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How Do I Conduct a Crash Study?

The majority of the highway system in the United States consists of two-lane rural roads. Typically, these roads carry relatively low traffic volumes; however, some of these roadways are becoming congested because of expanding urban areas, recreational travel, seasonal residencies, and special events.[1]

According to the National Highway Traffic Safety Administration, in2004 approximately 57 percent of all fatal crashes happened on rural roads. Approximately 90 percent of these fatalities occurred on two-lane roads. Problems on rural roads have been related to three basic causes: (1) inadequate road geometry (e.g., width, grades, alignment, sight distance) either at specific locations or over long sections, (2) lack of passing opportunities due to either limited sight distance or heavy oncoming traffic volume, and (3) traffic conflicts due to turns at access points (e.g., intersections, driveways).2 Widening or realigning an existing two-lane road is expensive, so as an alternative many agencies are considering low cost safety improvements which can solve many operational problems.

Crash statistics are commonly used by transportation engineers to identify locations with above-average crash occurrences or crash patterns that are a significant portion of the total crashes. Crash studies are essentially comprised of six steps: (1) identify sites with potential safety problems, (2) characterize crash experience, (3) characterize field conditions, (4) identify contributing factors and appropriate countermeasures, (5) assess countermeasures and select most appropriate, and (6) implement countermeasures and evaluate effectiveness.[1,3]

Identify Sites with Potential Safety Problems

The following methods can be used to identify sites with potential safety problems: crash data, traffic measures (e.g., speed studies, volume/capacity studies), field observations, citizen input, enforcement input, and surrogate measures for crashes (e.g., number of conflicts, brake activation).[1,3] Crash statistics are the most common of these methods; however, they can be computed in variety of ways. Users of crash data must understand the limitations of each approach.

For spot locations, the number of crashes is the simplest and most direct approach. Various minimum numbers of crashes are used to determine if a site is a having a safety problem. For roadway sections with consistent characteristics, crash density can be used. Typically the minimum distance of the roadway section is 1 mile. Crash density is then the number of crashes per mile.[1]

If there are considerable variations in traffic volumes throughout the road system, crash analyses using the number of crashes can result in misleading conclusions. For example, two locations can have the same number of crashes, but do not reflect the same degree of hazard potential, if one carries twice as much traffic as the other. To account for exposure, crash rates are used. Crash rates are the number of crashes divided by the number of entering vehicles and the number of miles of roadway.

The crash rate method is presented below. While this method is more complex, it generally provides better results.[1]

Crash Rate Method[1]

1. Locate all crashes in accordance with accepted coding practices.
2. Identify number of crashes in each established section and at individual intersections and spots.
3. Calculate the actual crash rate for each established section during the study period.

$$\text{Rate/MVM} = \frac{(\text{number of crashes on section})(10^6)}{(\text{ADT})(\text{number of days})(\text{section length})}$$

(ADT is the average daily traffic. MVM is million vehicle miles.)

4. Calculate the actual crash rate for each intersection or spot during the study period.

$$\text{Rate/MV} = \frac{(\text{number of crashes at intersection or spot})(10^6)}{(\text{ADT at location})(\text{number of days})}$$

(ADT at location represents the sum of all vehicles entering the intersection. MV is million vehicles.)

5. For the same period, calculate the systemwide average crash rates for sections, intersections, and spots-using the formulas above and the summation of total crashes, total vehicle miles, and total vehicles, respectively, for each category of location.
6. Select appropriate rate cutoff values as criteria for identifying high crash locations. A value about twice the systemwide rate is usually realistic and practical.
7. If actual rates exceed the minimum established criteria, the location is identified as a high crash location and placed on the list for investigation and analysis.

Selection of the cutoff value (step 6) is not as critical as it might appear. The principal purpose is to control the size of the list of locations to be investigated – a shorter list with high values, a longer list with low values. Experience will disclose the proper level for a particular agency.

Additional improvements to the crash statistics can be achieved using the number rate method and quality control methods. However, these methods are recommended for agencies with large complex systems and thus, are not discussed herein.

Two additional crash evaluation methods that can be used are crash severity measures and crash indexes. Crash severity measures allow for more severe crashes (e.g., fatal and injury crashes) to be given more importance than less severe crashes (e.g., property damage-only crashes). An overall crash index can be used to combine different methods into a single measure. Each measure can be weighted the same or differently. The combination minimizes the weaknesses of the individual measures.[1]

Characterize Crash Experience

Once the sites with potential safety problems have been identified, the crash experience needs to be characterized. Activities that help to characterize the crash experience include: a list of the types of crashes, a review of crash report forms, preparation of collision diagrams, and field visits. The information gathered in this step helps identify contributing factors, which can be used to identify appropriate countermeasures.[1]

Characterize Field Conditions

Next, the physical condition of the site must be investigated. The geometries of the roadway are needed as a basis for all data collected about the roadway. On-site observation by an engineer is recommended. The timing of the visit should correspond to the safety problem; thus, the visit may need to take place during off-peak periods or at night. Photographs are a good tool for documenting geometric or operational problems for later review. Condition diagrams may also be developed. Condition diagrams are scale drawings of the location of interest that show geometric and traffic control details. Traffic volume counts and vehicle classification counts are also needed. In addition, supplementary traffic studies can be employed to further define the safety problem and help identify appropriate countermeasures.[1]

Identify Contributing Factors and Appropriate Countermeasures

The next step is to determine potential countermeasures that could effectively correct or improve the situation. Countermeasures can be identified using the following sources: detailed investigations of crashes, review of site plans, site visits, other transportation engineering studies, practices and previous experiences, and technical literature.[1] Many references are available that suggest countermeasures for certain situations including: the Institute of Transportation Engineers (ITE) *Traffic Engineering Handbook;*3 National Cooperative Highway Research Program (NCHRP) Report 440- *Accident Mitigation Guide for Congested Rural Two-Lane Highways*[1]*;* and the NCHRP 500 report series.[4]

Assess Countermeasures and Select Most Appropriate

When selecting the most appropriate countermeasure the following should be considered: (1) identify all practical countermeasures including doing nothing,(2) identify all practical combinations of countermeasures, (3) identify practical limitations and constraints, and (4) for each alternative identify the potential effect. Documentation of the data and process is needed.[1]

The proposed countermeasures should be evaluated to determine which will provide the greatest return. Evaluations may be as simple as listing the advantages and disadvantages of each alternative. In contrast, a complete economic analysis using benefit-cost or cost effectiveness could be completed. Typically, evaluations involve the following six steps: (1) estimate net crash reduction, (2) assign values to crash reduction, (3) estimate secondary benefits, (4) estimate improvements costs, (5) analyze effectiveness at each location, and (6) assign program priorities. The final part of this step is to narrow down the range of possibilities to one or more measures.[1]

Implement Countermeasures and Evaluate Effectiveness

The final step in the process is to implement the selected improvements and evaluate their effectiveness. The Federal Highway Administration (FHWA) developed a detailed procedure consisting of the following six tasks: (1) develop evaluation plan, (2) collect and reduce data, (3) compare measures of effectiveness, (4) perform statistical tests, (5) perform economic analysis, and (6) prepare evaluation documentation.[5] Several sources provide additional information on conducting evaluation studies.[5, 6, 7, 8, 9]

The following four evaluation approaches are also recommended by the FHWA: before-and-after study with control sites, before-and-after study, comparative parallel study, and before, during, and after study. Of these techniques, the before-and-after study with control sites is considered to be the most desirable. This technique involves matching the improved sites with similar comparison sites that are not improved. By using a comparison site, the crash experience that would have been observed at the improved sites had the improvement not been made can be estimated.[1] The phenomenon known as regression to the mean affects the validity of a before-and-after study of a crash countermeasure. If a safety improvement is implemented at a site based on a high short-term crash experience, it is likely that even if no improvement was made the crash experience would decrease (regress to the mean). Thus, regression to the mean effects can be mistaken for the effects of crash countermeasures.[1] Newer Empirical Bayes techniques account for the effect of regression to the mean, but are more complicated.[8]

In conclusion, the majority of the highway system in the United States consists of two-lane rural roads. According to the National Highway Traffic Safety Administration, in 2004 approximately 90 percent of the fatalities that happened on rural roads occurred on two-lane roads. Crash studies can be used by transportation engineers to identify locations with safety problems, identify contributing factors, and assess potential countermeasures.

1 Fitzpatrick, K., K. Balke, D.W. Harwood, and I.B. Anderson. *Accident Mitigation Guide for Congested Rural Two- Lane Highways*. NCHRP Report 440. Transportation Research Board, National Research Council, Washington, D.C., 2000.

2 Harwood, D.W. and C.J. Hoban. *Low-Cost Methods for Improving Traffic Operations on Two-Lane Roads: Informational Guide*. FHWA-IP-87-2. Federal Highway Administration, Washington, D.C., January 1987.

3 Pline, J. *Traffic Engineering Handbook*. 5th Edition. Institute of Transportation Engineers, Washington, D.C., 1999.

4 NCHRP Report 500 Series, Volumes 1-16 (more forthcoming). Transportation Research Board, Washington, D.C., 2003-2005. http://www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+17-18(3) or http://safety.transportation.org/guides.aspx.

5 *Highway Safety Evaluation – Procedural Guide*. FHWA-TS-81-219. Federal Highway Administration, Washington, D.C., November 1981.

6 Robertson, H.D., J.E. Hummer, and D.C. Nelson. *Manual of Transportation Engineering Studies*. Institute of Transportation Engineers, Washington, D.C., 1994.

7 Council, F.M., et al. *Accident Research Manual*. FHWA/RD-80/016. Federal Highway Administration, Washington, D.C., February 1980.

8 Hauer. E. *Observational Before-After Studies in Road Safety*. Pergamon/Elsevier Science, Inc., Tanytown, New York, 1997.

9 Latham, F.E. and J.W. Trombly. *Low Cost Traffic Engineering Improvements: A Primer*. FHWA-OP-03-078. Federal Highway Administration, Washington, D.C., April 2003. http://ops.fhwa.dot.gov/publications/low_cost_traf/low_cost_traf.pdf.

Reference: ATSSA, Low Cost Local Road Safety Solutions, Volume 1, No. 17