A CASE STUDY ON THE EFFECTIVENESS OF SPEED ENFORCEMENT ON ROADWAYS IN TURKEY

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TÜRKİYE KARAYOLLARINDAKİ HIZ DENETİM SİSTEMLERİNİN ETKİNLİĞİ ÜZERİNE BİR ALAN ÇALIŞMASI

Öz

Bu çalışma Türkiye karayollarındaki hız denetim yöntemlerinin etkinliğini araştırmaktadır. Polisin ve sabit radar uygulamalarının ne kadar uzaklığı kadar etkili olduğunu görmek için 452 sürücü üzerinde bir araştırma geliştirilerek uygulanmıştır. Bulgular, hem polisin hem de sabit radar uygulamalarının ortalama etkisinin 1 km’den öteye geçmediğini ortaya koymuştur. Sabit radar uygulamaları ile polisin radar uygulamalarının sürücüler üzerindeki etkileri arasında herhangi anlamlı bir fark görülmemiştir. Polis tarafından uygulanan hız cezalarının sürücü davranışlarını üzerinde genellikle etkisinin olmadığını anlaşılmıştır. Bu bulgular ışığında, ortalama hız kontrolü gibi yeni metotlara birlikte sabit ve hareketli tam zamanlı açık ve gizli kameraları zaman zaman polis refakatinde birlikte uygulayacak entegre bir sistem olmaması halinde, Türkiye’deki karayollarında hız denetimlerinin başarı şansının son derece düşük olacağı sonucuna ulaşılmıştır.

Anahtar kelimeler: Hız yönetimi, Hız denetimi, Hız davranışları

Abstract

This paper delves into the effectiveness of speed enforcement methods on roadways in Turkey. In order to find out the distance halo effects of physical policing and fixed speed cameras, a research was developed and conducted on 452 drivers. The data was revealed that the average distance halo effects of both physical policing and speed cameras were not more than 1 km. Any significant differences were not detected between the speed behaviors of drivers those who have been enforced by physical policing with radars and that of those enforced by overt fix speed cameras. The tickets applied by the police were found mostly to be ineffective on the speed behaviors of drivers. In light of these findings it is concluded that unless a mix system including full-time operating overt and covert cameras both fix and mobile accompanying by random physical policing and the new methods such as average speed control, the success of speed management on roadways in Turkey is hardly possible.

Keywords: Speed management, Speed enforcement, Speed behaviors

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1. Introduction

In the year 2011, 3,835 people died and 238,074 people were injured due to the road traffic crashes in Turkey (GDH, 2012). Fatality numbers per a hundred thousand vehicles in 2011 corresponds to 24, which is far more than many European countries (IRF, 2011). It was reported that 90.2% of total crashes happened in 2011 were caused by driver faults and that at that year, speed violations has been found to contribute to 33.5% of total crashes (GDH, 2012).

Excessive speed is known to increase both the risk of a crash and the severity of crash outcomes (ETSC, 2008, 4). That is, the higher the speed of a vehicle, the higher the probability of becoming involved in a crash and the greater the likelihood of more severe injuries sustained (Afukaar, 2003, 77). The logical consequence of this reasoning is that if the speeding is reduced, both the likelihood and severity of crashes will be lowered (Wilson et al., 2006). Therefore, measures aimed at reducing speed on the roads are considered of vital importance. However, while speeding remains one of the most important cause of traffic death and injury, sped enforcement is argued to be insufficient even in many developed countries (ETSC, 2006). As for Turkey, there is quite a little empirical evidence currently exists for the relative effectiveness of the methods used in controlling vehicle speeds in Turkey. Therefore, in this paper, it will be scrutinized whether the speed enforcement practices in Turkey reduce the incidence of speeding on roadways effectively or not. Besides, the relative effectiveness of the methods used in enforcing speed limits will be compared.

2. Literature Review

2.1. Speed and road traffic crashes

Speed violations are considered as one of the most common contributing factors in vehicle crashes. The OECD estimated that speeding contributed to as much as one third of all fatal accidents in the world (OECD, 2006). Several studies have identified speed to be at the core of road safety arguing that there is a strong relationship between speed and both the frequency and the severity of the road traffic crashes (OECD, 2006; Peden et al., 2004). Speed increases both the risk of a crash happening and the severity of injuries resulting from crashes (ETSC, 2008, p.5). The faster the speed, the greater the probability of a crash and the severity of crashes. Nilsson (1981) suggested that a change in mean speed is
followed by a change in traffic crashes, injuries and fatalities. However, studies concluded that the relationship between speed and road traffic crash rates is not linear but is described as having an exponential function: as speed increases the crash rate increases much faster than the increase in speed. Thus, small changes in mean speeds is expected to result in significant changes in crash outcomes (Lynam and Baruya et al., 2000).

It is contended that, if the number of drivers who are speeding is reduced, both the likelihood and severity of a traffic crash will be lowered (Pilkington, 2002). While there exist various factors attributing traffic crashes on roads, on average, a 1% reduction in the mean speed of traffic flow is argued to lead to a 2 % reduction in injury accidents, a 3 % reduction in severe injury accidents and a 4 % in fatal accidents (Aarts and Van Schagen, 2006). From 1984 to 1987, field trials limiting the speed to 100 kph (kilometers per hour) on the motorways in the federal state of Hessen in Germany is reported to led to a 25 % to 50 % reduction in fatal/serious injury accidents per billion km travelled (Umweltbundesamt, 2003).

2.2. Speed Management

Speed management can be defined as a set of measures to limit the negative effects of illegal or inappropriate speed (ETSC, 2008, 5). However, enforcement is difficult as speeding remains the most widespread offence (ETSC, 2008, 4). Most drivers in both the industrialized and developing countries are argued to travel usually at speeds far above the speed limit (Afukaar, 2003, 78). The OECD estimated that at any moment, half of total drivers are exceeding legal speed limits (ETSC, 2008, 4). Therefore, managing speed is a fundamental priority and the most crucial measure to provide road safety by reducing death and injury on the roads (Elvick and Vaa, 2004). In order to prevent road traffic crashes and decrease their sever consequences, effective speed enforcements have to be applied vigorously. There is no single solution to the problem of speed violations. Therefore, a package of countermeasures is necessary, increasing the effectiveness of each individual measure (OECD, 2006).
2.3. Speed enforcement methods

Managing speed is only practical if the required speed enforcement is provided. It is argued that only when accompanied by strict police enforcement, posted speed limits led drivers reduce their speeds. The most prominent and wide-spread speed enforcement methods are known as physical policing and speed cameras. Physical policing check drivers and detect traffic offenders alongside the road and apply tickets where needed. Physical policing is advantages for it provides immediate feedback to drivers and it increases the apprehension and vigilance of passing drivers. The presence of police has been regarded to have an effect in decreasing speeds. However, on the other hand, this method is more labor-intensive and its impact area is quite narrow (Safetynet, 2009, 8). It is criticized for being too selective, sporadic, inconsistent, and in the end, being rather expensive and ineffective (Zaidel, 2000).

On the other hand, speed cameras, fixed or mobile, detect speed offenders through an electronic system and then apply fines to those drivers exceeding speed limits and send them by mail. Speed cameras can operate either automatically on a system or in a patrol car overt or covert (Safetynet, 2009, 8). Controlling vehicle speed by speed cameras inside a police patrol is regarded as the most recognized traditional method. This is called shortly as “radar” among drivers in Turkey. For the police cannot be present on all roads at all times, in many countries, there is increasing use of automatic speed enforcement, that may be manned or unmanned, mobile or fixed as well as overt or covert (Wilson et al., 2006, 3). Chen (2000) argued that the introduction of cameras had reduced speeding, with a corresponding decrease in crashes, injuries and fatalities. A study by Elliot and Broughton (2005) indicated that speed cameras are more effective than physical policing methods in reducing speeds and crashes. For example in U.K., accidents at sites where speed cameras were introduced were reported to reduce by 28 % (Hooke et al., 1996).

On the other hand, the automated methods triggering automatically by speed violations is argued to offer high levels of continuous and widespread enforcement and reduce road traffic crashes and related road injuries and deaths (Wilson et al., 2006, 26). Automatic camera enforcement is claimed to a reduction of 15 to 20 % in crashes (Elvik and Vaa, 2004). For example countries that apply high numbers of automated speed devices, such as the Netherlands and the UK, are reported to have low numbers of road deaths whereas countries with no or low numbers of such devices generally have much higher deaths rates (ETSC, 2008, 16). In France, speeding rates dropped radically for all types of vehicles, to
the 31% reduction in road deaths between 2001 and 2005 and three quarters of this reduction was attributed to improved speed management based on the new automated camera system (ETSC, 2007).

Physical speed restraint measures such as rumble strips and speed humps can also be utilized on roads where a high frequency of traffic crashes observed (Ross et al., 1991). However, on the long term, police enforcement would be largely replaced by new technological systems of speed control. New vehicle technologies such as black boxes, will enable police enforce speeding at all times and places (Safetynet, 2009, 3). Average speed control is one of these new speed enforcement techniques measuring the average speed over a road section between the entering and leaving points. It is quite effective for it operates full-time and full-coverage. Intelligent speed assistance is another technology which should play a great role in mitigating road crashes in the future. This is an advanced system in which the vehicle knows the speed limit for any given location and is capable of using that information to give feedback to the driver or directly limit the vehicle speed (ETSC, 2008, 18).

Speed enforcement is not a stand-alone measure. Managing traffic safety should increasingly be carried out as a combination of measures (ETSC, 2008, 5). Credible speed limits and publicity are the two factors contributing effective speed enforcement. The speeds that most drivers think appropriate come out to be more than 10% higher than the posted speed limits (Johansson, 1996). In order for the drivers to conform to speed limits these limits have to be conceived as natural by the drivers. Problem of speeding is not a matter for the law enforcement organizations alone. Public-private partnerships are essential in the creation of awareness on the importance of speed control in reducing road traffic crashes, injuries and fatalities (Afukaar, 2003, 81). Police enforcement can only be effective if it operates in a supportive environment of laws, regulations, public, and a sensitive penal system (Safetynet, 2009, 4).

2.4. The effectiveness of speed enforcement methods

Despite being an essential element of effective speed enforcement, the effects of speed enforcement are still fairly unknown. A study conducted in the UK indicated that drivers respond differently to speeding fines. At about 41 - 56% of drivers included in the study are observed to drive more slowly, including both at camera sites and elsewhere. Those who only slow down at camera sites, but not elsewhere were 30 - 32% and
those not doing either were 14 - 15% after receipt of a punishment (Campbell and Stradling, 2002).

There are two halo effects used in regards to speed management: Time and distance. “Time halo” refers to the length of time and “distance halo” refers to the distance over which the effects of an enforcement operation on drivers’ speed behavior last after a driver passed the enforcement point (Safetynet, 2009, 13). According to the findings of Elliott and Broughton (2005), the effects of physical policing on driving speeds last 1 hour to up to 8 weeks and are halved for every 900 meters downstream of the enforcement site typically lasting up to 8 km. Automatic speed enforcement methods’ effects are argued to be more limited than physical policing in terms of both time and distance halo (Vaa, 1997; Hess, 2004). It is contended that 500 meters is about the maximum distance halo of a speed camera. However, these halo effects are to be increased if the policing method is randomized and if the cameras operate 24-hour continuously and are covertly located through a specific route. When visible and invisible mobile camera operations are used together, the effects are more widespread over the road network (Keall et al., 2002).

Whether overt or covert cameras should be preferred depends on the contingencies. When enforcing drivers slow down nearby a populated area, it is more effective to locate visible cameras accompanying warning signs. Drivers tend to keep within the speed limits when the cameras are visible (Gains et al., 2004). On the other hand, visible camera’s distance halo is quite short. In managing speed limit through a long distance, it is more practical to use hidden cameras because the drivers are less tempted to violate speed limits when they are aware of the possibility of a hidden camera existence (Safetynet, 2009, 10; Goldenbeld and Schagen, 2005). It is thought that while overt cameras should reduce speeds at road crash black spots, covert cameras should reduce speeds over a wider area (Keall, 2001). Further, fixed camera should be placed at high risk sites to clearly curb the casualty risk of speeding and help the drivers understand that speed enforcement is designed for their own safety (ETSC, 2008, 16).

Speed enforcement applications influence drivers’ behavior through two processes: general deterrence and specific deterrence (Zaal, 1994). Specific deterrence is the impact of the actual legal punishment on those who are apprehended. However general deterrence can be defined as the impact of the threat of legal punishment on the public at large. Thus, general deterrence led people stay out of speed violations in order not to be exposed to the punishments (Safetynet, 2009, 5). The most important
requirement for speed enforcement is that it deters drivers from speeding; not only those drivers that have been apprehended for a speeding violation, but even more so, those who have not.

Thus, a ‘policy mix’ of measures is necessary to tackle the problem of speeding effectively (ETSC, 2008, 4). Therefore, both the traditional and automated methods have to be applied altogether in order to reach high levels of effective speed controlling. Fulltime speed cameras fixed or mobile accompanied by physical policing random in time and location over a route, will enforce drivers effectively speed limits (Safetynet, 2009, 8; Jorgenson, Karlaftis and Sinha, 2000).

3. Method

This research is conducted on the segments of two different double-lane (110+ 10% tolerance) kph roads in Turkey. In the first part of the research, the effects of physical policing with radars on drivers’ speed behaviors were examined. In the second part of the research, the effects of overtly deployed fixed speed cameras on speed behaviors were tried to be assessed. Three measurement sites 500 meters apart from each other were identified on the both roads where vehicle speeds were recorded. One located upstream and the other two downstream from the enforcement site. Police speedometers were used for the experiment. The vehicle speeds have been measured for two days at different times in 2010 summer.

Speed behaviors of drivers before and after the enforcement sites were scrutinized. A comparison of the vehicle speeds between and after the enforcement sites are made in order to find out the effectiveness of speed enforcement methods. Distance halos were measured both by using mean speed values and frequencies of vehicles those exceeding speed limit of 121 (110+10% tolerance) kph downstream from the enforcement sites. A t-test was conducted whether there existed any significant differences between the speed behaviors of drivers those who have been enforced by physical policing with radars and that of those enforced by overt fix speed cameras or not are investigated. The speed behaviors of those drivers both who have been ticketed by the police and those who passed by the enforcement site without being apprehended have also been compared by t-test.

Our hypotheses are as:
H₁: Although both the methods contribute to significant amount of speed reductions around the enforcement sites, they are ineffective to keep away drivers from speed violations.

H₂: There are not any significant differences between the speed behaviors of drivers those who have been enforced by physical policing with radars and that of those enforced by overt fix speed cameras.

H₃: There are not any significant differences between the speed behaviors of drivers those who have been ticketed by the police and those who have not been.

4. Results

As it is demonstrated in Table 1, significant reductions in vehicle speeds were observed both in physical policing and speed camera enforcements at and 500 m downstream the enforcement sites. Mean speeds were reduced by 13.0 kph to 110.2 kph at the enforcement site of physical policing and by 13.8 kph to 108.8 kph at the enforcement site of speed cameras.

However, soon after passing by the enforcement sites, the speeds were increased up to a mean value of 113.9 kph at 500 m downstream the physical policing enforcement site and 113.5 kph at 500 m downstream the speed cameras. At the site of 1000 m downstream the enforcement sites, both mean values of the two groups were measured as more than the posted speed limit (Physical Policing=122.9, Speed Cameras=122.1). Speed reductions caused by physical policing were just 0.3 kph at the 1000 m downstream the enforcement site. 124 out of 216 vehicles were detected to violate speed limits at that point. Looking at the speed camera enforcements, the case was almost the same. Speed reductions achieved by overt fix speed cameras were just 0.5 kph at the 1000 m downstream the enforcement site and 134 out of 236 vehicles were detected to violate speed limits at that location.

These findings supported the H₁ asserting that although both physical policing with radars and overt fixed speed cameras contribute to significant amount of speed reductions around the enforcement sites, they are ineffective to keep away drivers from speed violations.
Table 1. Statistics of speed measurement at enforcement, upstream and downstream sites

<table>
<thead>
<tr>
<th>Enforcement Type</th>
<th>Measurement Sites</th>
<th>Sample Size</th>
<th>Mean Speed a</th>
<th>SD a</th>
<th>ΔV b</th>
<th>Mean</th>
<th>N&gt;121 kph</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Policing</strong></td>
<td>500 m upstream</td>
<td>216</td>
<td>123.2</td>
<td>17.1</td>
<td>13</td>
<td>131</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement site</td>
<td></td>
<td>110.2</td>
<td>7.5</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500 m downstream</td>
<td>m</td>
<td>113.9</td>
<td>9.3</td>
<td>9.7</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000 m downstream</td>
<td>m</td>
<td>122.9</td>
<td>12.8</td>
<td>0.3</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td><strong>Speed Cameras</strong></td>
<td>500 m upstream</td>
<td>236</td>
<td>122.6</td>
<td>18.4</td>
<td>141</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Enforcement site</td>
<td></td>
<td>108.8</td>
<td>6.8</td>
<td>13.8</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500 m downstream</td>
<td>m</td>
<td>113.5</td>
<td>10.3</td>
<td>9.1</td>
<td>46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000 m downstream</td>
<td>m</td>
<td>122.1</td>
<td>14.0</td>
<td>0.5</td>
<td>134</td>
<td></td>
</tr>
</tbody>
</table>

a Kilometers per hour
b Difference in mean speed between 500 m upstream and other measurement sites

We could not find any significant differences between the speed behaviors of the two groups at any measurement sites (p>.001). Therefore, H2 “There are not any significant differences between the speed behaviors of drivers those who have been enforced by physical policing with radars and that of those enforced by overt fix speed cameras” was supported.

Looking at the punishments for speed violation, 12 drivers have been ticketed by the police. We then wondered the answer of the question that how “being ticketed by the police” will effect on the speed behaviors of drivers. The mean speed values downstream the enforcement site of those 12 drivers ticketed by the police for speed violation revealed that while the mean speed value decreased at about 20.8 kph from 136.0 kph to 115.2 kph at 500 m downstream the enforcement site, at the point of 1000 m downstream the enforcement site it was again reached to a level of 131.5 kph (Table-2).
We then conducted a \( t \)-test to find out whether a significant difference between the behaviors of drivers those who have been ticketed by the police for speed violation and those who have not been, downstream the enforcement sites. It was revealed that there were not any differences both at 500 m (\( t=.9, p>.01 \)) and 1000 m (\( t=3.2, p>.01 \)) downstream the enforcement sites between the two groups (Table 2). This finding supported the \( H_3 \) arguing that there were not any significant differences between the speed behaviors of drivers those who have been ticketed by the police and those who have not been.

### 5. Discussion and Conclusion

In this research, we attempted to find out the relative effectiveness of two methods used in speed enforcement in Turkey on the speed behaviors of drivers namely physical policing with speed radars and overt fix speed cameras. It was revealed that although both the methods contribute to significant amount of speed reductions around the enforcement sites, they are ineffective to keep away drivers from speed violations beyond 1000 m vicinity of the enforcement sites. Though most of the drivers decelerated their speeds at the enforcement sites, they reaccelerated their speeds soon after passing the enforcement sites. This finding is consistent with many other studies (Safetynet, 2009, 8; Zaidel, 2000).
We could not find any significant differences between the effects of both methods on the drivers’ speed behaviors.

We also examined the effects of the punishments applied for speed violations on the speed behaviors of drivers. It was revealed from the findings that there were not any significant differences between the speed behaviors of drivers those who have been ticketed by the police and those who have not been. This led to a conclusion that the fines applied by random physical policing for speed violation do not have any significant positive effect on the speed behaviors of drivers. One of the underlying logic of this consequence is supposed to be the presumption that there would not be any extra speed enforcement by physical policing for a certain amount of distance. Rather, it is rarely possible to come across two speed enforcement practices within around a hundred kilometers.

Therefore, for these two speed enforcement practices are ineffective on their own to prevent speed violations, this paper suggests that new methods of speed enforcement such as average speed control or full-coverage automated camera enforcement should be introduced in the speed enforcement system or a combination of various methods should be applied together on the same route in order to reach the full coverage. For example Keall et al. (2002) argued that when visible and invisible mobile camera operations were used together, the effects were more widespread over the road network. We were unable to conduct a research to compare the effectiveness of the new methods with physical policing and fixed speed cameras, because there is not any speed enforcement such as average speed control or a route which is controlled by full-coverage automated speed cameras in Turkey. However, there are plentiful studies indicating the effectiveness of these methods elsewhere (Wilson et al., 2006, 26; Elvik and Vaa, 2004; ETSC, 2008, 16; ETSC, 2007).

As a consequence, although both physical policing with radars and fix speed cameras provide effective speed enforcement at around the enforcement sites, they are ineffective in controlling speeding beyond 1 km downstream the enforcement sites. Therefore, in order to provide an effective speed management, which enforces drivers effectively speed limits in Turkey, a combination of new and various methods such as fulltime automated speed cameras fixed or mobile, accompanied by physical policing random in time and location over a route, and average speed controls have to be introduced and applied in the speed management system.
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