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Digesting the safety effectiveness of cable barrier systems by numbers

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ABSTRACT

This paper presents median cable barrier safety effectiveness by numbers as experienced on Tennessee highways. Apart from descriptive statistics and parametric tests, before and after statistical evaluation utilizing Empirical Bayes (EB) was used to estimate the cable barriers Safety Effectiveness. The findings from the descriptive statistics, paired *t*-test and EB evaluation were very similar which reinforces the positive safety effectiveness performances of the cable barriers in Tennessee. The study found that the statewide cable barriers Safety Effectiveness (statistical percentage change in crash frequency across all statewide cable barrier segments) for fatal crashes is 94%, incapacitating injury crashes is 92% and fatal and incapacitating injury crashes combined is also 92%. The safety effectiveness for fatal and all injury crashes combined was found to be 85%. In a direct comparison through descriptive statistics, statewide fatal crashes were reduced by 82% after the cable barriers installation while the incapacitating injury crashes were reduced by 76%. In addition, head-on crashes went down by 96% and crashes involving two or more vehicles went down by 92%. Fatalities due to median crossover crashes were reduced by 83% while number of people injured went down by 71% as a result of cable barriers. Through modeling, wider cable offsets and inside shoulders were found to help reduce number of median related crashes while high differential elevations and high posted speed limit segments significantly had higher number of crashes compared to the opposite features. The findings can be used by state transportation agencies as a decision tool when considering installation of median cable barriers as well in determination geometry and traffic factors that play role in enhancing or worsening performance of the median cable barriers.

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1. Literature on median cable barriers system

Apart from cross-median crash reductions, lowering injury severities, e.g. reduction of fatal or incapacitating and certain types of crashes were some of the expected benefits of the median cable barriers systems in Tennessee and throughout the United States (Lee and Mannering, 2002; McNally and Yaksich, 1992; Hunter et al., 2001; Bane, 2003; Monsere et al., 2003; Miaou et al., 2005; Bligh et al., 2005; Donnell and Mason, 2006a,b; Donnell and Hu, 2010, 2011; Gary and Jianping, 2005). Like many other states in US, for the past nine years, the Tennessee Department of Transportation (TDOT) has been installing median cable rail systems along some sections of the state highways. The intended benefit of the cable rail systems was the

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mitigation of cross-median crashes, specifically crashes that occur when a vehicle leaves its travel way enters or crosses the median and collides with vehicles on the opposite direction.

The objective of this research was therefore to evaluate the safety effectiveness of cable rail systems in Tennessee installed since 2006. The study applied descriptive statistics, parametric testing and Empirical Bayes (EB) observational evaluation to assess the safety effectiveness. Descriptive statistics of critical factors associated with median related crashes were performed including comparing the percentage of certain type of crashes and attributes to the total crashes before and after the cables were installed. Analysis compared percentage reduction or increase in the number of crashes or injury severities. The study also applied Empirical Bayes (EB) safety evaluation procedures as documented in Highway Safety Manual (HSM) and Safety Analyst Software (AASHTO, 2010). Through EB, the study evaluated the performance of the cable rail systems while weighing the past performance before the cables were installed. The focus was on crash frequency, crash rates, crash types, injury severities with respect to geometric and operational factors that contribute to crash trends, and identifying other factors that influenced the effectiveness of the cable rail systems at different capacities. Apart from quantifiable effects, the evaluation results help in responding to the general public perception of the cable rail system program. As a result of this study, the public is expected to be informed on whether and at what level the system is significantly reducing crashes and lowering severity.

The first step leading to installation of the cable rail system is to identify crash patterns for the subject highway location. Median related crashes are easy to identify due to their uniqueness compared to other crash types. A study in Minnesota reported that most states' crash records did not explicitly identify median crossover crashes but uses original accident reports to review the collision diagrams and crash notes to determine whether the crash was median related or not (Gary et al., 2009; Gary and Jianping, 2005). In another study conducted in Washington State, the analysis used median related crashes, such as: collision with median fixed objects, median roll-over crashes, and median crossover crashes as a basis for installing cable rails (AASHTO, 2006; Washington DOT, 2009). The Washington and Minnesota studies highlight the importance of developing lists of relevant crashes when conducting the analysis of the cable rail systems. A notable experience from other states is the overall number of crashes in the cable areas increased after the installation (mainly due to property damage crashes), but severe crashes and severity decreased (AASHTO, 2006). A study conducted in Washington State (Miller et al., 2006) for instance theorized that this increase could be due to more property damage crashes having to be reported once contact occurs with the cable barrier. In Florida, Alluri et al., 2012 reviewed a total of 8818 total police crash reports along 101 miles of median cable barriers and found only 549 were median related of which 16.4% were median crossover and 83.6% were contained or redirected by the barriers. In the same Florida study, fatal crashes were reduced by 42.2%, severe injury crashes by 20.1% and minor injury crashes by 11.6% while PDO went up by 88.1%.

1.1. Effectiveness evaluation methodologies

Safety effectiveness evaluation is the process of developing quantitative estimates of the effect of median cable barriers as treatments on expected average crash frequency. There is a long list of studies and researches focused purely on safety effectiveness evaluation of median cable barriers (Lee and Mannering, 2002; McNally and Yaksich, 1992; Hunter et al., 2001; Bane, 2003; Monsere et al., 2003; Miaou et al., 2005; Bligh et al., 2005; Donnell and Mason, 2006a,b; Donnell and Hu, 2010, 2011; Gary and Jianping, 2005; Alluri et al., 2012; Sicking et al., 2009). For instance, Miaou et al., 2005 prepared median barrier guidelines in Texas by estimating median-related crash frequencies using full Bayes approach for model specification. Their crash frequency models showed median width and posted speed as statistically significant explanatory. The expected median barrier crash frequency was shown to decrease as the median width increases. Donnell et al., 2002 investigated median barrier crash frequency on Pennsylvania interstate highways, including separate models for the Turnpike and other interstate-designated highways. They found that as the speed limit increases on the non-toll portion of the interstate highway, the frequency of median barrier crashes increases. Chimba et al., 2014 found that increasing in traffic volume tends to increase collision with median barrier as well as the presence of curves which tends to increase the frequency of crashes. However, they found that barriers placed farther from the lane (offset) tend to decrease injury and fatal crash frequencies.

Empirical Bayes (EB) is one of the methodologies used widely in examining the cable barrier efficiency once it has been installed. The EB method utilizes a before period crash on the treated site compared to possible crash trend if the facility or the site could have been left untreated. These results are then compared to the actual crash count seen after the site has been treated to determine the system's effectiveness (Bhagwant et al., 2009). The approach can either be abridged or full, the difference is that the abridged technique utilizes only the last 2–3 years of traffic data, while the full version can make use of more data. Although common thought is that the last 2–3 years best represent the current traffic trends, the full removes much of this error in its analysis. More data yields more accurate results (Harwood et al., 2002). When using the EB approach, it is important to develop the dispersion parameter, k, for each type of crash within the model. This dispersion parameter, k, is used to reflect the distribution of each type of crash within the prediction part of the model (Miller et al., 2006). HSM describes in detail different highway safety evaluation procedures. Equally, this study utilized some of these procedures (AASHTO, 2010). In EB analysis, the safety performance functions (SPFs) are regression equations as a function of annual average daily traffic (AADT) and the roadway segment length (L). The regression parameters of the SPFs are determined assuming that crash frequencies follow a negative binomial distribution with overdispersion, known as the overdispersion parameter that is estimated along with the coefficients of the regression equation. The overdispersion parameter is used to determine the value of a weight factor for use in the EB analysis (AASHTO, 2010).

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