



# Towards setting credible speed limits: Identifying factors that affect driver compliance on urban roads



Suliman A. Gargoum\*, Karim El-Basyouny, Amy Kim

Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, T6G 1H9, Canada

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## ABSTRACT

Road geometry, vehicle characteristics, and weather conditions are all factors that impact a driver's perception of a safe or credible speed and, consequently, the driver's decision on whether or not to comply with the posted speed limit. In fact, the role a road's environment plays in a driver's perception of a credible speed limit is a topic that has attracted the interest of many researchers in recent years. Despite that, not many studies have considered using empirical data to investigate what features of the road environment influence a driver's compliance choice. This paper aims to address this matter by exploring the relationships between features of the road surroundings (geometric, temporal factors, and weather conditions) and driver compliance with speed limits. The paper uses data from almost 600 different urban roads in the city of Edmonton, at which over 35 million vehicle spot speeds were collected. Compliance was represented using a categorical ordered response variable, and mixed-effects-logistic-regression models were fitted. Two different models were built, one for arterials and another for collector roads. In general, the findings show that the more restricted drivers become, particularly on arterials, the more likely drivers are to comply with speed limits; potential restrictions include on-street parking and the absence of lateral shoulders. Furthermore, higher traffic activity during peak hours, and presumably on shoulder weekdays, both increase the likelihood of compliance on arterials. Similarly, posted speed limits and traffic volume are both positively correlated with compliance on both arterial and collector roads. The findings of this research provide evidence of the existence of an empirical relationship between road features and compliance, highlighting the importance of setting credible speed limits on roads and the possibility of achieving higher compliance rates through modifications to the road environment.

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## 1. Introduction

Speeding is a major issue on roads all around the world, causing substantial damage and loss of life. Transport Canada reported that, in 2011, almost a third of fatalities and a fifth of serious injuries were speed-related (Road Safety Canada Consulting, 2011). Similarly, statistics from the US show that in 2012, 30% of road fatalities were speed-related (NHTSA, 2012). In addition to increasing the severity of collisions, speed has also been found to increase the risk of being involved in a crash (Aarts and Van Schagen, 2006). Despite that, drivers are still reluctant to comply with speed limits; statistics show that speed limit violations reach levels of 40% to 50% on some roads (OECD/ECMT, 2006). This percentage is highly discouraging, particularly when considering that perfect compliance

to speed limits could see fatalities and injuries drop by 38% and 21%, respectively (Elvik and Amundsen, 2000).

In response to high violation rates, several speed management countermeasures have been considered. However, not much has been done to understand what factors actually encourage drivers to violate or comply with posted speed limits (PSL) on a certain roadway. A European review on speed management found that, in addition to the utility (e.g., travel time savings, thrill-seeking) and the disutility (e.g., sanctions, accident risk) associated with non-compliance, the “reasonableness” of a speed limit is also one of the most important factors in determining the degree of compliance to a speed limit (OECD/ECMT, 2006). In order to assess how reasonable the speed limit set on a certain road is, drivers usually integrate other factors related to the characteristics of a road and its immediate surroundings in their assessment. Based on this assessment, drivers might decide that the speed limit on a certain road is inappropriate or too low and not worthy of complying with.

According to Kanellaidis et al. (1995) speed limits being unrealistic is a key reason why drivers violate speed limits. This has led

\* Corresponding author.

E-mail addresses: [gargoum@ualberta.ca](mailto:gargoum@ualberta.ca) (S.A. Gargoum), [basyouny@ualberta.ca](mailto:basyouny@ualberta.ca) (K. El-Basyouny), [amy.kim@ualberta.ca](mailto:amy.kim@ualberta.ca) (A. Kim).

many researchers to study factors influencing driver perception of what is considered an appropriate speed at a certain location, and how speed limits should be set to account for road environment and become more credible (Van Schagen et al., 2004; Goldenbeld and Van Schagen, 2007; Ivan et al., 2009).

The concept of credibility has also led transport agencies around the world to recommend that speed limits are set while taking into account the road environment. In New Zealand, for instance, the Ministry of Transport acknowledges that setting speed limits must be done in a manner that is consistent with the level of the roadside development and the function of the road; moreover, the ministry also recommends that road geometry be considered as a secondary factor when setting a speed limit (Ltsa, 2003). These guidelines have been put into practice and were found to have significant effects vehicle speeds as shown in the study by Charlton et al. (2010). In that study, traffic management features were used to create self-explaining roads and the study found significant reduction in vehicle speeds on local roads and increased homogeneity of speeds on both local and collector roads.

In one of the earliest studies that addressed the topic of speed limit credibility, Wilmot and Khanal (1999) mention that road geometric characteristics, land use and weather conditions all play a role in driver perception of a safe speed limit at a certain location. Moreover, Aarts et al. (2009) also integrated information about road design, road image, traffic characteristics and behavioural attributes into their algorithm, which was developed to assess the safety and credibility of a speed limit. Factors affecting compliance choice could also be extended to include vehicle characteristics and driver personality traits, since these factors have been found to affect speed choice.

Although driver judgment of an appropriate speed limit is highly subjective, designers and engineers should still work on increasing the harmony between the road environment and the Posted Speed Limit (PSL), in order to reduce the population of drivers doubting the credibility of a speed limit and, hence, increase compliance rates. That being said, creating this harmony between the road environment and PSL can only be achieved when the specific factors that influence compliance choice are identified and their effects are understood using empirical data from the field.

This paper attempts to address this matter using data collected at urban roads in the city of Edmonton, Canada. The data is used to develop ordered mixed-effects-logistic-regression models where driver compliance to speed limits is regressed on features of the road, climate and vehicles. The main aim of the analysis performed in this paper is to explore the effects of different factors, including features of the road environment, on drivers abiding to or violating speed limits, thereby providing design experts and enforcement officials with valuable information that will assist them in future planning and decision-making related to setting credible speed limits. As in case of the study by Goldenbeld and Van Schagen (2007), this paper aims to bring the concept of credible speed limits into practice by identifying the specific factors that affect driver compliance.

The current study contributes to the existing literature on speed limit credibility in that it:

- i) Analyzes empirical data from the field, as opposed to questionnaire data, which was used in the only other study that attempted to operationalize the concept of credible speed limits by Goldenbeld and Van Schagen (2007). In fact, Goldenbeld and Van Schagen (2007) actually called for empirical analysis to validate the findings of their research.
- ii) Analyzes the effects of the road and roadside environment on actual driver compliance, not perceived safe speed, speed choice or preferred speed.

- iii) Considers the effects of a variety of different factors on compliance including the effects of dynamic factors, such as peak/off-peak time of day and weather conditions.

## 2. Previous work

As already indicated, the majority of existing research, which has assessed the relationships between speed and features of the road environment, road design, traffic characteristics and climate conditions, has investigated the effects of those variables on speed choice, speed preference, perceived safe speed or in some cases speed variance. However, not many studies have assessed the impacts of those features on compliance to speed limits.

A common factor that has been considered in many studies is the posted speed limit (PSL). Fitzpatrick et al. (2001) developed linear regression models to assess factors affecting operating speeds on straight and curved suburban arterial road segments in Texas. The study found PSL to have the most significant effects on speeds. Similarly, Fitzpatrick et al. (2005) used data from different regions of the US to study the effects of different road features on operating speeds of tangent sections, using data from different regions of the US, and found PSL to be the most significant predictor of operating speed. In fact, the linear regression models developed showed that PSL was the only variable with statistically significant effects on speed. Aljanahi et al. (1999) and Finch et al. (1994) also found a significant relationship between speed and PSL, showing that reduction in PSLs is associated with reduction in observed speeds.

As part of the *SaCredSpeed* algorithm developed by Aarts et al. (2009) to assess the credibility of speed limits using general safety principles, the authors provided a summary of factors that they thought had an influence on driving speed and on which the credibility of the speed limit could be based. Among those variables were the presence of pedestrian facility (decelerator), the presence of a cycling facility (decelerator), the presence of on-street parking (decelerator), increased number of lanes (accelerator), increased road and lane widths (accelerator) and the higher density of the road environment (decelerator), which was defined in terms of dense vegetation or built-up areas.

In a study assessing the credibility of 80 kph speed limits on rural roads in the Netherlands, Goldenbeld and Van Schagen (2007) used questionnaire data, asking respondents about their preferred speed and their perceived safe speed on a selection of rural roads. The authors developed an Analysis of Covariance (ANCOVA) model to relate driver speed choice to characteristics of the road and its environment as well as the effects of person and personality characteristics. The study found that the absence of a horizontal alignment, the increase in sight distance and clarity of the situation (visibility) and the absence of buildings at the roadside all resulted in higher speed preference and higher perception of a safe speed. Moreover, the paper also found that perception of safe speeds also increased with the absence of trees and increases in road width. In terms of the size of the effects, the study found that the horizontal curves and sight distance had the strongest effects on speed preference.

Although not in the context of speed limit credibility, other works assessing the factors affecting speed choice also highlight the importance of road design and geometry. According to Várhelyi (1997), the significance of the effects road design has on speed choice is even greater than that of the PSL. Likewise, Quimby et al. (1999) concluded that site characteristics had the largest influence on driver speeds.

In a study using speed data recorded on curved road segments in Australia, McLean (1981) developed a regression model to predict speeds on horizontal curves. The study found that attributes of horizontal curves (e.g., radius of curve and degree of curva-

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