A STUDY ON THE EFFECTS OF TRAFFIC ENFORCEMENT ON THE TRAFFIC ACCIDENTS OCCURRENCE IN JAPAN

HAMAOKA, Hidekatsu, Akita University, hamaoka@ce.akita-u.ac.jp
MORIMOTO, Akinori, Utsunomiya University, morimoto@cc.utsunomiya-u.ac.jp

ABSTRACT

Traffic enforcement aims to decrease the number of traffic accidents. However, the methods of traffic enforcement that most effectively reduce traffic accidents have not been clarified yet. This study clarifies the influence of traffic enforcement on traffic accident occurrence by analyzing the relationship between traffic enforcement and traffic accidents. To understand that relationship, two kinds of analyses were conducted: data analysis of traffic enforcement and traffic accidents, and behavior analysis by simulated speed investigation. The data analysis of traffic enforcement and traffic accidents found an inverse relationship. It is important to match traffic enforcement with the number of traffic accidents by time or area. Driver behavior analysis using dummy speeding enforcement found that showing a dummy speeding camera is effective at lowering driving speeds on roads whose driving speed is not too high. These results will contribute to traffic enforcement planning.

Keywords: traffic accident, traffic enforcement

INTRODUCTION

In Japan, almost 700,000 traffic accidents occur each year. An analysis of the number of traffic accidents in the past 10 years found a trend of gradual decrease from 2004. This was attributed to improvements in the road and traffic environments and strengthening of traffic enforcement. Moreover, the penalties for drunk driving were stiffened because traffic accidents involving drunk drivers had been a social problem. These factors are considered to be contributed to the decrease in traffic accidents.

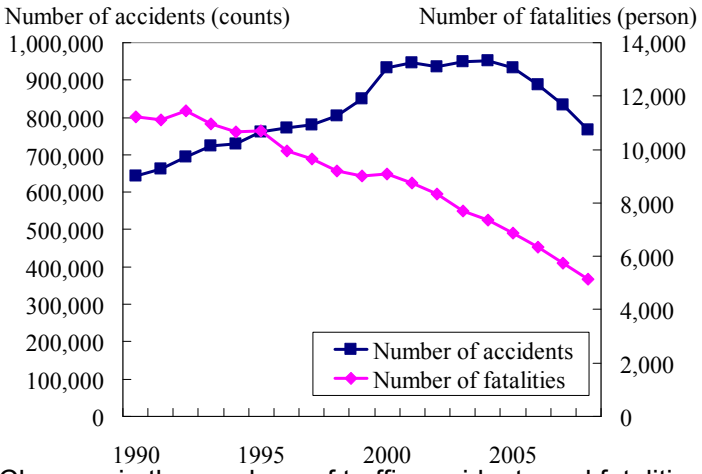


Figure 1 Changes in the numbers of traffic accidents and fatalities in Japan

Traffic enforcement aims to decrease the number of traffic accidents. However the methods of traffic enforcement that can best reduce traffic accidents have not been clarified yet. This study tries to clarify the influence of traffic enforcement on traffic accident occurrence by analyzing traffic enforcement data and traffic accident data. Regarding speeding violations, even a slight increase in the numbers of drivers charged for speeding violations results in a large decrease in the number of accidents induced by speeding. Therefore, it is important to clarify how traffic enforcement affects traffic accident occurrence. A survey of how driving speed changes with traffic enforcement is considered useful for clarifying the effect of traffic enforcement on accident occurrence.

In this study, we conducted a survey of vehicle speeds to clarify the effects of drivers' recognition that speeding enforcement is being conducted on their driving speed, and in turn on the occurrence of traffic accidents. In addition, we investigated how long drivers continued to practice "enforcement conscious driving" after recognizing a certain kind of traffic enforcement was being conducted. To this end, we analyzed data on drivers who had been charged for ignoring traffic signals or stop signs, for speeding violations or for drunk driving.

REVIEW OF THE LITERATURE

It is well known that exceeding the speed limit is one of the most common traffic safety violations. A considerable amount of research has linked excessive speed to increased accident risk and severity. Evans & Wasielewski (1) and (2) analyses the driving behaviour between the subjects whether they had already caused traffic accidents and also traffic violation or not. Results of these research show that the driver who had already caused traffic accidents or traffic violations keeps shorter headway in the traffic. Therefore, it is important to change driving behaviour by installing some countermeasures such as implementing traffic enforcement. In considering the method of traffic enforcement to reduce speeders, there are three types of police enforcement: stationary radar speed enforcement, mobile enforcement and speed camera enforcement.

Stationary Speed Enforcement

In stationary speed enforcement, the police establish and staff a point for monitoring vehicle speed by radar. Most studies evaluating the effect of increased stationary visible speed enforcement have shown a decrease in traffic accident numbers. Elvik & Vaa (3) combined the results of 16 speed studies, evaluating the effect of stationary speed enforcement on accidents. Significant reductions in fatal accidents and injury accidents were observed, but no significant effects were detected for minor accidents. In general, speeding violations decrease when stationary police enforcement is present. Mean speeds decrease by roughly 3 mph, and the proportion of drivers exceeding the speed limit was found to decrease by 3% to 64% in various studies across different road types (4).

More recently a large-scale retrospective study was carried out on the rural road network in the Netherlands (5). The study used radar devices to detect speeders. A significant decrease in the number of road accident was observed after drivers recognized the radar device, and this was attributed to drivers driving slower than without radar devices.

Mobile Enforcement

In general, mobile enforcement is conduced as the same way as general police patrol. Mobile policing increases the area covered and can be used for a more general level of enforcement. A study in the United Kingdom examined mobile enforcement on four motorways (6). On two motorways, large numbers of drivers were charged with traffic violations, whereas on the other two motorways the numbers were small. Even on the motorways with a high increase in enforcement, the measured reductions in speed were considerably smaller than those that have been reported in studies of stationary policing.

However, mobile enforcement was not always seen to have effects. When a direct comparison between mobile and stationary policing was made in a study in the USA (7), the effects of visible mobile vs. stationary policing on mean speeds and proportion of drivers exceeding the speed limit were not significantly different.

Speed Camera Enforcement

Speed cameras and other speed enforcement technologies allow speed violations to be detected continuously at appropriate sites without police officers being present. Elliott & Broughton (4) evaluated eight recent studies in the United Kingdom assessing the effect of speed cameras on speeding violations and accidents. Fatal accidents at speed camera sites were observed to decrease by up to 56% (8), and speeding violations by up to 71% (8). A meta-analysis of more than ten studies from various countries (3) estimated that speed cameras produced a 19% decrease in all accident types. Speed cameras were shown to be more effective in urban areas, with an estimated reduction of 28%.

Speed Enforcement Studies in Japan

In Japan, few studies have addressed the relationship between traffic accidents and speed enforcement. However, one study addressed effective methods of traffic enforcement by examining the correlation between numbers of traffic accidents and numbers of drivers charged with traffic violations in a small city (9). They studied the time-lag between the number of drivers charged with traffic violations and the number of traffic accidents, and reported that the highest correlation was observed between the number of drivers charged for traffic violations and the number of traffic accidents at two weeks after the beginning of traffic enforcement.

From the viewpoint of the driver's perception of speeding, Ushikoshi et al. (10) investigated whether younger drivers tend to assume a higher margin for enforcement beyond the speed limit than older drivers assume. In the survey, drivers were asked the speed at which they thought they would be at risk for being charged with speeding for driving on a road whose speed limit was 60 km/h. Respondents in their sixties answered 13 km/h over the speed limit, whereas the respondents in their thirties answered 18 km/h over the speed limit.

In Japan, the effects of traffic enforcement on the reduction of traffic accidents are recognized. However, the unavailability of detailed traffic enforcement data has made quantitative assessment difficult.

CURRENT SITUATION OF SPEEDING IN JAPAN

In Japan, according to data from 1965 to 2009, the numbers of traffic accidents, deaths and injuries increased sharply from 1965 to 1971, due to the insufficiency of traffic safety measures in light of the sharp increase in the number of vehicles. Recently, the numbers of traffic accidents and injuries have decreased for five consecutive years. In 2009, fatalities from traffic accidents numbered 4,914, marking the ninth consecutive year-on-year decrease. The fatality rate in accidents involving high speeds (over 80 km/h) was 49.7 times higher than in those involving lower speeds. The decrease in traffic fatalities is attributed to a decrease in high-speed accidents (11). This attests to the importance of reducing speeding in efforts to reduce traffic accidents.

A study on the drivers who caused traffic accidents in 2009 revealed that many of them had been charged with speeding between 2005 and 2009 (Table 1). Among the types of violations committed by drivers who caused traffic accidents, speeding was accounted for the greatest share of violations. More male drivers than female drivers were charged for violating traffic regulations. 27% of male drivers who caused traffic accidents in 2009 had been charged with speeding in previous five years. Speeding offenders tend to get caught repeatedly for speeding.

Table 1 Previous-five-year-records of Traffic Violations by Type among Drivers at Fault for Traffic Accidents in 2009 (Population: Drivers who caused accidents: 694,782)

Violation	Male	Female
Running a red light	11%	5%
Illegal parking	10%	6%
Drunk driving	1%	0%
Speeding	27%	15%
Driving where not allowed	10%	5%
Failure to stop at a stop sign	12%	10%
Failure to fasten the seatbelt	25%	14%

Figure 2 shows that drivers charged for speeding in the five years from 2005 to 2009 (10,488,785 persons) account for one eighth of the drivers license holders in Japan (80,811,945 persons). 18% of the drivers who had been charged for speeding in the five years (2005-2009) were charged for speeding at least twice in that period. Among drivers who caused traffic accidents in 2009, 24% were charged for speeding violations at least twice. Therefore, we can assume that drivers who cause traffic accidents tend to be repeat speeding violators.

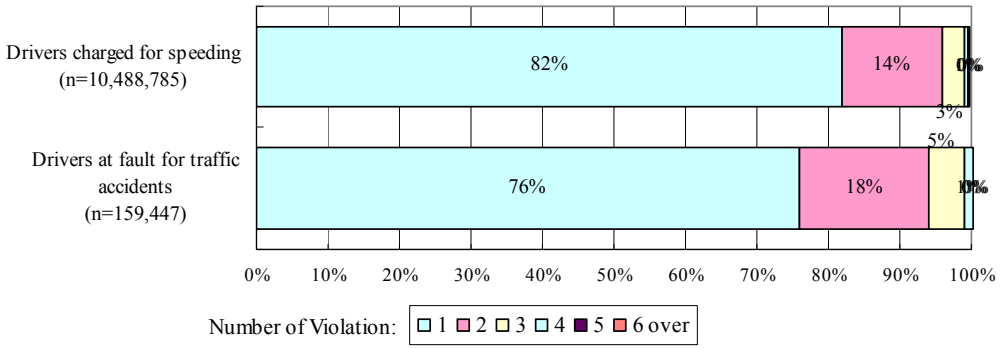


Figure 2 Breakdown of drivers by number of times charged for speeding in the five years from 2005 to 2009

The comparison of two driver groups, a group of safe drivers who were never charged with speeding (safe drivers) and a group of drivers who were charged with speeding at least six times (habitual speed offenders) in the five-year period shows that the two driver groups differ greatly in terms of age distribution. The young driver group (age: 25-34) has a high proportion of habitual speed offenders.

Figure 3 shows that the age group that has the highest percent of safe drivers and of habitual speed offenders is the same for male and female and that this age group is 25-34. The second highest habitual speed offender age group is 35-44 for males and 16-24 for females. The older the age group, the smaller is the share of at least six speed violations. This means there is a smaller share of habitual speeders in the age group than in the younger age groups.

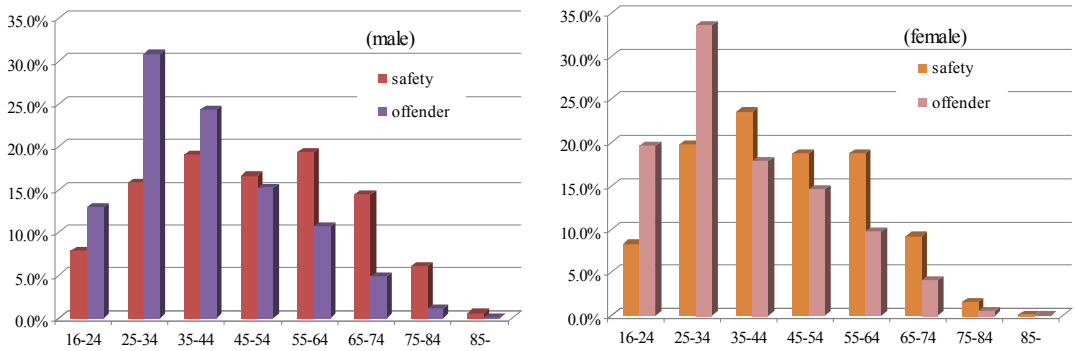


Figure 3 Safe drivers and habitual speeder by age group (left: male, right: female)
*At least six violations in five years

ANALYSIS OF THE RELATIONSHIP BETWEEN TRAFFIC ENFORCEMENT AND TRAFFIC ACCIDENTS

Outline of the Data

In this study, police data were used to understand the relationship between traffic enforcement and traffic accidents. Both data were obtained for the 22 months from Jan. 2009 to Oct. 2010. As traffic enforcement data, we used 4,160 instances of drivers being charged with failure to stop, running a red light or driving drunk. As traffic accident data, we used 1,175 data of fatal or injury accidents.

Table 2 Outline of the Data

Duration		January 2009 to October 2010
Area		Akita Central Police station
Number of the data	Traffic enforcement	4160
	Traffic accident	1175
Intended traffic violation		Red light running, failure to stop, speeding, drunk driving
Accident type		Rear-end collision, crossing conflict, right-turning, pedestrian

Comparison Between the Numbers of Drivers Charged with Traffic Violations and the Number of Traffic Accidents

Figure 4 shows the relationship between the numbers of traffic accident and driver charged with traffic violations by week. The figure shows a decrease in traffic accidents with increases in the number of drivers charged traffic violations and vice versa, i.e., an inverse relationship between the two. Traffic accident and traffic violation is considered as having same trend because these are occurred by the illegal driving behaviours. An interesting relationship between the number of traffic accident and traffic violation per week is shown in Figure 4. The reason of this result is considered that when traffic enforcement is stricter, drivers tend to drive more carefully, which in turn results in fewer accidents. However, the coefficient of correlation between the numbers of drivers charged with traffic violations and of the numbers of traffic accidents is not significant. To confirm whether there is a relationship, time-lag

should be considered between traffic enforcement and number of accidents, because the effects of enforcement are not thought to become evident until several weeks after it is implemented.

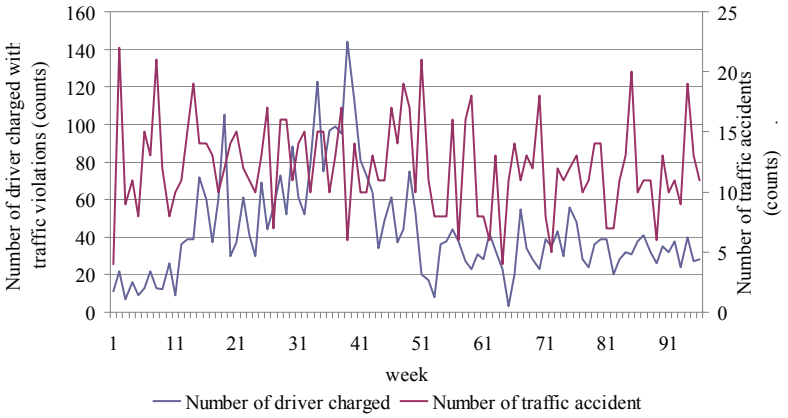


Figure 4 Numbers of traffic accidents and numbers of drivers charged with traffic violations by week

Figure 5 shows the numbers of traffic accidents and of drivers charged with traffic violations by time. If the numbers of traffic accidents and drivers charged with traffic violations had a high correlation, they would have similar trends. However, they have different trends. For example at 08:00 there are many traffic accidents even though the number of drivers charged with traffic violations is comparatively small, and at midnight there are few traffic accidents even though the number of drivers charged with traffic violations is large. Therefore, according to this figure, there is more need to conduct traffic enforcement at 08:00 and less to conduct it around midnight. In considering the types of traffic enforcements, this should be matched with the types of traffic accident. Hence, it is not effective to conduct traffic enforcement for speeders at 08:00. The number of police officer is limited; therefore, it is important to make an efficient deployment plan. Figure 5 plots all data for numbers of traffic accidents and drivers charged with traffic violations. It is important to group traffic accidents by cause, such as "crossing conflict" for traffic accident, and to group violations of traffic regulations by type, such as "failure to stop." If this kind of analysis were conducted, the effect of traffic enforcement would be clearer.

Figure 5 Numbers of traffic accidents and drivers charged with traffic violations by time of day

Traffic accident data and traffic enforcement data include location data, so they can be analyzed according to the area of occurrence. Area analysis can assist in the development of a detailed traffic enforcement plan. Akita, the target city of the survey, consists of 29 areas. The areas with a high number of traffic accidents and traffic enforcement can be determined by tallying the data. Table 3 and Figure 6 show the results. In the Figure 6, size of oval does not show the number of traffic accidents and also that of traffic violations. In Table 3, the top 5 areas in each category are highlighted. From the figure, areas are categorized into three types: 1) both the numbers of traffic accidents and drivers charged with traffic violations are high or low; 2) only the number of traffic accidents is high; and 3) only the number of drivers charged with traffic violations is high.

At the areas near the railway station (Nos. 13 and 14) and at the arterial by-pass (No. 12), both the numbers of traffic accidents and the numbers of driver charged with traffic violations are high. There tends to be a lot of traffic in these areas. This result indicates the difficulty in decreasing the number of traffic accidents by traffic enforcement. Therefore, in depth analysis is needed to establish the effective accident countermeasures. In suburbs, the number of drivers charge with traffic violations is large, but the number of traffic accidents is small. It could be that traffic enforcement keeps the number of traffic accidents low. However, it is possible that traffic enforcement is overdone given the small number of traffic accidents. It is important to analyze the relationship between these in this area. In residential areas, there are few traffic accidents and few drivers charged with traffic violations. It is important to conduct traffic enforcement in this area, because drivers might make many mistakes that lead to traffic accident.

Table 3 Numbers of Traffic Accidents and Drivers Charged with Traffic Violations by Year

Area		Traffic Violation				Accident Type			
		Failure to stop	Red light running	Speeding	Sub-total	Rear-end collision	Crossing Conflict	Pedestran	Sub-total
1	Toyoiwa	23	3	**295**	321	3	1	0	4
2	Shimohama	1	0	**93**	94	5	0	1	5
3	Hamada	6	1	**11**	18	1	1	0	2
4	Yabase	**148**	16	0	164	**37**	**42**	3	82
5	Barajima	120	**255**	0	375	**48**	23	**6**	77
6	Niida	**152**	28	0	180	**35**	26	3	64
7	Sanno	57	46	0	103	**33**	**32**	**8**	73
8	Yotsugoya	**164**	1	0	165	0	0	0	0
9	Kawajiri	3	**109**	0	112	20	18	3	41
10	Narayama	140	**64**	1	205	9	18	2	29
11	Izumi	57	12	0	69	20	**28**	1	49
12	Araya	**277**	**351**	**681**	1309	**34**	**32**	**6**	72
13	Ushijima	**208**	23	0	231	12	15	**6**	33
14	Nakadori	5	**62**	0	67	18	**30**	4	52

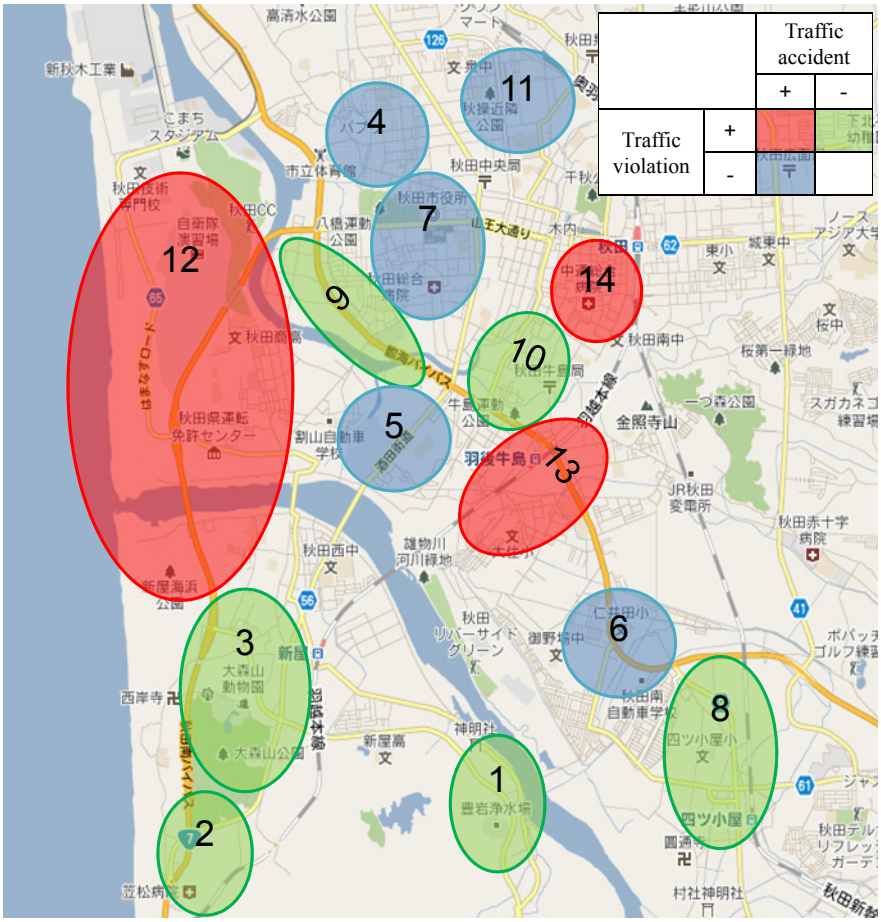


Figure 6 Relationship between the numbers of traffic accident and the numbers of drivers charged with traffic violations in each area of Akita city

Effect of Dummy Speed Enforcement

In the former section, the effect of traffic enforcement was analyzed by comparing traffic enforcement data and traffic accident data. In this section, in order to analyze the effect of traffic enforcement in detail, we made a driving speed survey in the Araya area of Akita where the number of drivers charged for speeding violations is high. The effects of enforcement on reducing driving speed can be clarified by surveying the speed change that occurs after a driver is shown a roadside speed-limit enforcement device on a road section with a high number of speed offenders. We selected two survey sites: one that had done speed enforcement and the other that had not. At these sites, video cameras were set to measure the vehicle speed. The cameras were of two types: unconcealed (set up to be obvious to the driver) and concealed (set up hidden in bushes to be not obviously to the driver). The effects of speed-limit enforcement can be analyzed by survey the vehicles driving speeds and making comparisons among the survey sites. The investigation is outlined in Table 4, and location of survey site is shown in Figure 7.

Table 4 Outline of Dummy Speed Camera Enforcement

Date	Nov. 6 to 25, 2010
Survey site	Experienced speed enforcement (A, B) Inexperienced speed enforcement (C)
Method	Video recording
Recording time	2 hours in each survey first 1 hour: concealed last 1 hour: unconcealed
Objective vehicle	Free-flow vehicle (5 second time headway)

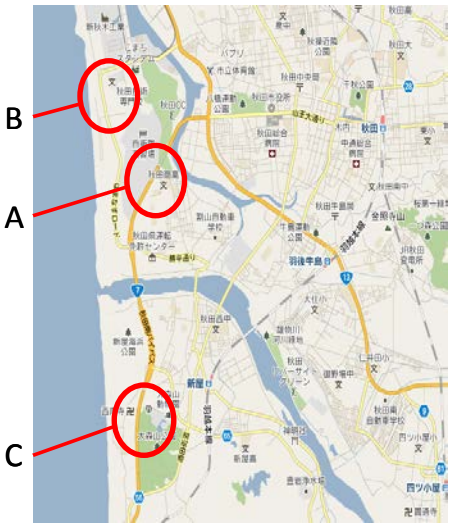
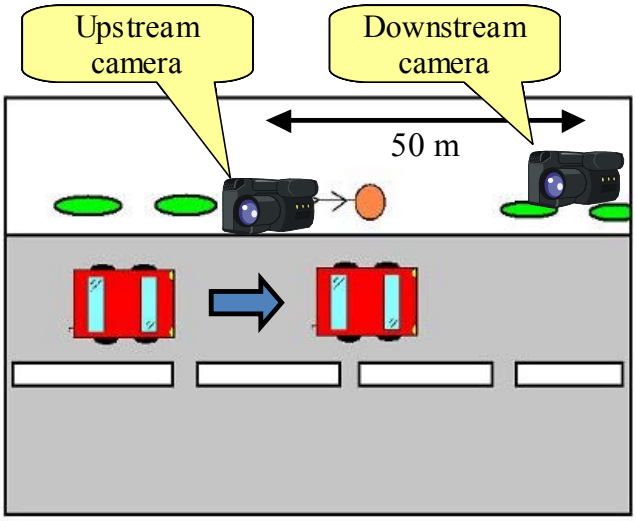


Figure 7 Location of survey site

Vehicle speed was measured by video investigation for each site. Video cameras were set at two locations (upstream and downstream) of each site. The distance between the upstream and the downstream camera was almost 50 m. The upstream camera was unconcealed so that drivers would think their speed was being measured there. The downstream camera was concealed so that drivers would not be aware that their speed was being measured there. Distance between cameras was decided by considering the characteristics of speed change for each vehicle. If the distance between cameras is longer than 50 m, driver could restore their speed again in spite of decreasing their speed due to the detection of the traffic enforcement. The total recording time was two hours in each survey: the downstream concealed camera (camera 1) recorded the traffic during the first hour, and both the upstream unconcealed camera (camera 3) and the downstream concealed camera (camera 2) made recorded the traffic during the second hour.

Upstream camera
(showing dummy radar gun)



	Upstream camera (unconcealed)	Downstream camera (concealed)
First 1 hour	-----	Video recording (camera 1)
Last 1 hour	Video recording (camera 3)	Video recording (camera 2)

Figure 8 Method of investigation

The difference in vehicle speed measured by the upstream camera (camera 3) and measured the downstream camera (camera 2) was calculated by comparing the speeds of the cameras. From this analysis, the effect of visibly placed dummy cameras on driving speed can be evaluated. In this analysis, the target vehicles are limited to those in free-flow traffic, i.e., those with a headway of at least 5 seconds.

Difference in Vehicle Speed between Showing and Not Showing Dummy Radar Guns

This section analyzes the difference in vehicle speed between showing and not showing drivers the dummy radar guns, in order to clarify the effect of the devices is clarified. In this analysis, cameras 1 and 3 are used for the comparison. Figure 9 shows the average vehicle speed for cases with and without showing the dummy speed guns for each of the three sites. A comparison of these speeds was made for three locations (A, B and C). Only at Location B was the average speed of vehicles higher with the dummy radar gun than without it. This means the showing the enforcement device was effective in reducing traffic speed at Location B. In contrast, vehicle speeds were higher at the downstream unconcealed camera than at the upstream unconcealed camera for the other two sites. The road geometry of the two sites is straight. Hence, the driver might not have easily noticed the unconcealed camera and thus might have delayed slowing down after noticing the camera.

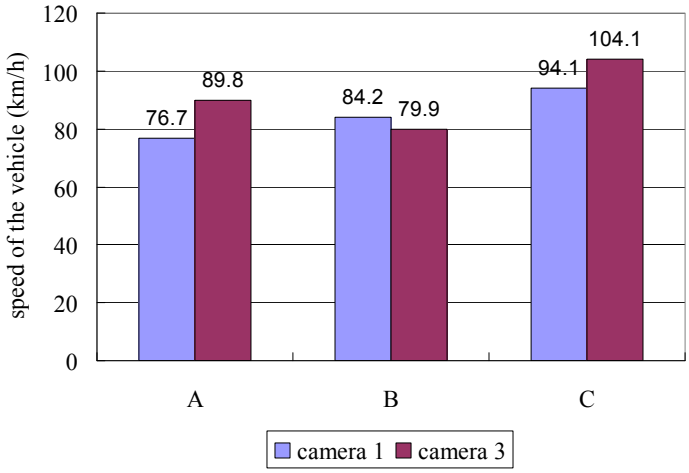


Figure 9 Average speed recorded by unconcealed upstream camera and concealed downstream camera for three survey locations

Speed Change after Recognition of Speed Investigation

By comparing the speed at the location of the unconcealed camera with the speed at the location of the concealed camera, the speed reduction behavior of each vehicle after recognizing the dummy speed enforcement device can be determined. In this analysis, cameras 1 and 2 are used for the comparison. Figure 10 shows the speed change of each vehicle at three survey locations. From this figure it is understood that vehicle speed at the location of the concealed camera decreases relative to the speed at the location of the unconcealed camera, for all sites. The decreases in speed are larger at Location A and C. It is considered that speed reduction for both sites would be high because drivers made greater deceleration in order to make up for the delay in responding to the dummy speed-limit enforcement device.

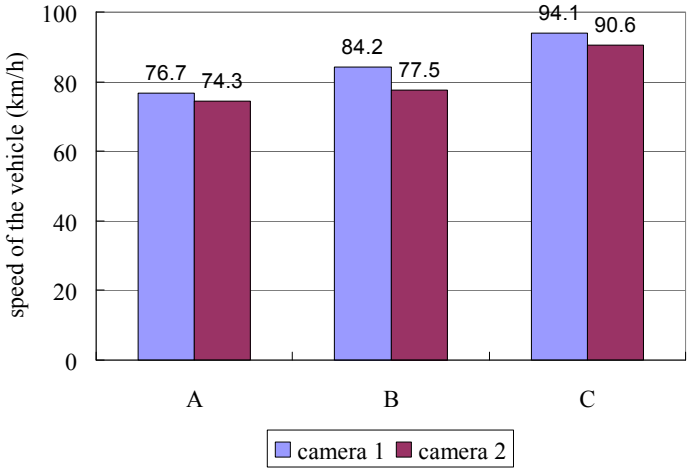


Figure 10 Speed change of each vehicle at three survey locations

These results of analysis show that the average speed at the unconcealed camera is lower than the speed of free-flow traffic only at Location B. The speed reductions after confirmation of the existence of the camera are large at Location A and C. From this result, it can be

understood that vehicle speeds at Location B tend to be low and that vehicle speeds at Location A and C tend to be high. Therefore, at Locations A and C, the changes in speed are very large.

CONCLUSION

This study proposes that effective traffic enforcement is important in decreasing the number of traffic accidents because there was no past study that addresses the types and the methods of traffic enforcement that can effectively reduce occurrences of traffic. To understand the relationship between traffic enforcement and traffic accidents, two kinds of analyses were conducted: data analysis of traffic enforcement and traffic accidents, and drivers' behavior analysis by dummy speed camera enforcement device.

From the data analysis of traffic enforcement and traffic accidents, it was found that traffic enforcement and traffic accidents have an inverse relationship. It is important to match traffic enforcement with the number of traffic accidents by time or area. From the behavior analysis by the simulated investigation, it was found that showing a dummy speeding camera is effective at lowering driving speeds on roads whose driving speed is not too high. These results will contribute to traffic enforcement planning. Our future plan is to conduct detailed analysis by attribute, such as type of traffic enforcement or accident.

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