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Driver behavior and accident frequency in school zones: Assessing the impact of sign saturation

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ABSTRACT

Based on the models of human information processing, if a driver observes too many of the same signs, he or she may no longer pay attention to those signs. In the case of school zones, this expected effect may lead to non-compliance to posted speeds, negatively impacting safety around nearby schools. This study aims to investigate the effect of the number of nearby school zones on driver behavior (vehicle speed and compliance) and accident frequency. As a measure of the density of school zones, this study introduced and defined a new term sign saturation and presented a methodology to calculate sign saturation for school zones. Results found a significant effect of sign saturation on vehicle speed, compliance, and accident frequency. This study also examined the speeding behavior in school zones for different time of the day and day of the week. Results found that speeding was more prevalent in the early mornings and during the weekends.

1. Introduction

School zones are often viewed as an effective way to reduce driving speeds and thereby improve safety near our nation's schools. The effect of school zones on reducing driving speeds, however, is minimal at best. Studies have shown that over 90% of drivers exceed speed limits posted in school zones (Trinkaus, 1996, 1998). Another study conducted in Atlanta found no effect of school zones on vehicle speed (Young and Dixon, 2003). Furthermore, similar studies done in Canadian cities Edmonton (Ash and Saito, 2006) and Saskatoon (Lazic, 2003) reported similar statistics of non-compliance in school zones. These findings imply that school zones are proven mostly ineffective in changing drivers' speeding behavior. A field survey study done by Reiss and Robertson (1976) reported that only 22% of the drivers complied with posted speed while passing through a school zone. Many drivers report that their lack of speed reduction was based on the fact that they were unaware that they were in a school zone (Ash, 2006).

1.1. Driver speed compliance

Speeding in general is influenced by a number of factors (Ellison and Greaves, 2010). For school zones, these factors include types of school zones (school zone compared to playground) (Tay, 2009; Kattan et al., 2011), number of lanes (2-lane roads vs. 4-lane roads) (Tay, 2009; Kattan et al., 2011), presence of children (Kattan et al., 2011), length of the speed zone (Strawderman et al., 2013; Kattan et al., 2011), approach speed (Saibel et al., 1999; McCoy and Heimann, 1990), types of schools (elementary school vs. high school) (Day, 2007), presence of fencing (Tay, 2009; Kattan et al., 2011) etc. Kattan, et al., (2011) found that in the situation when there is 2-lane roads, roads with fencing, traffic control devices and the presence of speed display device or children, and zones that were longer, drivers' mean speeds were lower, and the rate of compliance was higher. Drivers' speeding behaviors changes for different time of the day and day of the week. Many researchers reported that speeding on weekends is more likely than on weekdays (Wundersitz et al., 2009; Ellison and Greaves, 2010; Familar et al., 2011). To be more specific, speeding is reported to be prevalent on weekend late evenings/nights and in early mornings during the weekdays (Ogle, 2005; Ellison and Greaves, 2010). Studies that involve school zones also investigated the effects of the time of day and the day of the week on speeding. Lazic (2003) reported that there was no significant change in speed outside the restricted hours (school hours) and on weekend. Day (2007) studied the school zone speed variation for morning and afternoon peak hours and found no significant difference.

Researchers have investigated methods used to increase driver compliance for some time (McCoy et al., 1981). Based on the results of empirical studies, effective methods include increased enforcement (Dumbaugh and Frank, 2007; Cedar Rapids, 2006),

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appropriate speed zone settings (Day, 2007; McCoy and Heimann, 1990), visual placement of school buildings and play equipment (Clifton and Kreamer-Fults, 2007), and speed monitoring devices (Ash, 2006; Lee et al., 2006; Cedar Rapids, 2006). Traffic engineers and city planners have utilized a variety of school zone signage in an attempt to improve compliance. Signs, flashers, and roadway markings have all been implemented. While some studies have shown a positive effect from utilizing signs on reducing speed (Schrader, 1999; Aggarwal and Mortensen, 1993; Hawkins, 1993), others argue that signs have no effect on driver compliance with posted speed limits (Simpson, 2008; Burritt et al., 1990), leading to a lack of conclusive evidence on the value of school zone signage (Dumbaugh and Frank, 2007; Lee and Bullock, 2003).

1.2. School zone sign saturation

In many municipalities, school zone signs are often placed based on public requests or by political pressure. There is a clear lack of empirical evidence to demonstrate that the addition of such signs reduces driver speed. Furthermore, the addition of too many signs in a given area may actually reduce driver compliance. Based on models of human information processing, if a driver observes too many of the same stimulus, he or she no longer attends to the stimulus with a great deal of attention (Wickens et al., 2004). This overwhelming presence of stimuli (school zone signs) leads to a driver not noticing a particular stimulus.

In the case of school zone signs, the presence of too many signs in a compact area could lead to the same phenomenon. The presence of multiple school zones on a driver's route may lead the driver to ignore the zones altogether. The effectiveness of additional zones can be questioned, particularly if oversaturation of the signage leads to inattention. A balance between novelty and oversaturation of a stimulus must be reached to maximize a school zone's effectiveness at reducing driver speeds.

Adding a new school zone would be beneficial if it led to a reduction in crashes (in a previously unsafe location) or to an increase in compliance with posted speeds. The addition of a new school zone would be detrimental if it would lead to oversaturation, thereby diverting driver attention from multiple school zones in the municipality. This study aimed to quantify the impact of increasing number of school zones on driver speeding behavior and accident frequency, by this means allowing transportation officials the ability to make informed decisions on the expected benefits of adding school zone signage.

2. Methodology

To explain the impact of increasing the number of school zones, this paper introduced and defined the term sign saturation and presented a methodology to measure sign saturation for school zones. The study was conducted in the state of Mississippi, United States. Using the sign inventory provided by the Mississippi Department of Transportation (MDOT), sign saturation was calculated for each school zone in the state. The calculation of sign saturation was a prerequisite of this research.

This paper presents findings of two studies. Table 1 summarizes the study methods. In study 1, driver behavior (vehicle speed and speed limit compliance) in school zones was studied. For this study, four school zones were selected for data collection. In selecting the school zones sign saturation level, road type (number of lanes) and few control variables (Table 1) were taken into consideration. The complete dataset for this study included 168 h (7 days × 24 h) of vehicle speed for four school zones. Study 2 investigated the effect of sign saturation on accident frequency in school zones. Data for this study included the number of traffic accidents for a year of each school zone ($n = 79$) in Northeast Mississippi (MDOT district 1). The following sections provide details on the calculation of sign saturation, as well as data collection methods for the two studies.

2.1. Sign saturation

Sign saturation can be defined as the density of school zones around a reference school zone. For this study, sign saturation was quantified as the total number of other school zones within a 10 mile radius of the school zone being studied. To be able to calculate distances between school zones, multiple signs in the same school zone were needed to be converted into a single sign location. The methodology followed the below steps:

1. For each of the individual signs, the distance to all other signs situated in close proximity was calculated. Latitudes and longitudes of a pair of signs was used to calculate their distance. If the distance was less than a pre-specified (750 yard or 0.426 mile) value, this two signs were considered to be in the same school zone.
2. For each of the individual school zones, the number of the school zones located within a pre-specified radius (10 miles) was counted. The number of school zones within the 10 miles radius of the reference school zone was the measure of sign saturation.

Ideally the number of school zones should be half of the number of school zone signs as there are two signs per school zone. The pre-specified value mentioned above was taken as 750 yards as it gave the number of school zones equal to about half of the total number of signs. The choice of the two pre-specified distances (750 yards and 10 miles) mentioned above is arbitrary; these distances may be different for different states in the United States or other countries in the world.

Table 1
Summary of study methods.

Study objective		Dependent variable	Independent variable	Control variable	Data characteristics
Study 1:	Objective 1: Investigating the effect of time of the day and day of the week variable on driver behavior	Vehicle speed, speed limit compliance	Time of the day, day of the week	Accident frequency, sign type, and required speed reduction	7 days × 24 h of vehicle speed
	Objective 2: Investigating the effect of sign saturation on driver behavior	Vehicle speed, speed limit compliance	Sign saturation, road type	Same as study 1 objective 1	5 days × 2 h of vehicle speed
Study 2:	Objective 1: Investigating the effect of sign saturation on accident frequency	Accident frequency	Sign saturation, lane number	None	1 year of accident frequency