

“Analyzing the Driver Behavior Compliance Toward Point-to-Point and Roadside Camera Speed Limit Enforcements”

Researchers:

Nayef Almutairi

Ahmad Alshuwaib



Abstract:

Traffic safety is a crucial part of transportation engineering, and speed limit enforcement plays a major task to accomplish the traffic safety. This research aims to examine the effect of the point-to-point and roadside camera enforcements on the driving behavior compliance and performance. The area of concern is King Fahad Bin Abdulaziz Road in Kuwait. The data were gathered from Ministry of Interior and site observations to maintain the results. Performance analysis was conducted to introduce infringements per kilometer covered, average speeds and standard deviation comparisons. The most notable results are the changes in average speeds through different site observation, which are 2.52% and 7.83% between the point-to-point and roadside camera respectively. Also, the changes in standard deviation through different site observation are 9.8% and 31.29% between the point-to-point and roadside camera respectively. The results reveal a significant advantage of the point-to-point speed enforcement over the roadside camera enforcement. Thus, the objective of the study was fulfilled; traffic safety was enhanced by applying the point-to-point speed enforcement to control the speed limit.

Keywords: Driver behavior compliance; Point-to-point; Roadside camera; Speed limit enforcement.

1. Introduction and background

Roads are one of the most common ways in the world for transport at the present time. In the beginning roads were invented for military purposes and developed after then for civil transport to link areas, cities and counties. The increase of population coincide the importance of the roads as their way to transport accompanied by the increase of demand on roads. There are many difficulties facing the transportation engineers nowadays and one of the most important issues is traffic safety.

The roads become more complex to accommodate more vehicles and users. Furthermore, the drivers do not always concentrate on driving and to obey the traffic rules and regulations which lead to accidents. Moreover, accidents are varying in severity through injuries up to fatality in some cases depending on increased vehicle speed. In 2015 the World Health Organization (WHO) has published a report reflecting over 180 countries indicates the deaths of road injury exceed 1.25 million per year. The report also published Kuwait profile to reported road traffic fatalities in 2012 to be 487. In Figure 1 it is shown the deaths per 100,000 populations.

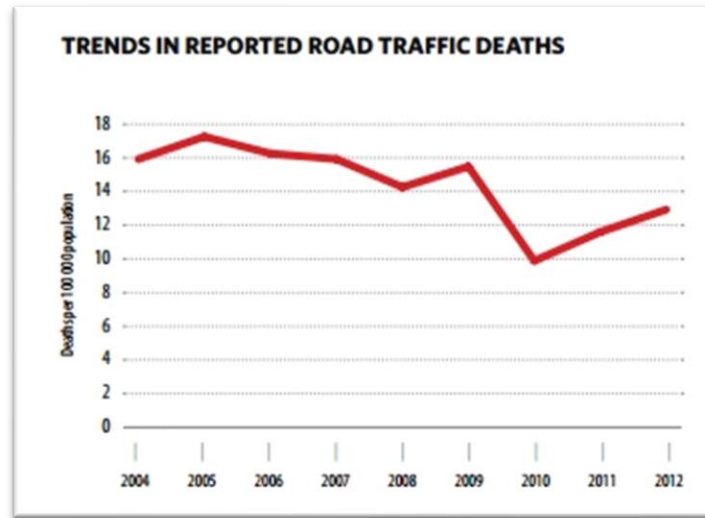


Figure 1: Trends of deaths per 100,000 populations in Kuwait

Due to the increased number of traffic accidents especially road injuries and fatalities, traffic safety concerns have become just as important as road construction and capacity. Thus, the importance of traffic safety engineering is noticeable. Accomplishing the traffic safety depends on engineering, education, emergency and enforcement.

This research focuses on enforcement type to control speed limits of the drivers to measure the effect and impact on driver behavior compliance. Especially, examine the relation between point-to-point average speed detection and roadside speed camera on driver behavior compliance. The area of concern is King Fahad Bin Abdulaziz Road in Kuwait. The area is located in the only place that has point-to-point in Kuwait. In addition, this location has many roadside cameras that bring a good opportunity to compare these types of enforcement to driver behavior compliance. Mainly, most of the road users of King Fahad Bin Abdulaziz Road sharing the same criteria as going to chalet, camping or traveling in road trip. This research aims to examine the effect of the point-to-point and roadside camera enforcements on the driving behavior compliance and performance.

2. Literature Review

2.1. Traffic Safety Factors

There are many factors affect the traffic safety and accidents involvement. In previous research conducted in the UAE (Hassan et al., 2012) examines the factors affecting the traffic safety and the main deficiency is the driver behavior among the other factors. In addition, the law enforcement is to be considered in the study. Moreover, in China (Tian et al., 2013) investigated a freeway to discover that most of the accidents are rear-ends and side-swipe. The main attribute of these

accidents are speed difference. According to the previous work the driving behavior, law enforcement and speed difference are playing major role in traffic safety.

Previously, (Aarts et al., 2006) study the driving speed with crash rates. Consider the driving speed is main factor of traffic safety. Moreover, driving speed reflects the severity of crashing and even the risk of involving in crash. The results show that higher speed variance between the vehicle speed and the traffic flow speed increases the risk of involving in crashes.

2.2. The impact of enforcement on driving behavior

Traffic enforcement has played a major role in improving the traffic safety. Especially, the police enforcement affects the driver behavior. (Stanojevic et al., 2013) has study the unordinary situation in Serbia and North Kosovo where one with traffic enforcement and the other without. The comparison indicates that North Kosovo are more engage with risky driving behavior, exceed the speed limit more frequently and violate the law more often than Serbians. This experiment shows the presence of enforcement has significant influence on driver behavior compliance.

2.3. Fixed camera effects

Recently in Belgium (Pauw et al., 2014) studies the effects of roadside fixed camera. Two upstream points, one at the camera and two downstream points were taken to examine the impact of fixed camera. The results shows high differences in average speed at speed camera locations that produce V-profile shape indicating the differences in speed over the measurement points.

According to (Liu et al., 2011) who studies the automated speed enforcement of rural highway in China. The speed camera has remarkable results in reducing the vehicles speed at the camera location. In contrast, the effect of speed camera reduced beyond the area of influence. Furthermore, drivers decrease their speed within 400m and recover their original speed within 400m which determine the area of influence to be less than 1km. Also, one of the recommendations was to implement new live speed enforcement.

2.4. Point-to-point effects

Speeding violence is a major contribution in freeway accidents. The frequently and severity of the accidents depend on speed variation. According to (Soole et al., 2013) the effects of average speed enforcement (point-to-point technology) are not limited speed reduction. Moreover, this type of enforcement reduce the crash rates and shows improvement in traffic

flow, travel time reliability and vehicle emissions. Also, this study reported high acceptance of the drivers for the average speed enforcement.

Recently, in Italy (Montella et al., 2015) has examine the point-to-point speed enforcement system and its efficiency to speed compliance and safety. Using seven sections to analyze the speed data and using empirical Bayes (EB) approach to evaluate the safety. The results were remarkably positive on both speed and safety. Furthermore, the decrease in standard deviation of speed is 26% which means less speed variation in the road and a reduction by 32% in crash rates.

3. Methodology

The considered methodology is performance analysis. The performance analysis is based to examine the existing previous solutions. This research is study and evaluates the existing types of enforcement. Examine the relation between point-to-point average speed detection and roadside speed camera on driver behavior compliance.

3.1. Data gathering

There are two data sources for this research. The first data source is Ministry of Interiors (MOI) infringements record and road volumes for the road of concern. The second data source is observation to maintain the vehicles speeds in different site locations.

The record of speed infringement and road volume has been collected from MOI. The data record has been collected in two periods; the first period start from 1/2/2014 to 31/12/2014 and the second period start from 1/1/2015 to 30/4/2015. The road volumes were divided into two periods and according to direction.

There are three lanes in each direction in King Fahad Bin Abdulaziz Road. The directions are from Kuwait City to Al-Nuwiseeb and vice versa as shown in figure 2. The road volumes of each direction according to the periods are shown in table 1.

Table 1: Road volume of King Fahad Bin Abdulaziz in each direction according to the periods

Direction	Volume in first period	Volume in second period
Kuwait City to Al-Nuwiseeb	6,952,845	1,873,277

Al-Nuwiseeb to Kuwait City	9,183,494	1,897,754
-----------------------------------	-----------	-----------

3.1.1. Point-to-point data

The MOI infringement data were for bulk periods and not detailed nor specified. The data for point-to-point were involving two segments as shown in figure 2, the first segment is 9.5km including both directions and the second segment is 14km including both directions of King Fahad Bin Abdulaziz Road. As shown in table 2, the number of infringements over the two periods including the two segments in King Fahad Bin Abdulaziz Road.

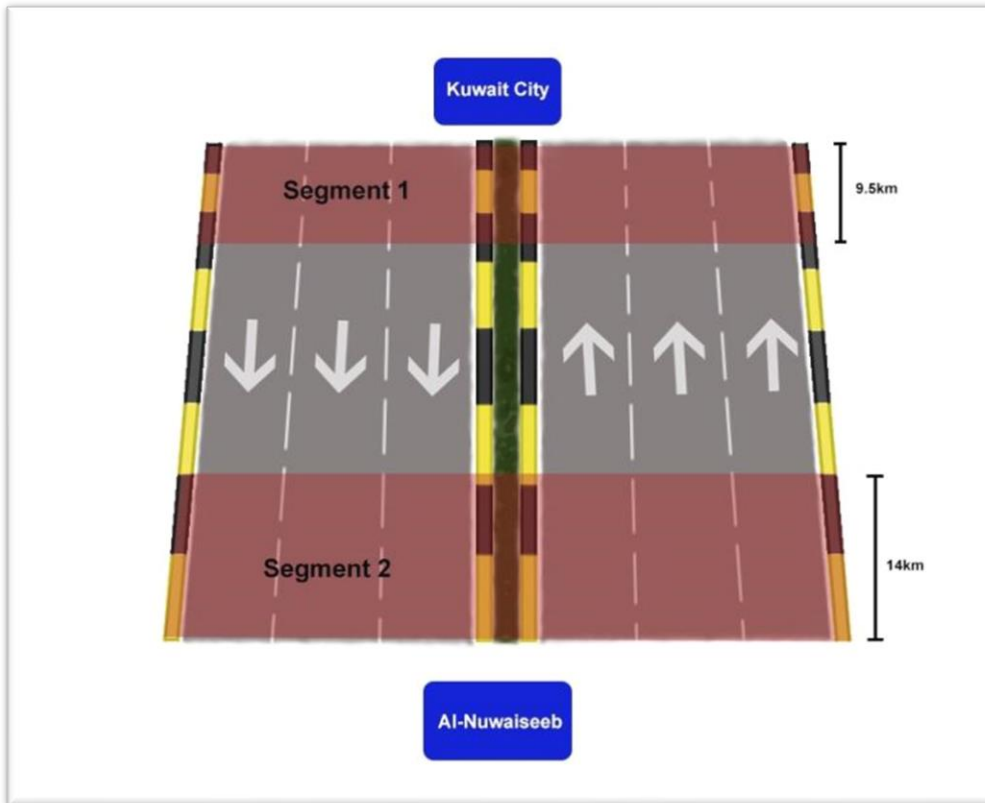


Figure 2: The segments of point-to-point in King Fahad Bin Abdulaziz Road

Table 2: Point-to-point infringements number in King Fahad Bin Abdulaziz Road

Period	1/2/2014 – 31/12/2014	1/1/2015 – 30/4/2015
Point-to-point	420,190	97,515

As the observation considers being one of the most powerful tool to collect data. The observation was conducted in three different locations to collect the vehicles speeds. The observation was including one segment of point-to-point

enforcement. The site locations of observation were at entrance and exit of point-to-point segment. In addition, there is one point added to increase the accuracy of the observation in between the entrance and exit points.

To reflect the real behavior and attitude of the driver as they choose their speed the observation of the road to detect the vehicles speed were in free flow. There are total of 390 vehicles included in the observation. There are 130 vehicles at each site locations were included in the observation. The observation involves cars and trucks to obtain the real speed variation between the all types of road users. Table 3 shows the average speed at each location.

Table 3: Average vehicles speed in different site observation location for point-to-point

Site location	Average Speed
Point-to-point entrance	109.4
Between two bridges	110.9
Point-to-point exit	108.1

3.1.2. Roadside camera data

Road side camera data were obtained from MOI infringement record and site observation to collect the vehicle speeds. The MOI record gives 5 roadside cameras in King Fahad Bin Abdulaziz Road. However, the roadside camera detect speed limit in one direction only. The infringement record for the two periods is shown in table 4.

Table 4: Roadside camera infringements number in King Fahad Bin Abdulaziz Road

Period	1/2/2014 – 31/12/2014	1/1/2015 – 30/4/2015
5 roadside cameras	88,340	31,417

The site observation consider as one of the most effective ways to collect information. The observation in this research is to collect the vehicles speed before, after and at the roadside camera. There are three locations for site observation to collect the vehicles speed for the roadside camera. The first observation point is located 700m before the speed camera. The second observation point is located at the speed camera. The third observation point is located 700m after the speed camera. The locations of site observation were chosen to eliminate the effect of other roadside cameras since they are located within close range.

There is one roadside camera included in observation. In order to reflect the driver behavior compliance towards roadside camera especially, before and after comparison situation there must be free flow. This situation allows the drivers to choose their speed according to their attitudes and behavior. Working accordingly, there are 390 vehicles included in the observation at King Fahad Bin Abdulaziz Road.

There are 130 vehicles at each site locations were included in observation. The observation involves cars and trucks to obtain the real speed variation between the all types of road users. Table 5 shows the average speed at each location.

Table 5: Average vehicles speed in different site observation location for roadside camera

Site location	Average speed
Before 700m	107.4 km/h
At roadside camera	100.1 km/h
After 700m	108.6 km/h

4. Results and discussion

This section concerned in analyzing and discusses the raw data for point-to-point and roadside camera.

4.1. Point-to-point analysis

The site observations were conducted in three different locations to analyze the driver behavior compliance towards point-to-point enforcement. The results were differ than expected as known that reckless attitude and behavior of Kuwaiti drivers. The average speeds for point-to-point site locations are shown in figure 3. The reason stands behind the average speeds to be reasonable low and below the speed limits that the observations include cars and trucks.

The results in figure 3 show a slight change in average speeds within the observation site which was 9.5km. The average speeds approximately remain the same in the whole covered distance by the point-to-point enforcement according to the observations. Moreover, the results confirms that the driver comply with point-to-point enforcement which means that the effect of such enforcement are not limited to the entrance and exit bridges. There is 2.52% change in average speeds between the highest and lowest observation sites.

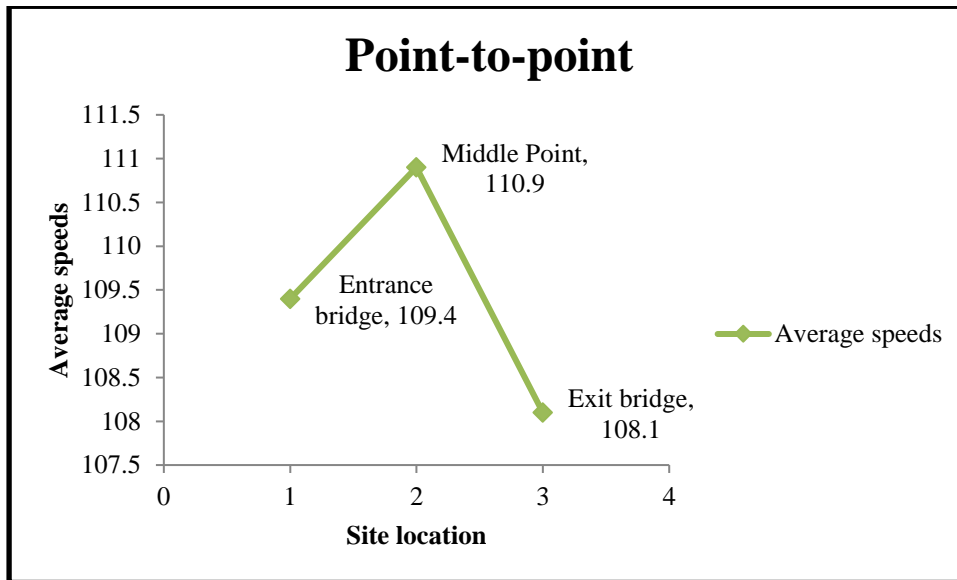


Figure 3: Average speeds of point-to-point

In addition to average speeds, the standard deviation was conducted in the analysis. The standard deviation analysis is the quantitative investigation of the difference between actual and planned behavior. In this situation, the standard deviation indicates the speed of observed cars and trucks with the average speed. The results of standard deviation for point-to-point are shown in figure 4. The standard deviation at the entrance bridge is equal to 15.3km/h, at middle point is equal to 13.8km/h and at the exit bridge is equal to 14.3km/h. As figure 4 represent a slight difference in standard deviation between the observation locations although the covered distance is 9.5km. There is 9.8% change in standard deviation between the highest and lowest observation sites.

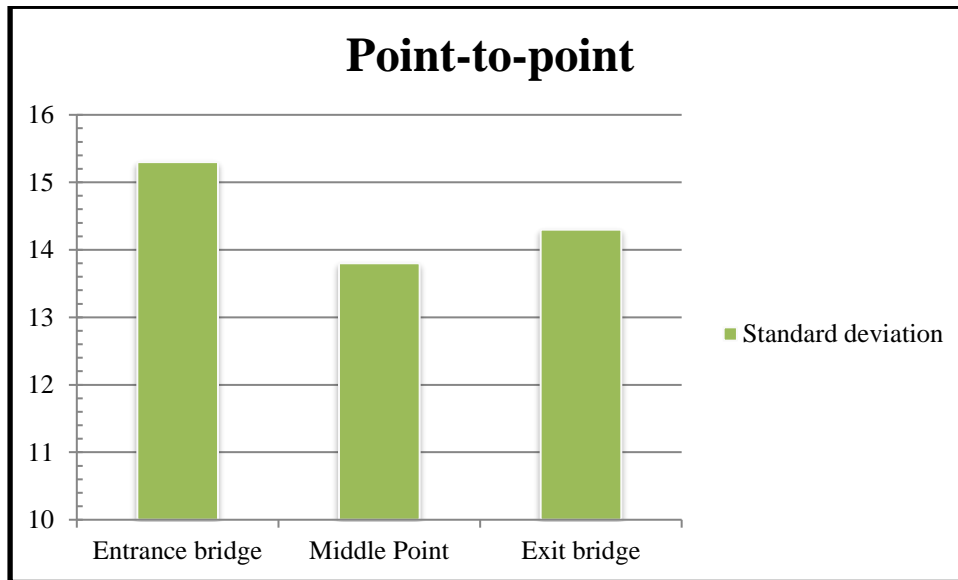


Figure 4: standard deviation of point-to-point

4.2. Roadside camera analysis

The site observations were conducted in three different locations to analyze the driver behavior compliance towards roadside camera enforcement. The results were predictable as Kuwaiti drivers are careless, aggressive and tend to violate the regulations. The average speeds for roadside camera in each observation location are shown in figure 5. The average speeds include every car or truck passed through the observation period, thus the average tends to be within speed limit.

As shown in figure 5, there is decrease in average speed at the camera location which indicates its effectiveness at certain point in the road at driving behavior. However, figure 5 shows also great difference between the observation site locations that produces V-shape graph which confirms that the roadside camera effect is positional at certain point. The results assure that the driver behavior is predictable; as the driver recognizes any type of enforcement he will comply accordingly to correct his misbehavior. There is 7.83% change in average speeds between the highest and lowest observation sites.

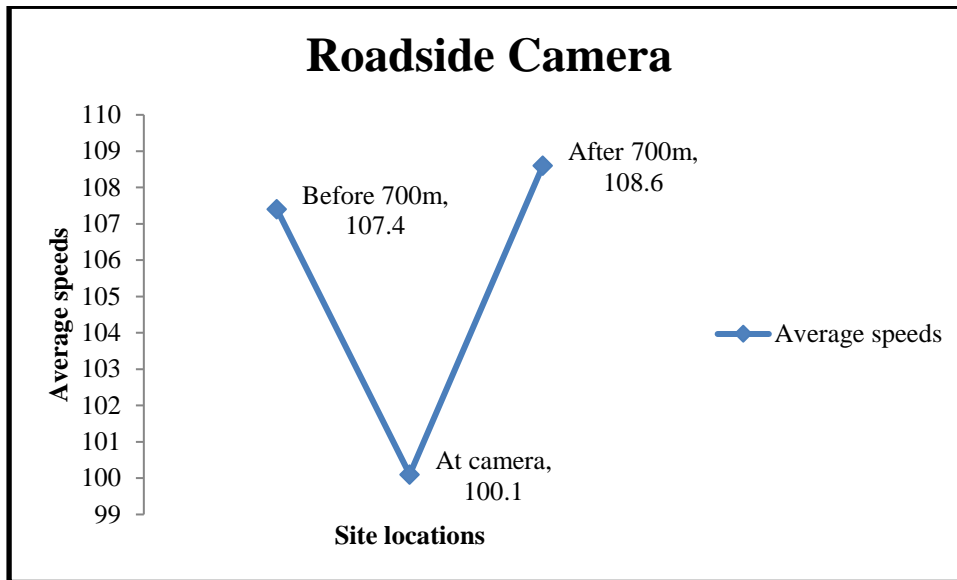


Figure 5: Average speeds of roadside camera

Moreover, standard deviation is another indicator beside the average speeds to analyze the roadside camera. The standard deviation analysis is the quantitative investigation of the difference between actual and planned behavior. In other words, the standard deviation shows the difference in speed between the average speed and the other road users' speed. Figure 6 represent the standard deviation before 700m is equal to 15km/h, after 700m is equal to 16.3km/h and at the camera location is equal to 11.2km/h. The results show great difference and gap between the before-after locations and at camera location. Further explanation for figure 6, the less standard deviation means less speed variation which increases the road safety traffic and vice versa. There is 31.29% change in standard deviation between the highest and lowest observation sites.

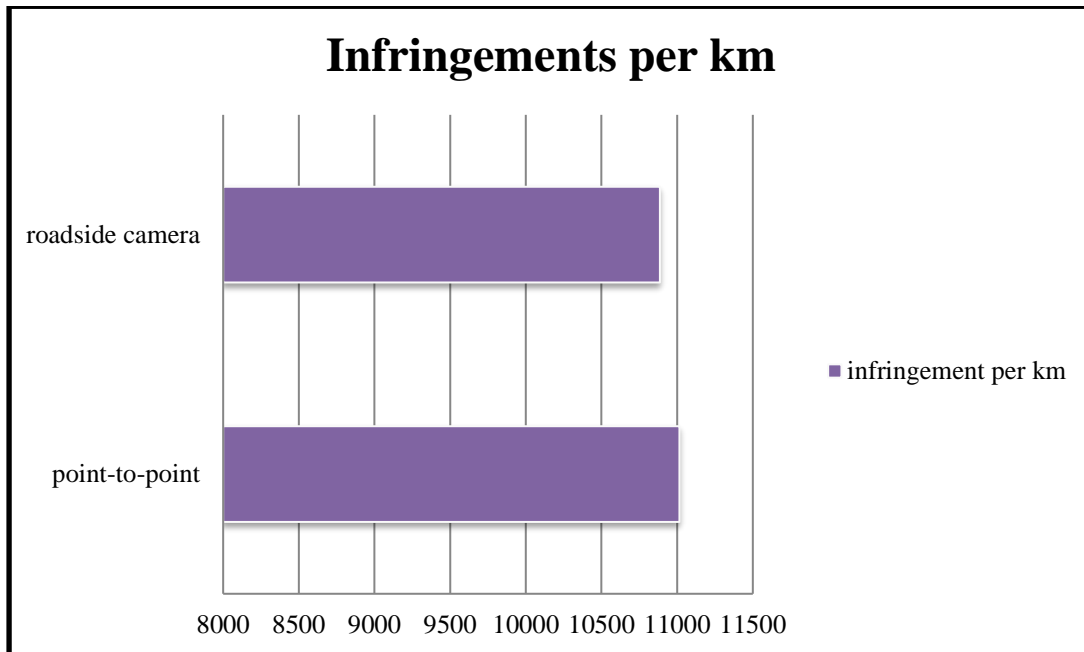


Figure 7: comparison in infringement per km between different enforcement types

The second comparison would include the average speeds between the point-to-point and roadside camera enforcement. The observation for collecting the speeds were held in free flow to ensure the driver choose his speed according to his attitude and behavior. These comparisons consist of supposed covered area of each type of speed limit enforcement. The suggested coverage area in total for roadside camera was 1.4km that affects the driver behavior compliance. Meanwhile, the point-to-point proposed coverage area was within the entrance and exit bridges since it is already covering 9.5km.

As revealed in figure 8, there is a great difference between the two types of speed limit enforcements. The roadside camera shows different response at the camera rather than before or after. Moreover, the observation produces V-shape which indicates that the influence is limited to the camera point. The point-to-point enforcement shows a uniform response in the whole covered distance. The drivers comply indicates that the affect of point-to-point is extend to the entire point-to-point covered distance.

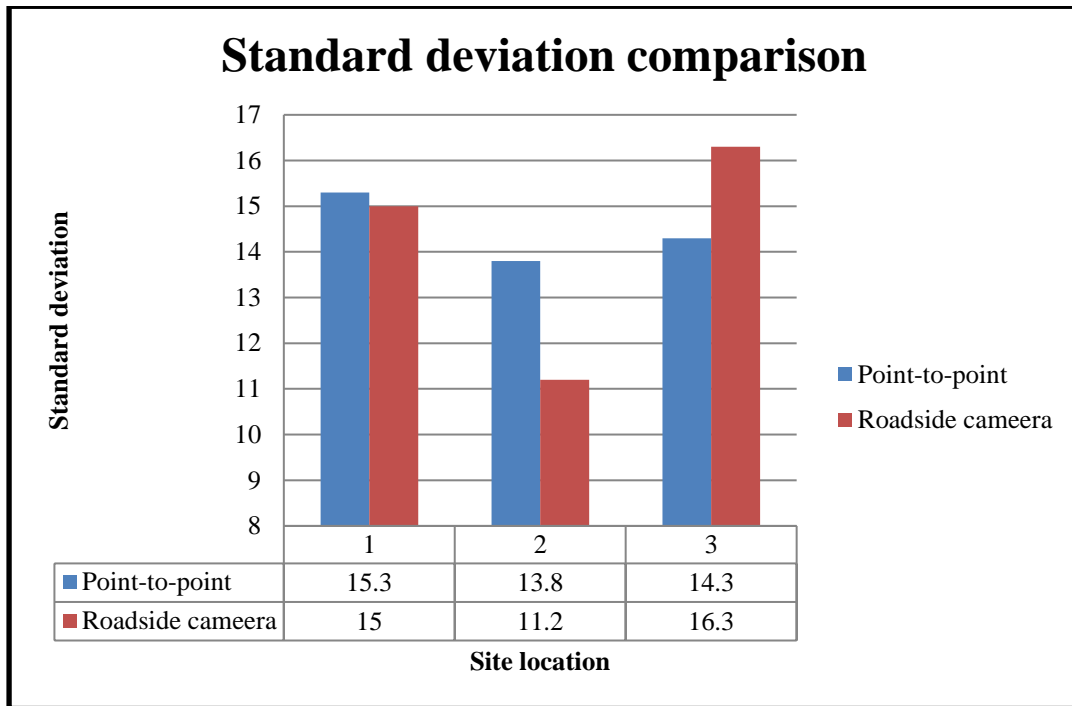


Figure 9: comparison in standard deviation between different enforcement types

5. Conclusion

Traffic safety is a crucial part of transportation engineering, and applying enforcement to regulations plays a major task to accomplish the traffic safety. The road of concern was King Fahad Bin Abdulaziz which consists of point-to-point enforcement and roadside camera enforcement for controlling the speed limit. This paper studied the drivers behavior compliance and performance towards the point-to-point and roadside camera enforcements.

This research aims to examine the effect of the point-to-point and roadside camera enforcements on the driving behavior compliance and performance. The comparisons in this study are infringements per kilometer, average speeds and standard deviation. These comparisons were conducted to examine the performances of the drivers and to analyze the driving behavior compliance towards different enforcement type. The infringements per kilometer for roadside camera is 10887 while for point-to-point is 11015. The infringements per kilometer shows a slight advantage to roadside camera over the point-to-point yet, the camera is fixed point and easy to avoid and detect one direction only rather than the point-to-point. In addition, the results of the change in average speeds over the observation sites are 2.52% and 7.83% between the point-to-point and roadside camera respectively. Also, the results of the change in standard deviation over the observation sites are 9.8% for point-to-point enforcement and 31.29% for the roadside camera enforcement. Both comparisons indicate to a great

evidence and advantage to the point-to-point over the roadside camera. That reflects more compliance and uniform performance from the drivers in point-to-point enforcement over the covered distance. Overall, the point-to-point speed enforcement reveals significant results over the roadside camera.

Although the results were valuable, more wide studies should be conducted before stating the optimum enforcement. This research could be considered as a starting point in comparing the different types of enforcement. There are several limitations in this study could be in the future researches. The data from MOI are considered as raw data not specified nor detailed. In addition, the observations were limited to time issue and could be more intense. Further studies to be conducted using other methodology tools and to examine the different types of enforcement such as hidden cameras and the presence of a police car on driver behavior compliance and performance. This study has successfully determined that the point-to-point is more effective than roadside camera enforcement with noticeable compliance and performance in the driving behavior.

6. References

- Montella, A., Imbriani, L., Marzano, V., & Mauriello, F. (2015). Effects on speed and safety of point-to-point speed enforcement systems: Evaluation on the urban motorway A56 Tangenziale di Napoli. *Accident Analysis & Prevention*, Volume 75, 164-178.
- Soole, D., Watson, B., & Fleiter, J. (2013). Effects of average speed enforcement on speed compliance and crashes: A review of the literature. *Accident Analysis & Prevention*, Volume 54, 46-56.
- Stanojević, P., Jovanović, D., & Lajunen, T. (2013). Influence of traffic enforcement on the attitudes and behavior of drivers. *Accident Analysis & Prevention*, Volume 52, 29-38.
- Pauw, E., Daniels, S., Brijs, T., Hermans, E., & Wets, G. (2014). Behavioural effects of fixed speed cameras on motorways: Overall improved speed compliance or kangaroo jumps? *Accident Analysis & Prevention*, Volume 73, 132-140.
- Global Status Report On Road Safety 2015. World Health Organization, 2015.
- Hassan, M., Hawas, Y., & Maraqa, M. (2012). A holistic approach for assessing traffic safety in the United Arab Emirates. *Accident Analysis & Prevention*, Volume 45, 554-564.

Tian, R., Xiang, Q., & Hu, S. (2013). Research on Traffic Safety of Freeway Upgrade Section. *Procedia - Social and Behavioral Sciences*, Volume 96, 548-556.

Aarts, L., van Schagen, I., (2006). Driving speed and the risk of road crashes: a review. *Accident Analysis & Prevention*, Volume 38, 215–224.

Liu, P., Zhang, X., Wang, W., & Xu, C. (2011). Driver Response to Automated Speed Enforcement on Rural Highways in China. *Transportation Research Record: Journal of the Transportation Research Board*, Volume 2265, 109-117.

"تحليل سلوك السائقين في الامتثال لقوانين السرعة من خلال كاميرات مراقبة السرعة النقطية والجانبية"

إعداد الباحثان:

نايف المطيري

أحمد الشويح

الملخص:

تعتبر سلامة المرور جزءاً حيوياً من هندسة النقل، ويؤدي تطبيق حدود السرعة دوراً مهماً لتحقيق سلامة المرور. تهدف هذه الدراسة إلى فحص تأثير تطبيقات كاميرات السرعة النقطية والجانبية على سلوك السائقين في الالتزام والأداء. المنطقة المستهدفة هي طريق الملك فهد بن عبد العزيز في الكويت. تم جمع البيانات من وزارة الداخلية والملاحظات الميدانية لضمان دقة النتائج. تم إجراء تحليل الأداء لتقديم انتهاكات لكل كيلومتر تم قطعه، والمقارنة بين السرعات المتوسطة والانحراف المعياري. من النتائج الملحوظة هي التغيرات في السرعات المتوسطة من خلال ملاحظات ميدانية مختلفة، والتي كانت 2.52% و 7.83% بين الكاميرات النقطية والجانبية على التوالي. أيضاً، كانت التغيرات في الانحراف المعياري بين الملاحظات الميدانية المختلفة 9.8% و 31.29% بين الكاميرات النقطية والجانبية على التوالي. تكشف النتائج عن ميزة ملحوظة لتطبيق السرعة النقطية بالمقارنة مع تطبيق كاميرات السرعة الجانبية. وبالتالي، تم تحقيق هدف الدراسة؛ حيث تم تعزيز سلامة المرور من خلال تطبيق نظام السرعة النقطية للسيطرة على حدود السرعة.

الكلمات المفتاحية: الامتثال لسلوك السائق؛ نقطة إلى نقطة؛ كاميرا جانبية؛ تطبيق حدود السرعة.