwAS): Red Light Camera (RLC) in Malaysia. Since 2012, the government has installed the then Automated Enforcement System (AES) cameras at selected locations as a measure to reduce red light running. Its installation is controversial as to whether it improves safety or merely acted as a revenue generator to Malaysia. Four accident-prone signalized intersections were chosen as the study location. Four enumerators, together with four video cameras were placed unobtrusively to collect data in terms of traffic volume and number of violations for pre and post-installation (six months, one year, two years, and four years) considering factors influencing red light violations (location type, vehicle type, time and type-of-day). Results showed an overall reduction in violation rate two years after installation with 2.61% compared to before installation (4.29%) and an increase again four years after with 3.82%. Motorcycles are the highest RLR violator whereas cars and other types of vehicles recorded almost similar violation rates. Based on location type, Perak had higher violation rates before installation (5.19%) compared to Kuala Lumpur (3.71%). However, the tables have turned with Kuala Lumpur having the higher violation rates with 2.49% two years after and 4.55% after four years; whereas Perak with 1.57% and 2.64% respectively. The violation rate trend for both times and type-of-day were also similar. Findings in the study revealed that the implementation of AwAS was undoubtedly timely and was found to be beneficial in Malaysia.*

KEYWORDS: Red light running, signalized intersection, Automated Enforcement System (AES), red light camera, intersection

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1. INTRODUCTION

In Malaysia, traffic crashes are among the five principal causes of death after ischemic heart disease, pneumonia, and cerebrovascular diseases. The Statistical Report on Road Accidents in Malaysia for 2015, which was published by the Royal Malaysia Police (RMP, 2015) stated that there were 489,606 traffic crashes reported in that year, 1.4% of which involved fatalities. In total, 6,706 road users lost their lives that year. Fourteen of the fatal crashes in 2015 occurred at signalized junctions as a result of traffic light violations or commonly referred to as red-light running (RLR).

Disobeying traffic lights at intersections is perhaps one of the riskiest driving behaviors a driver can have. Increasing numbers of red light running-related crashes in recent years were reported in many studies across the continents (Johnson et al., 2011; Lum & Wong, 2002; Retting et al., 1999a; Romano et al., 2005) emphasizing the significance of red light running as a major traffic safety concern. Among

the focus of previous studies are the characteristics of red-light runners and the factors behind the decision made by drivers to run the red lights. In addition, there has been substantial research on the evaluation of engineering countermeasures to prevent RLR. It is noted that some of the drivers are prone to risk-taking and might run the red lights deliberately; but often time, drivers are left with difficult choices when it comes to red light running.

Red light cameras (RLC) can play a significant part in encouraging drivers to stop instead of violating the red light. Studies in two U.S. cities – Oxnard, California and Fairfax City, Virginia – found that violation rates have decreased by approximately 40% during the first year of RLC enforcement (Retting et al., 1999b). It has been reported that automated enforcement is used in 75 countries throughout the world (Bochner & Walden, 2015; Bochner, 1998). Apparently, there have been reductions of between 5 to 60% in speeding violations, 40 to 90% in red signal violations, and 15 to 90% in crashes (Bochner, 1998). However, there are a few studies overseas that show otherwise.

Since 2012, a system called Automated Enforcement System (AES) (later rebranded to Awareness Automated Safety System or AwAS) for solving red light running issues was installed at four locations with a high number of accidents. A before-and-after study was designed to evaluate the impact of RLC on RLR. The violations before camera installation were compared to those obtained after installation (along each individual approach) of RLC (referred to as the camera approach), on a lane-by-lane basis. The data was analyzed using SPSS and a comparison was made by calculating the rate of violation per junction, in terms of total violations per volume. The installation of RLC is questionable as to whether it really is effective in reducing RLR or simply acts as a revenue generator to Malaysia, as some alleged from the start. This paper discusses the trend of red light running (RLR) due to the implementation of AwAS: RLC in Malaysia. With the reduction of RLR occurrence, the likelihood of crashes to happen will also reduce. The findings of the study can also help the authorities (and stakeholders) to make decisions on whether to proceed with AwAS throughout Malaysia or only stops at these four locations.

2. METHODOLOGY

Figure 1 shows the flow of the study. Applying the same methodology for each data collection throughout the years, the flow started with preparatory works, data collection, data analysis, and reporting. Prior to data collection, researchers determined if any significant changes or modifications has been made at the site that might affect the results. The geometry of the intersection, traffic signalization, traffic signal phasing, and cycle length were assessed for changes. Table 1 provides traffic characteristics for the four intersections.

FIGURE 1: Flow of the study

MIROS has identified 800 highly accident-prone locations, of which 265 of these locations were determined for RLC installation. Four locations were selected as pilot locations for RLC, namely: Jalan Ipoh – KL, Jalan Klang Lama, Sg. Siput (KM26 Jalan Ipoh – Kuala Kangsar) and Jalan Pasir Putih. Enumerators were given training on how to collect the data to ensure that they are familiar with data collection at the site prior to the actual data collection period.

TABLE 1: Intersection characteristics

Location	Zone	Type of Intersection	Traffic Volume				
			Before	6 Months After	1 Year After	2 Years After	4 Years After
Sg. Siput	A	3 - legged	30,434	26,782	24,692	24,822	24,856
Ipoh - Pasir Puteh		4 - legged	32,271	30,974	31,539	29,767	28,828
Jalan Klang Lama	B	3 - legged	36,959	59,253	49,640	53,251	45,394
Jalan Ipoh - KL		3 - legged	60,312	54,369	56,557	43,881	42,084

2.1 Data Collection

A total of four enumerators were tasked with jotting down particulars regarding the sites such as the site layout and landmarks. The enumerators were placed unobtrusively on each leg so that drivers were unaware that their behavior was observed. A video camera was also placed on each leg for ease of data collection. RLR and traffic volume were collected at the selected four intersections for a duration of six hours daily: differentiating weekdays and weekends within five years.

Data were categorized using the following characteristics considering factors affecting red light running:

(1) vehicle type (motorcycle, car, others)
(2) type of location (KL, Perak)
(3) time of day (peak hour, off-peak hour)
(4) signal timing (red, amber, green)
(5) type of day (weekdays, weekends)

Peak hour here describes the busiest hour when the traffic volume is at its highest whereas off-peak hour means the exact opposite. Traffic volume and violations were both recorded for all directions of the chosen route, which consisted of a right/left turn and through traffic and separated by vehicle type. For all the sites, data were collected before installation, six months after, one year after, two years after, and four years after installation of the AwAS camera.

2.2 Data Analysis

The outcome measure in this study was motorists performing red light running violations. The definition of violation is that (1) the front wheels of a vehicle entered the defining boundary of an intersection after the traffic signal changed to red; and (2) the vehicle proceeded through the intersection while the traffic light was red (Kulanthayan et al., 2007). Therefore, based on this definition, the sample population of the study is vehicles crossing the road junction. Drivers that stopped partially over the stop line were not considered violators. Motorists who entered the intersection on a green or amber light were coded as compliant, even when the light turns to red while crossing. However, motorists that stopped before, and crossed the junction before the light they are facing turned to green, were coded as violators (Johnson et al., 2011). The data captured on video was counted by research assistants (RA) and entered into the MS Excel program. Descriptive analyses were performed, and the percentage of violations for before and after the installation was calculated. Chi sq. analysis before and after the installation was done in SPSS 17 to determine the effectiveness of the AwAS. The odds ratio and 95% confidence interval were computed and taken as the final result of assessing the AwAS effectiveness.

3. RESULTS AND DISCUSSION

This section will be discussing on the data collected before installation, six months after, one year after, two years after, and four years after installation of RLC. A total of 786,665 vehicles were observed for their red-light running profile for a duration of five years.

3.1 Overall RLR Violations

The results of RLR for before and after installation (six months, one year, two years, and four years after installing RLC) are shown in Table 2. The violation percentage is the number of vehicles that violates the red light to the number of total vehicles.

TABLE 2: Overall violation rate

	Violate	Comply	Violate rate (%)	OR (95% CI)
Before installation	6870	153106	4.29%	-
Six months after installation	3778	167600	2.20%	1.991 (1.912,2.072)
One year after installation	1991	160437	1.23%	3.616 (3.438,3.803)
Two years after installation	3275	148446	2.16%	2.304 (1.950,2.122)
Four years after installation	5396	135766	3.82%	1.129 (1.089, 1.171)

The percentage of RLR violations was found to have significantly decreased ($p<0.001$) up until one year after the installation of the RLC with 4.29% before, 2.20% for six months after installation, and further reduced to 1.23% for one year after installation before steadily increasing to 2.16% two years after and 3.82% four years after. Overall, drivers tended to violate 1.991 (95% CI: 1.912, 2.072) times more before installation as compared to six months after installation, and 3.616 (95% CI: 3.438, 3.803) times more before installation than one year after installation. However, after two years of installation, the tendency of drivers to violate has decreased to 2.034 times and further decreased to 1.129 times after four years. A clearer interpretation of the trend is shown in Figure 2 below.

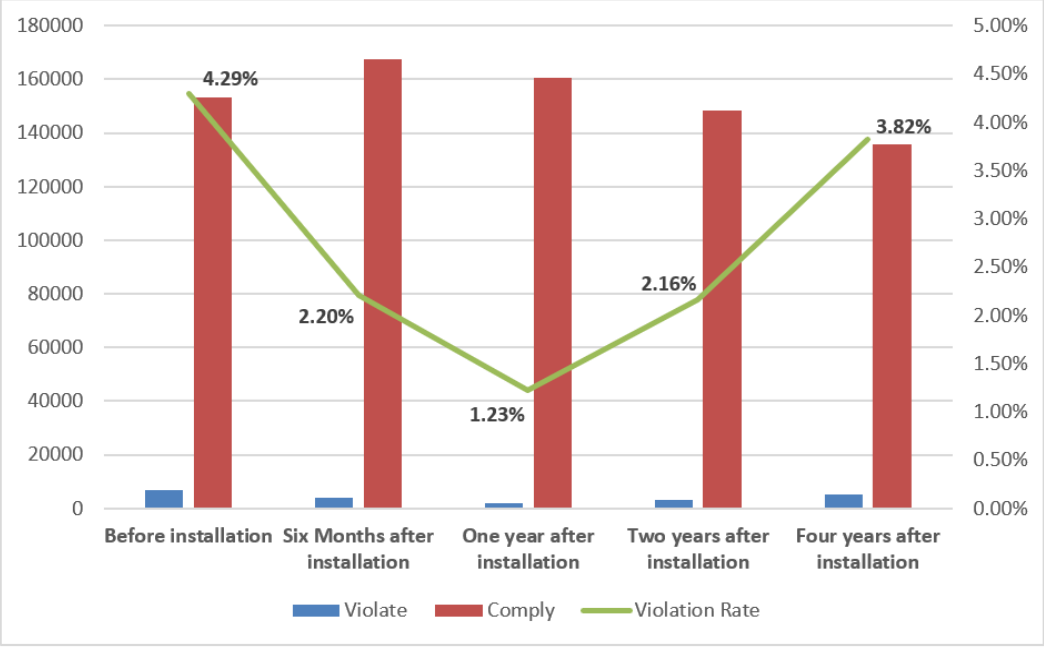
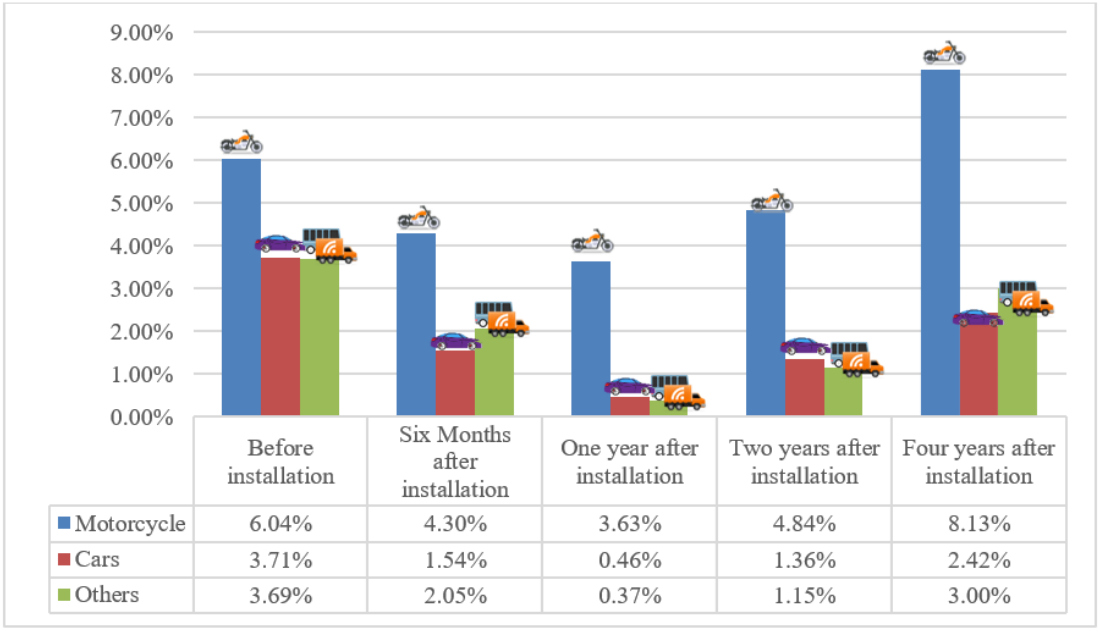


FIGURE 2: Overall violation rate graph

3.2 RLR Violations by Vehicle Type

When stratified by vehicle type, results indicated that motorcycle is the main violator as compared to cars and other vehicles type throughout the study duration; regardless of RLC installation. Figure 3 shows the violation rate for each type of vehicle, comparing before and after installation (six months, one year, two years, and four years after). Based on the trend of overall RLR violations, there is a reduction in violation rate after installation until the first half of the data collection before it started to increase. Motorcycles are the highest violators with 6.04% before installation and 4.30% for six months after installation before further decreasing to 3.63% one year later, then slowly increasing to 4.84% two years after and continuing with a sharp increment to 8.13% four years after installation; followed by cars (before: 3.71%; six months after: 1.54%; one year after: 0.46%; two years after: 1.36%; four years after: 2.42%) and other types of vehicles (before: 3.69%; six months after: 2.05%; one year after: 0.37%; two years after: 1.15%; four years after: 3.00%). On the other hand, the position between cars and other vehicle types regarding the 2nd and the 3rd place varies throughout the year.



	Before installation	Six Months after installation	One year after installation	Two years after installation	Four years after installation
Motorcycle	6.04%	4.30%	3.63%	4.84%	8.13%
Cars	3.71%	1.54%	0.46%	1.36%	2.42%
Others	3.69%	2.05%	0.37%	1.15%	3.00%

FIGURE 3: Violation rate by vehicle type

Looking further in terms of the difference in percentage, Table 3 shows the difference in violations in the respective year with before installation. It can be seen that motorcycles and other vehicle types showed a larger percentage of difference compared to before installation than cars. After one year of installation exhibit the highest violation difference with almost 90% for motorcycle and other vehicle types and 40% for cars. While motorcycle and other vehicle types display a reduction in violation percentage overall, cars recorded a 20% to 40% reduction in violation percentage throughout the years except for after four years; in which the percentage of violations increases by 35% when compared to before installation.

TABLE 3: The difference in percentage by vehicle type

	6 Months After	1 Year After	2 Years After	4 Years After
	-58%	-87%	-63%	-35%
	-29%	-40%	-20%	35%
	-44%	-90%	-69%	-19%

As mentioned above, after one year of installation showed the biggest dropped in violation rate. Other vehicle types, showing the highest reduction after one year of installation, have the tendency to violate the red light 10.3 times more before installation (95% CI: 7.415, 14.306), followed by cars with 8.42 times (95% CI: 7.524, 9.034) and motorcycles with 1.71 times (95% CI: 1.594, 1.822) more for before installation. However, after four years of installation, the tendency of drivers (cars and other vehicle types) to violate has decreased to 1.552 (95% CI: 1.475, 1.633) and 1.240 (95% CI: 1.036, 1.484) respectively for before installation whereas motorcycles have the reverse effect as they tend to violate 1.38 times (95% CI: 1.301, 1.457) more after the installation as compared to before installation (refer Table 4).

TABLE 4: RLR violation and traffic volume by vehicle type

	Motorcycle		Car		Others	
	Violate	**Comply**	**Violate**	**Comply**	**Violate**	**Comply**
Before Installation	**2,437**	**37,931**	**4,088**	**106,162**	**345**	**9,013**
6 Months After Installation	**1,700**	**37,851**	**1,890**	**120,761**	**188**	**8,988**
O.R (95% CI)	1.431 (1.342, 1.524)		2.460 (2.328, 2.600)		1.830 (1.528, 2.191)	
1 Year After Installation	**1,429**	**37,914**	**522**	**111,760**	**40**	**10,763**
O.R (95% CI)	1.705 (1.594, 1.822)		8.244 (7.524, 9.034)		10.300 (7.415, 14.306)	
2 Years After Installation	**1,709**	**33,587**	**1,460**	**105,753**	**106**	**9,106**
O.R (95% CI)	1.263 (1.185, 1.346)		2.789 (2.626, 2.963)		3.288 (2.640, 4.096)	
4 Years After Installation	**2,766**	**31,271**	**2,439**	**98,310**	**191**	**6,185**
O.R (95% CI)	0.726 (0.687, 0.769)		1.552 (1.475, 1.633)		1.240 (1.036, 1.484)	

In Malaysia, motorcycles comprise approximately 60% of vehicles that use the road and contribute to the highest number of fatalities each year. Motorcycles are smaller in comparison with other vehicle types, move faster, and are harder to notice when they are on the road. As such, they are the most vulnerable group and are highly exposed to accidents. Furthermore, it is quite impossible for a motorcycle to come to an abrupt stop when traveling at high speed, especially at signalized intersections. A study done by Retting & Williams (1996) stated that red light runners are most likely those who drove the older and smaller vehicle.

3.3 RLR Violations by Location Type

Figure 4 illustrates the violation rate by location, comparing before and after installation. As in the previous stratification, the trend also showed a reduction in violation rate after installation up to two years after installation. Perak had a higher violation rate both before and after installation (after six months and one year) with 5.19%, 3.07%, and 1.67% before plunging below Kuala Lumpur with 1.57% two years after and 2.64% four years after installation. On the other hand, Kuala Lumpur stated a violation rate of 3.71% before, 1.76% six months after, 0.99% one year after, 2.49% two years after, and finally shot up to 4.55% after four years of installation.

In terms of absolute numbers, it can be seen that at both Kuala Lumpur and Ipoh, the total violation decreased over time and started to increase again after two years in Kuala Lumpur and after four years of installation in Perak. At Kuala Lumpur, the number of violations is 3,613 before installation, dropped slightly to 2003 six months after, and further decreased to 1,054 after one year before starting to increase to 2418 two years after and 3978 after four years of installation (Table 5). As for Perak, the reduction of violation pattern is more or less the same as Kuala Lumpur (before: 3,257; six months after: 1,775; one year after: 937; two years after installation: 857; four years after installation: 1,418). Looking at the violation trend, it can be safely said that the number of violations reduces until two years after installation and significantly increases four years after installation. These patterns were found to be statistically significant ($p<0.05$) in terms of violation at all locations before and after RLC installation. Drivers in Kuala Lumpur were found to be prone to violating 3.848 times more before installation than

after one year and deflate to 1.511 (95%CI: 1.4341, 1.5922) more before as compared to two years after installation (Table 5). Interestingly, drivers in Kuala Lumpur tend to violate 1.235 times more after four years of installation as compared to before installation.

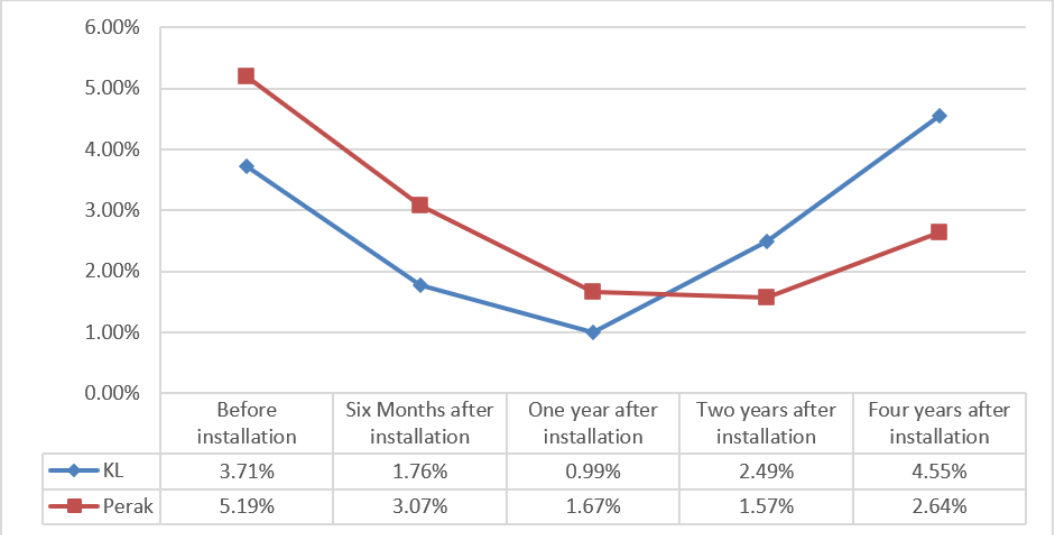


FIGURE 4: Violation rate before and after by location

From this study, it was found that the traffic volume in Perak was significantly lower than the traffic volume in Kuala Lumpur. Nevertheless, Perak stated almost similar red light running violations with Kuala Lumpur except for two years and after four years of installation. This could be due to the fact that drivers tend to violate more when there is a lesser volume of vehicles. This is concurred by a study done by Green (2003) that suggests drivers feel safe disobeying a traffic signal when there are fewer vehicles on the roads.

TABLE 5: Violation and volume by location type

	KL		Perak	
	Violate	**Comply**	**Violate**	**Comply**
Before Installation	**3,613**	**93,658**	**3,257**	**59,448**
6 Months After Installation	**2,003**	**111,619**	**1,775**	**55,981**
O.R (95% CI)	2.150 (2.034, 2.274)		1.728 (1.629, 1.833)	
1 Year After Installation	**1,054**	**105,143**	**937**	**55,294**
O.R (95% CI)	3.848 (3.591, 4.124)		3.233 (3.004, 3.480)	
2 Years After Installation	**2,418**	**94,714**	**857**	**53,732**
O.R (95% CI)	1.511 (1.434, 1.592)		3.435 (3.183, 3.707)	
4 Years After Installation	**3,978**	**83,500**	**1,418**	**52,266**
O.R (95% CI)	0.810 (0.773, 0.848)		2.109 (1.895, 2.152)	

3.4 RLR Violations by Time and Type-of-day

Time is one of the many factors affecting RLR. Drivers tend to run the red light when they are pressed for time. A study conducted by Green (2003) using Australian crash data on afternoons and on the weekends, suggested that red light running is related to drinking and driving. Retting et al. (1999a) concluded the time of day is a factor influencing RLR. It was found that there are different characteristics of RLR-related crashes during the night as compared to daylight crashes. Being male and young

showed high involvement with nighttime crashes. As for days of the week, a study done by Lum & Wong (2003) observed a higher tendency of stopping at junctions during weekdays.

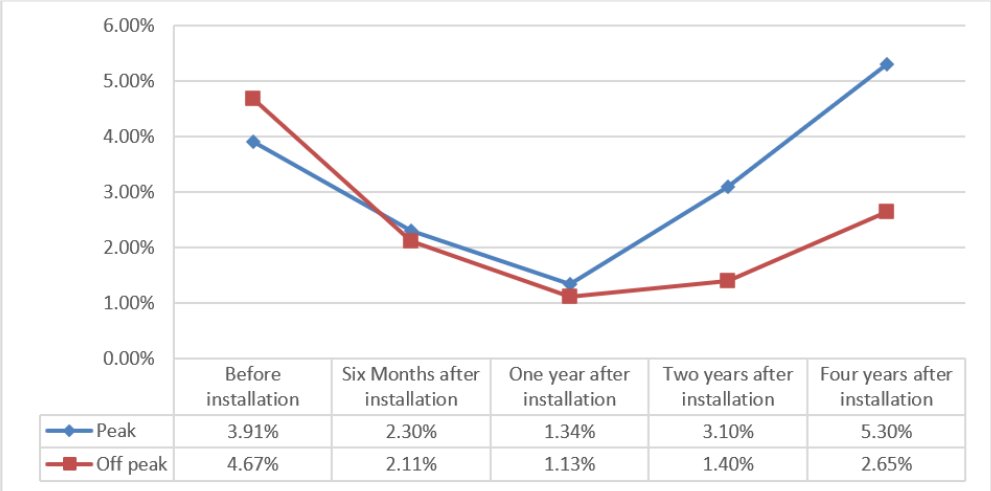


FIGURE 5: Violation rate before and after by time of day

With regards to this study, before installation of the RLC, drivers were more likely to run the red light during off-peak hours (4.67%), as compared to during peak hours with 3.91% (refer to Figure 5). This could be due to the volume between peak and off-peak before installation being more or less the same but violation during off-peak is much higher. The violation rate for both peak and off-peak hours showed a decreasing trend until two years after (peak hour: 3.10%; off-peak hour: 1.40%) and then increased four years after installation (peak hour: 5.30%; 2.65%). This could be due to a much lower volume recorded during peak hours for two years and four years after installation. Comparing the odds, drivers during off-peak hours indicated that they have the tendency to be 3.455 (95% CI: 3.2338, 3.6921) times more likely to run the red light than drivers during peak hours (1.273 times, 95% CI: 1.2033, 1.3468) for before to two years after installation (Table 6). After four years of installation, the odds for peak hour have changed to 0.726 (95% CI: 0.691, 0.7638) times as compared to an off-peak hour with 1.802 times (95% CI: 1.7062, 1.9025). This simply means that drivers violate 1.376 times more during peak hours four years after installation than before installation. On the other hand, the RLC was found to be statistically significant in reducing the violation rate, as stratified by time of day and day of the week ($p<0.001$).

TABLE 6: Violation and volume by time of day

	Peak		Off Peak	
	Violate	**Comply**	**Violate**	**Comply**
Before Installation	**3,113**	**76,489**	**3,757**	**76,617**
6 Months After Installation	**1,863**	**78,962**	**1,915**	**88,638**
O.R (95% CI)	1.725 (1.627, 1.828)		2.270 (2.146, 2.400)	
1 Year After Installation	**1,013**	**74,511**	**978**	**85,926**
O.R (95% CI)	2.994 (2.787, 3.216)		4.308 (4.013, 4.625)	
2 Years After Installation	**2,101**	**65,719**	**1,174**	**82,727**
O.R (95% CI)	1.273 (1.203, 1.347)		3.455 (3.234, 3.692)	
4 Years After Installation	**3,308**	**59,049**	**2,088**	**76,717**
O.R (95% CI)	0.726 (0.691, 0.764)		1.802 (1.706, 1.903)	

As for the type of day, the attributes considered in this study are weekdays and weekends. Figure 6 demonstrates the violation rate for the type of day, comparing between before and after installation. Based on the graph, for both weekdays and weekends, a similar pattern of violation rates was seen before and after installation, which is the declining violation rate until one year of installation while an inclining trend started after two years of installation. Weekdays have higher violation rates than weekends. In general, weekdays stated a much higher violation rate with 4.30% before installation, which decrease to 1.38% (one year after) and started to increase to 2.86% after two years of installation and 4.63% after four (which is much higher than before) as compared to the weekend.

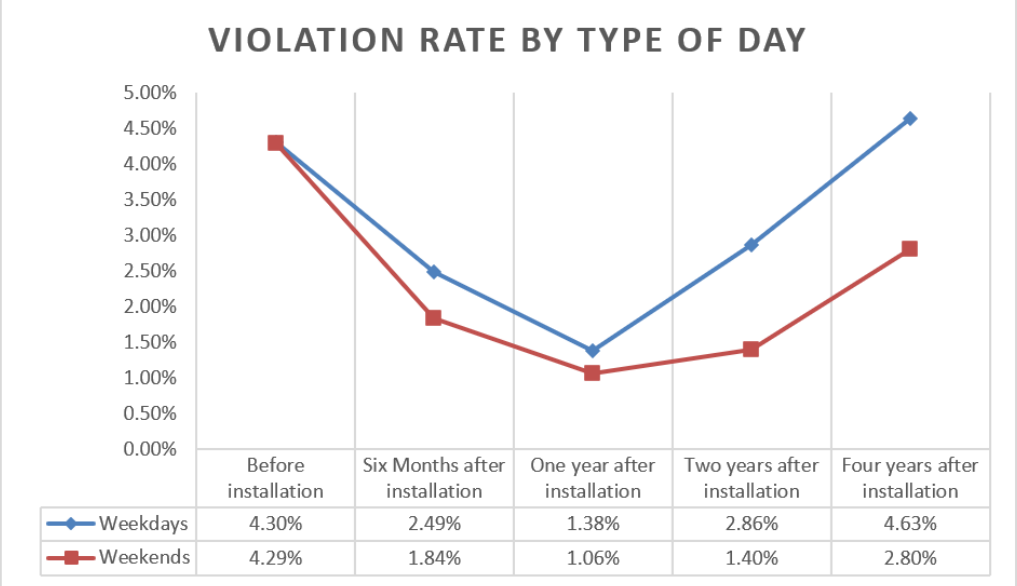


FIGURE 6: rate before and after by type-of-day

Looking by the odds, drivers on weekends tended to violate 4.164 times (95% CI: 3.857, 4.496) before installation when compared to one year after installation. The number decreased to 1.553 (95% CI: 1.463, 1.649) times more before to four years after installation. The trend of odds is similar to weekdays. After four years of installation, drivers are more likely to violate 1.081 times more when compared to before installation.

TABLE 7: Violation and volume by type-of-day

	Weekdays		Weekends	
	Violate	**Comply**	**Violate**	**Comply**
Before Installation	**3,868**	**86,060**	**3,002**	**67,046**
6 Months After Installation	**2,402**	**94,062**	**1,376**	**73,538**
O.R (95% CI)	1.760 (1.671, 1.854)		2.393 (2.243, 2.553)	
1 Year After Installation	**1,136**	**80,923**	**855**	**79,514**
O.R (95% CI)	3.202 (2.995, 3.423)		4.164 (3.857, 4.496)	
2 Years After Installation	**2,253**	**76,486**	**1,022**	**71,960**
O.R (95% CI)	1.526 (1.447, 1.609)		3.153 (2.934, 3.387)	
4 Years After Installation	**3,644**	**74,984**	**1,752**	**60,792**
O.R (95% CI)	0.925 (0.883, 0.989)		1.553 (1.463, 1.649)	

Based on these results, it can be safely said that day of the week seems to be one of the factors affecting red light running. In support of this, a study conducted by Green (2003) also found that incidents of red light running occurred higher during weekdays than during weekends.

4. CONCLUSION

In general, the study showed an overall reduction in violation rate up until one year after installation with 1.23% as compared to before installation (4.29%) before being on the rise four years after with 3.82%. Motorcycles held the position of the highest violator, whereas cars and other types of vehicles recorded almost similar violation rates. As for location type, Perak was found to have higher violation rates before installation with 5.19% as compared to Kuala Lumpur with only 3.71%. However, from two years onwards after installation, the tables have turned with Kuala Lumpur being the higher violator with 2.49% and 4.55% after four years, whereas Perak with 1.57% and 2.64 respectively.

On the other hand, the trend of violation rates for both times and type-of-day was almost similar. Drivers ran the red light more often during off-peak hours (4.67%) as compared to during peak hours (3.91%) before installation, which then changed to more violations during peak hours (six months after: 2.30%; one year after: 1.34%; two years after: 3.10% and four years after: 5.30%) as compared to off-peak hours (six months after: 2.11%; one year after: 1.13%; two years after: 1.40% and four years after: 2.65%). As for the type of day, weekdays showed a higher violation rate with 4.30% before, plunged to 1.38% one year after, and climbed up to 4.63% after four years than weekends with 4.29% before, 1.06% one year after and 2.80% after four years.

Looking at the results, the installation of AwAS is indeed timely and was found to be very beneficial in Malaysia. AwAS has been proven in previous studies to be an effective tool in reducing red light crashes, but only a few studies had been carried out in Malaysia. A study performed by Universiti Putra Malaysia (Kulanthayan et al., 2007) has recommended that cameras be installed at traffic light intersections to detect violations. Nonetheless, there were issues with the public about whether the installation of AwAS is beneficial and whether they have improved safety or merely acted as a revenue generator to Malaysia. Those issues have led to revising the number of fines and many unsettled summonses. This initiative has created an opportunity and attitude for drivers to ignore their summonses since previous traffic offenders that must pay the full fine will feel unfair. This could explain the increase in violation trend starting two years after implementation.

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