Accident Analysis and Prevention 40 (2008) 2015–2023

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Statistical comparisons of the crash characteristics on highways between construction time and non-construction time

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ARTICLE INFO

Article history:
Received 12 February 2008
Received in revised form 13 August 2008
Accepted 17 August 2008

Keywords:
Work zone crash analysis
Crash rate comparison
Work zone safety

ABSTRACT

Many studies in the past reported that crash frequencies during construction time were higher than during non-construction time at the same highway sections. A question was raised whether this trend applies to work zones in Utah. Descriptive statistics (mean, standard deviation and histogram), a paired *t*-test, a two-way ANOVA, and a Tukey test were used to test whether the crash rates are statistically higher during construction time than during non-construction time at the same highway sections using 202 work zone sites located on Utah's highways. These highway sections were grouped into four highway classes and the crashes were grouped into six crash severity levels. It was found that the difference in mean crash rates between construction time and non-construction time was not statistically significant at the 95% confidence level, indicating that the trend of higher crash rates during construction time reported by previous work zone safety-related studies was statistically not supported by Utah's work zone crash records. The observance by contractors of Utah Department of Transportation's (UDOT's) guidelines for work zone traffic control may have helped them achieve a similar level of traffic safety during construction and non-construction times.

1. Introduction

Traffic control in work zones must satisfy dichotomous goals: protecting the work zone to keep it as safe as possible and keeping a free flow of traffic through the work zones. In order to establish effective and efficient traffic safety policies for work zones, traffic safety engineers need to know whether crash frequencies or crash rates are higher during construction time than during non-construction time at the same highway sections. Although many researchers in the past have shown that crash frequencies were higher during construction time than during non-construction time at the same highway sections, the traffic safety engineers at the Utah Department of Transportation (UDOT) were not sure whether such a trend was universally true for all highway sections. Hence, the present study was conducted for testing whether crash rates were higher during construction time than during non-construction time.

The objectives of this study were (1) to gather as many work zone-related crash data as possible from UDOT's crash records filing system, (2) conduct statistical analyses to test the hypothesis "crash rates are higher during construction time than during non-construction time," and (3) evaluate which highway classes (defined in a subsequent section) would require special attention in order to provide safe highway work zone environments.

Using the records of 202 out of 508 construction projects that took place on Utah's highways between 2002 and 2005 (as identified by UDOT), this hypothesis was tested using several statistical methods. Descriptive statistics (mean, standard deviation, and histogram), a paired *t*-test, a two-way ANOVA, and a Tukey test were used to test whether the crash rates are statistically higher during construction time than during non-construction time at the same highway sections. This paper presents the methodology of the study, analysis results, and pertinent findings.

2. Literature review

Many studies have reported that work zones can be more dangerous than non-work zones. Rouphail et al. (1988), in their Chicago Area Expressway System study from 1980 to 1985, showed that the crash rate increased by 88 percent at long-term work zones and by 69 percent at short-term work zones, respectively. Also, the crash rate increased from 0 to 0.219 crashes per mile-day of construction at long-term work zones and 0.8 crashes per mile-day of construction at short-term work zones, respectively

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doi:10.1016/j.aap.2008.08.024

Hall and Lorenz (1989) examined work zone crashes on rural state highways in New Mexico for a 3-year period. They identified highway sections that experienced construction work and located crash records for those sections. Crash occurrences at these sites during the period of construction were compared with crash occurrences during the identical period in the previous year as the period of non-construction. They reported that in comparison with the prior year, crash experience increased by 26% during construction. Also, Ha and Nemeth (1995) reviewed work zone crash data of ten states and reported that the increase in crash occurrences in work zones ranged from 6.8 to 119.0%.

Ullman et al. (2006) found in their analysis of two types of construction projects that the number of crashes increased significantly during periods of work activity than during periods of inactivity. They also reported that the potential for increased number of crashes during work activity was somewhat higher at night than during the day.

Qi et al. (2005) on the other hand conducted a detailed investigation of rear-end crashes in work zones in New York and recommended measures to lessen the frequency of this specific type of crashes. Garber and Zhao (2002) analyzed the location of typical work zone such as advanced warning area, transition area, buffer area, activity area, and termination area with work zone crashes which occurred in Virginia between 1996 and 1999. In their research, they found that the activity area was the predominant location for work zone crashes regardless of highway type and that rear-end crashes were the predominant type of crash.

In his North Carolina work zone crash study, Udoka (2005) studied the crash rates for work zones and the nature of traffic-related crashes in work zones, identified the similarities and differences between nighttime and daytime crashes, and developed management practices that would promote safety and mobility in work zones.

Although many research studies in the past showed that crash frequencies were higher during construction time than during non-construction time at the same highway sections, UDOT's traffic safety engineers wanted to find out whether such trends are universal to different highway classes, especially on Utah's highways, in order to effectively allocate traffic control funds to work zones on different highway classes.

3. Methodology

3.1. Data collection and reduction

UDOT identified 528 road construction projects between 2002 and 2005, and crash records related to these construction projects were collected. Using the procedure discussed below, 202 projects were eventually selected for further analysis, which consisted of 45 projects on rural interstate highways, 65 projects on rural non-interstate highways, 26 projects in urban interstate highways, and 66 projects on urban non-interstate highways. The following actions were taken for data reduction to select the projects for the study:

(1) Add milepost and route number to the work zones,
(2) remove projects with unclear milepost data (station number, no milepost),
(3) remove projects with unclear route numbers,
(4) remove projects that spanned into 2006 because there was no crash data available in UDOT's crash record system at the time of the study,
(5) remove projects where construction lasted less than 1 month,
(6) remove projects that had the same beginning and ending mileposts and
(7) remove projects that did not have crash data.

3.2. Grouping of data for construction and non-construction times

In order to avoid the bias of non-construction time crash data caused by road environment and traffic condition when compared with the crash data of construction time, crash data for non-construction times were obtained from the same highway sections where construction times were available. The crash data used to represent non-construction times were the average crash rates of the 3 years prior to the time construction began.

3.3. Calculation of crash rate

Crash rates in million miles traveled (MVMT) were used as the unit for comparison in order to overcome the differences that existed among the work zones including traffic volume, work zone length, geometric conditions, highway functional class, etc. In order to calculate the crash rate using MVMT, Annual Average Daily Traffic (AADT) and the length of the highway affected by each of the chosen 202 construction projects were needed. AADTs were estimated using AADT data available through the Traffic on Utah Highways (UDOT, 2007b). The length of each project was obtained by identifying the beginning and ending mileposts of the project during the data sorting process. Also, crash records by severity level for each project were obtained from ALAMC, UDOT's crash data website (UDOT, 2007a). Crash rates for each project were categorized by highway class.

3.4. Analysis method

Crash rates of the 202 projects were analyzed using statistical analysis tools such as SPSS (Apache Software Foundation, 2003) and S-plus (Insightful Corp., 2005). Descriptive statistical analyses (mean, standard deviation, confidential interval, and histogram), a paired *t*-test, a two-way ANOVA, and a Tukey test were performed using two major factors: highway class and crash severity level. Highway classes were composed of Rural Interstate (RI) highways, Rural Non-Interstate (RNI) highways, Urban Interstate (UI) highways, and Urban Non-Interstate (UNI) highways. Crash severity levels consisted of No Injury (NI), Possible Injury (PI), Bruises and Abrasion (BA), Broken Bones and Bleeding Blood (BBBB), Fatal, and a combination of BBBB and Fatal crash severity levels (BBBB + Fatal).

Note that control groups were not used in this comparison because it was practically impossible to randomly select multiple control segments that have characteristics similar, if not identical, to each of the 202 work zones analyzed. The analysis was carried out using each highway segment as its own control. The data showed that the majority of the work zones selected for the analysis did not experience significant shits in traffic patterns before and during the construction times. Therefore, using the before data as the control for each segment was considered appropriate.

4. Analysis results

4.1. Summary of descriptive statistics

Table 1 presents a summary of descriptive statistics by crash severity level with highway class as a factor. The difference in mean crash rates between construction and non-construction time