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Traffic Safety Risks from Digital Advertising Billboards in Alabama

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Abstract:- Increase in the number and sophistication of digital advertising billboard signs raises safety concerns over potential contribution of such signs to traffic crashes. This paper describes a study that analysed 5 years of historical crash records from Alabama to examine potential correlations between crash locations and their proximity to digital advertising billboards. First, the research team identified locations of digital advertising billboards along major limited-access facilities in Alabama and selected eight suitable sites for analysis. Eight sites immediately downstream of the digital billboard locations were also considered as control sites. Then, historical crash data were retrieved for all study sites and crash rates were calculated for digital advertising billboards influence zones and adjacent control sites. Statistical analysis was employed to determine if correlations can be established between crash occurrence and digital advertising billboard presence. The crash data analyses revealed that the presence of digital billboards increased the overall crash rates at digital advertising billboard influence zones by 29% compared to the study control sites. Moreover, sideswipe and rear-end crashes were found to be overrepresented at digital advertising billboard influence zones compared to control sites.

Keywords:- Digital advertising billboards, traffic safety, driver distraction, crash rates, crash analysis.

I. INTRODUCTION

According to the Outdoor Advertising Association of America (OAAA), there were over 365,000 unique billboard faces in the United States in 2013 [1]. The majority of roadside advertising billboards in the US are static. Static billboards show the same message for an extended period of time (typically days). Digital billboards (DBBs) were introduced in the recent years and utilize light-emitting diode (LED) technology to display multiple messages that are updated using computer input. Because DBBs flash images every four to ten seconds [2], a single board can advertise to far more clients than a traditional static billboard, making them an attractive advertisement option [1].

The increased number and sophistication of DBBs raises questions about their potential impact on traffic safety. As an advertising medium, DBBs purposely encourage drivers to shift their attention away from the driving task. Moreover, their brightness can be especially problematic at night and may affect drivers' ability to observe changes in the surrounding environment such as brake lights or signal changes. Also, frequently changing images may compel more glances, and sequential messages may hold drivers' gazes longer until the entire message is read. Lastly, targeted messages that engage drivers are particularly troublesome as they create driver distractions [3].

Earlier studies sponsored by billboard advertising companies stated that the presence of digital advertising billboards does not cause a change in driver performance in terms of visual behaviour, speed maintenance, or lane keeping [4]. In the past, some studies showed that drivers' diminished attention could result in more crashes in the vicinity of such billboards; however, because of methodological problems of these studies, the conclusions are deemed not reliable [5]. Due to the growing debate on this issue, an evaluation is needed to determine if the presence of digital advertising billboards really distracts drivers, and whether or not the distraction may be linked to an increase in traffic crash risk in the vicinity of digital advertising billboards.

II. LITERATURE REVIEW

Crash studies typically involve statistical analyses of historical crash databases and provide fast and easy-to-obtain results. However, often the final conclusions can be limited in scope due to the highly variable and confined nature of crash data. In the case of advertising billboards, many of the crash studies reported in the literature were funded by the outdoor advertising industry, thus raising some concerns related to objectivity and motive. Nevertheless, a brief summary of the literature is important to establish a foundation for future studies. An extended synthesis of the literature on this topic is available at reference [6].

In a 2010 report, Tantala and Tantala [7] examined the statistical relationship between digital billboards and traffic safety in Albuquerque, New Mexico. Analysis of traffic and crash data was conducted for a 7-year period on local roads near 17 DBBs. Each billboard contained one digital plane that was converted from traditional signage between 2006 and 2007. The researchers reviewed the frequency of crashes near the billboards before and after the conversion from static to digital. The study analysed crashes within 0.2, 0.4, 0.6, 0.8, and 1.0 miles both upstream and downstream of each sign. Also, time of day and age of driver dynamics were factored into the study. The researchers also performed a spatial analysis to investigate the potential correlation between the locations of billboards and crashes. The results of the study indicated that the 17 digital billboards in Albuquerque have no significant relationship with crash occurrence. Specifically, crash rates near the digital boards showed a 0.3% decrease in crash rate within 0.6 miles of the signs over a period of six years. Furthermore, the spatial component of the study found no significant clustering of crashes in the vicinity of billboard sites [7].

In another study, Tantala and Tantala [8] examined the statistical correlation between digital billboards and crash data in Henrico County and Richmond, Virginia. The study analysed crash data in the vicinity of 14 digital billboards at 10 study locations. Data sources included municipal police departments, Henrico County, and the Virginia Department of Transportation (VDOT). The analysis approach was similar to the Albuquerque study; 7 years of crash data were examined at sites near the selected billboards, which were converted from conventional to digital faces between 2006 and 2009. Once again, temporal and spatial components were investigated within ranges of a half mile upstream and downstream of the billboards. An Empirical Bayes Method (EBM) analysis was utilized to calculate the number of crashes that could be expected in the absence of signs. Results indicated that digital billboards in the Richmond area had no statistically significant relationship with crash occurrence. The EBM analysis showed that the actual number of crashes at each location was consistent with what would be expected with or without the installation of digital billboards [8].

In 2012, Yannis and colleagues [9] conducted a statistical analysis on road sites in Athens, Greece metropolitan area. The goal of the research was to investigate the relationship between the placement and removal of advertising signs and the related occurrence of crashes. Crash data from the test sites were obtained from the Hellenic Statistical Authority database and analysed. The analysis showed no correlation between crashes and advertising signs at any of the nine sites examined [9].

In another research effort, the city of Toronto requested an investigation of the effects of billboards and safety on three downtown intersections and one expressway. The latter indicated that there was no substantial increase in crashes near signed approaches [10].

Epidemiological and other studies that investigated traffic safety aspects of roadside advertising generally agree that the relationship between digital billboards, driver distraction, and traffic safety is quite complex. Consequently, given the dynamic state of the industry and the fact that many related studies are currently outdated, new research on traffic safety risks from digital billboards is needed that takes under consideration local conditions and common practices.

III. METHODOLOGY

A. Objective

The objective of this study was to examine potential correlation between presence of the digital billboards and traffic safety along limited-access facilities (i.e., interstates and expressways) in Alabama. Historical crash records for the period 2008-2012 were retrieved and analysed to allow comparisons of crash rates in areas of potential influence of digital advertising billboards to crash rates in control segments downstream of digital billboard locations.

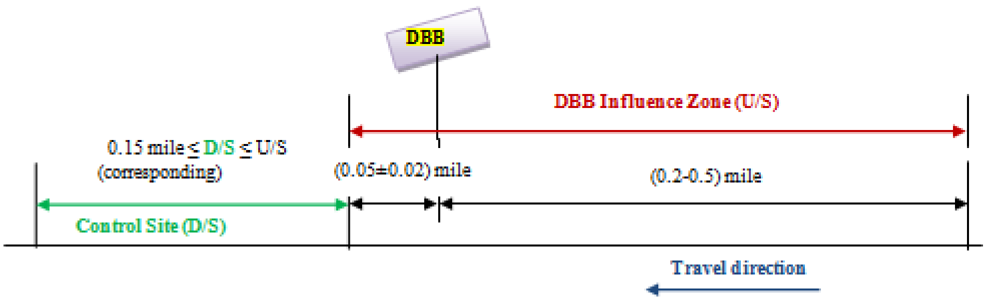
B. Approach

Digital advertising billboard locations along limited-access roadway facilities in the state of Alabama were identified from existing databases, on-site visits, and Google Earth’s Street View. The Google’s Street View, within the Google Earth environment, provided a user-friendly measuring tool to measure distances. An example of a study location is shown in Fig. 1.

Fig.1: Example of study site (I-459 WB in Bessemer, Alabama)

After the identification of the digital billboard locations, a procedure was developed and implemented to define the DBBs influence zone (i.e., zone within which the driver might be distracted). Observation of digital billboard images from various distances showed that the drivers could clearly see the digital billboard at a distance of 0.15 miles to 0.25 miles upstream of the digital billboard location. On the other hand, digital billboards remained slightly visible to the drivers at a distance of 0.3 to 0.4 miles upstream of the digital billboard, and were nearly invisible at a distance of 0.5 miles and beyond.

As depicted in Fig. 2, the “DBB influence zone” (U/S) consists of two segments. The first segment is upstream of the digital billboard (with respect to the oncoming vehicle facing the digital face) and the second one is immediately downstream of the billboard. The former distance has been selected based on driver visibility with no obstruction (another static or digital billboard, tree, etc.), and has been considered as 0.2-0.5 miles. The concept of the second segment came from the fact that the drivers might continue to be cognitively distracted by the digital billboard for a short while after passing the billboard location. This distance has been chosen as a minimum of 0.05 mile (with 0.02 mile accuracy). In some cases the roadway curvature and other obstacles have restricted the visibility to 0.353 miles (driver cannot see the digital billboard beyond this distance while approaching the billboard).



Note: U/S: Upstream D/S: Downstream

Fig.2: Example of study site (I-459 WB in Bessemer, Alabama)

The “control site” (D/S) for each digital billboard study location represents a non-influence zone and is a segment further downstream from the digital billboard. As shown in Figure 2, the length of this segment has been set at a minimum of 0.15 miles and the maximum lengh varied depending on the obstruction (e.g. another billboard, visibility problem due to trees, road bend, etc.).

In this study, the DBB influence zone and the corresponding control at each of the study locations were selected so that they experienced the same traffic and geometric conditions (i.e., number of lanes, roadside features, no weaving manoeuvres, and presence of inside and outside shoulders). The details of the 8 study locations are summarized in Table I.

Table I: List of Digital Billboard Study Locations

ID	City	County	Route	Direction of Travel	Road Side	Land Use	Length (miles)[1]	
							DBB Site	Control Site
1	Mobile	Mobile	I-65	SB	Right	Urban	0.453	0.453
2	Mobile	Mobile	I-65	NB	Right	Urban	0.467	0.237
3	Montgomery	Montgomery	I-85	SW (West Bound)	Right	Suburban	0.396	0.396
4	Madison	Madison	I-565	NE (East Bound)	Right	Urban	0.373	0.373
5	Huntsville	Madison	I-565	NE (East Bound)	Right	Urban	0.353	0.353
6	Huntsville	Madison	I-565	SW (West Bound)	Left	Urban	0.486	0.207
7	Bessemer	Jefferson	I-459	NW (West Bound)	Right	Urban	0.505	0.505
8	Bessemer	Jefferson	I-20/59	SB	Right	Suburban	0.497	0.497

[1]DBB influence zone length includes 0.05 (±0.02) miles downstream of digital billboard; control site length minimum 0.15 miles

IV. DATA ANALYSIS PROCEDURE

To meet the study objectives, crash records for the locations of interest were obtained from the Critical Analysis Reporting Environment (CARE) crash database for a 5-year span ranging from 2008 through 2012 [11]. CARE is a data analysis software package developed by the staff of the Center for Advanced Public Safety at the University of Alabama that summarizes historical crash records based on police reports. Then crash rates per million vehicle miles travelled at the DBB influence zones (U/S) and control segments (D/S) were determined and comparisons were made to establish if there exists any relationship between presence of digital billboard and crash occurrence.

More specifically, the crash rate (in crashes per million vehicle miles (MVM) per year) was calculated for each segment as shown below. Note that the AADT in the dominator was multiplied by 0.5 to calculate the crash rate for the affected roadway direction assuming a 50/50 directional split.

$$CR = \frac{Crash\ Count\ * 10^6}{0.5 * AADT * 365 * L * N}$$

Where:
Crash Count = count of crashes at each segment,
AADT = annual average daily traffic for both directions in vehicles/day,
L = segment length in miles, and
N = number of study years (N=5, i.e., 2008-2012)

The crash rates were determined for both the DBB influence zones and control sites. The crashes were counted based on the direction of the vehicles approaching the digital face of the billboard (U/S) and the vehicles that passed the digital face (D/S).

The combined VMT (of 5 years) was used to calculate average annual crash rates at each location. The number of crashes in each year for a particular location was small, and therefore, the total number of crashes for five years was used to calculate the crash rates. Overall, a total of 77 crashes were included in the safety assessment.

V. RESULTS

A. Crash Analysis Results

1) Crash Analysis by Location: Table II shows the summary statistics of crash rates at the eight study sites (both for the DBB influence and control sites). As far as the number of crashes is concerned, the majority of the sites experienced more crashes in the DBB influence zone than the control sites.

Table II: Crash Summary Statistics at the Digital Billboard Locations

Loc	City	DBB Influence Zone (U/S)				Control Site (D/S)				% Change In Crash Rate
		Len. (mi)	Total Crash Count	AADT	Crash Rate*	Len. (mi)	Total Crash Count	AADT	Crash Rate*	
1	Mobile	0.453	6	368990	0.197	0.453	7	368990	0.229	16.67
2	Mobile	0.467	15	470500	0.374	0.237	9	470500	0.442	18.23
3	Montgomery	0.396	5	228640	0.303	0.396	2	228640	0.121	-60.00
4	Madison	0.373	4	291580	0.202	0.373	1	291580	0.050	-75.00
5	Huntsville	0.353	3	453160	0.103	0.353	4	453160	0.137	33.33
6	Huntsville	0.486	3	453160	0.075	0.207	0	453160	0.000	-100.00
7	Bessemer	0.505	4	249850	0.174	0.505	5	249850	0.217	25.00
8	Bessemer	0.497	9	248480	0.399	0.497	0	248480	0.000	-100.00
Total crashes		3.53	49	344489	0.221	3.021	28	324859	0.156	-29.19

***Crash rate refers to 'average annual crash rate' and is in crashes per million vehicle miles per year.**

When compared to control sites, crash rates at DBB influence zones were higher at locations 3, 4, 6, and 8, but lower at the other locations. Two locations (locations 6 and 8) reported 3 and 9 crashes, respectively in the DBB influence zone and none at the control site, hinting a potential influence of the DBB presence. Over the analysis period, a total of 49 crashes occurred at all the DBB influence zones combined, as opposed to 28 in the control sites. Thus, the crash rates at DBB influence zones were 29% higher than those of their counterparts (i.e., control sites), indicating a higher likelihood for crash occurrence in the presence of a digital billboard.

A paired t test was performed to test whether the presence of DBB has a significant impact on crash occurrence. The null hypothesis was set as $\mu_D=0$ indicating that the means of crash counts at the two zones (i.e., U/S and D/S) are the same. For the level of significance of $\alpha=0.05$, the criterion was to reject the null hypothesis if t >1.415 (d.f.=7) where:

$$t = \frac{D-0}{S_D/\sqrt{n}}$$

and D and SD are the mean and standard deviation of the differences (D=2.625 and SD=3.623) and n=8. It was found that t=2.05>1.415, thus, the null hypothesis must be rejected at level of significance $\alpha=0.05$. We conclude that, based on the Alabama crash records analysed in this study, there is a statistically significant difference in the frequency of crashes reported at the DDB sites when compared to the control sites, thus confirming an association between DBB presence and crash occurrence.

2) Crash Analysis by Crash Type: The summary statistics with respect to the crash type for all eight study sites are shown in Table III. It can be seen that the study locations experienced six types of specified crashes. Among the specific crash types, the sideswipe and rear end crashes are clearly overrepresented at the DBB influence areas. In fact, according to the study crash database, non-collision, angle (front to side; same direction), side impact (90 degrees) and sideswipe (same direction) crashes occurred only at the DBB influence zones.

Table III: Crash Summary Statistics by Crash Type

Crash Type	DBB Influence Zone (U/S)		Control Site (D/S)		%Change in Crash Rate
	Crash Count	Crash Rate[1]	Crash Count	Crash Rate[1]	
Non-collision	1	0.005	0	0	-100.00
Single Vehicle Crash	7	0.032	8	0.045	40.63
Angle (front to side)	1	0.005	0	0	-100.00
Rear End	11	0.050	7	0.039	-22.00
Side Impact (90 degrees)	1	0.005	0	0	-100.00
Sideswipe – Same Direction	6	0.027	0	0	-100.00
Record from Paper System	22	0.099	13	0.072	-27.27
Total Crashes	49	0.221	28	0.156	-29.19

3) Crash Analysis by Crash Severity: Table IV shows the severity of crashes at the DBB influence zones and control study sites in aggregate for all eight study locations in Alabama. There are a total of five levels of specific crash severity considered. A total of three fatalities (two along I-65 in Mobile in 2011 and 2008, one along I-565 at Huntsville in 2009) have observed during the analysis period, two of which occurred at DBB areas of influence. It should be noted that the number of crashes is small and does not allow for in depth analysis. Still, the data show that a higher number of more severe crashes occur at DBB influence zones, compared to control sites, once again suggesting a link between driver distraction from DBB presence and crash severity.

Table IV: Summary Statistics by Crash Severity

Crash Severity	DBB Influence Zone (U/S)		Control Site (D/S)		% Change in Crash Rate
	Crash Count	Crash Rate[1]	Crash Count	Crash Rate[1]	
Fatal Injury	**2**	**0.009**	**1**	**0.006**	**-33.33**
Incapacitating Injury	**6**	**0.027**	**1**	**0.006**	**-77.78**
Non-incapacitating Injury	**0**	**0.000**	**2**	**0.011**	**---**
Possible Injury	**4**	**0.018**	**1**	**0.006**	**-66.67**
Property Damage Only (PDO)	**35**	**0.158**	**22**	**0.123**	**-22.15**
Unknown	**2**	**0.009**	**1**	**0.006**	**-33.33**
Total Crashes	**49**	**0.221**	**28**	**0.156**	**-29.19**

VI. CONCLUSIONS

The impact of digital billboard on traffic safety on high-speed, limited-access facilities was explored at eight sites in Alabama. The methodology of crash investigation in both states relied on comparing the crash rate statistics upstream and downstream of each billboard location. The upstream and downstream segments were selected such that they experienced similar traffic and geometric conditions, i.e., number of lanes, roadside features, no weaving manoeuvres, etc.

The crash data analysis revealed that the presence of digital billboards increased the overall crash rates in areas of billboard influence compared to control areas downstream of the digital billboard locations by 29% in Alabama. This increase was statistically significant, thus implying that digital billboard presences shows a positive correlation with increased crash frequency. Individual site data showed mixed results with crash rates decreases at half of the study locations. The analysis by crash type revealed that sideswipe and rear end crashes (often related to driver distraction) were clearly overrepresented at the DBB influence zones in Alabama. Furthermore, consideration of crash severity provided some evidence of overrepresentation of severe crashes at DBB influence zones; however, the sample size is small to allow for a detailed statistical analysis or generalization of the findings.

This study offers an important contribution to the state of practice as it provides evidence of links between DBB presence and increased crash risk. However, it should be noted that the findings from the crash analysis in Alabama were based on a relatively small sample of locations and relatively short segment lengths. It is recommended to validate the results of the crash analysis using larger sample sizes and longer segments. Future research should extend to analysis of crash records at other states to determine how the impact of digital billboard on traffic safety varies across states. The scope of the present study was restricted to limited-access roadway facilities. Crash analysis on arterial streets can also be conducted to evaluate the potential safety impacts of DBB on such facilities.

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REFERENCES

[1]. Outdoor Advertising Association of America [OAAA].Out of home media formats: (2013), October 14, 2013. http://www.oaaa.org/OutofHomeAdvertising/OOHMediaFormats/OOHMediaFormats.aspx.

[2]. Copeland, L. More Communities Banning ‘Television on a Stick.’ USA Today; March 23, 2010.

[3]. Sisiopiku, V.P., D. Hester, A. Gan, D. Stavrinos, and A. Sullivan. Roadside Advertising and Traffic Safety.3rdAnnual International Conference on Civil Engineering, Athens, Greece, 2013.

[4]. Lee, S., M. McElheny, and R. Gibbons. Driving Performance and Digital Billboards. Prepared for Foundation for Outdoor Advertising Research and Education by the Virginia Tech Transportation Institute (VTTI), Center for Automotive Safety Research, 2007.

[5]. Institute for Road Safety Research, Roadside Advertising and Information, 2013. http://www.swov.nl/rapport/Factsheets/UK/FS_Advertising.pdf

[6]. Sisiopiku, V.P., Hester, D., Gan, A., Stavrinos, D., and Sullivan, A. “Roadside Advertising and Traffic Safety”, 3rd Annual International Conference on Civil Engineering, ATINER’s Conference Paper Series, No: CIV2013-0489, Athens, Greece, 2013.

[7]. Tantala, M., and A. Tantala. A Study of the Relationship between Digital Billboards and Traffic Safety in Albuquerque, New Mexico.Submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), March 2010.

[8]. Tantala, M., and A. Tantala. A Study of the Relationship between Digital Billboards and Traffic Safety in Henrico County and Richmond, Virginia. Submitted to the Foundation for Outdoor Advertising Research and Education (FOARE), November 2010.

[9]. Yannis, G., E. Papadimitriou, P. Papantoniou, and C. Voulgari. A Statistical Analysis of the Impact of Advertising Signs on Road Safety. Department of Transportation Planning and Engineering, School of Civil Engineering, National Technical University of Athens, Athens, Greece, May 2012.

[10]. Smiley, A., B. Persaud, G. Bahar, C. Mollett, C. Lyon, T. Smahel, and W. Kelman. Traffic Safety Evaluation of Video Advertising Signs. In Transportation Research Record: Journal of the Transportation Research Board, No. 1937, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 105-112.

[11]. CARE 9.0.0, Critical Analysis Reporting Environment. User Manual. CARE Research & Development Laboratory. Computer Science Department. The University of Alabama (UA), 2007.