Synthesis of Safety For Traffic Operations

Leanna Belluz
Transport Canada

Gerry Forbes, M.Eng., P.Eng., P.T.O.E.
Intus Road Safety Engineering Inc.

Paper prepared for presentation

at the Traffic Operations Research and Applications Session

of the 2003 Annual Conference of the
Transportation Association of Canada
St. John's Newfoundland and Labrador

Abstract

Safety is one of the most important and complex aspects of transportation engineering. It takes a traffic professional considerable time and effort to keep abreast of research in the field of safety as it relates to traffic engineering improvements. Reading through research reports and summarizing the results is an overwhelming task; especially when having to identify the constraints of each study and relate them to the situation under evaluation. The only accepted Canadian reference document related to traffic operations and engineering is the Manual of Uniform Traffic Control Devices for Canada (MUTCD). The MUTCD is basically, a collection of traffic control device standards with limited information on their safety benefits or how they should be used to improve safety. New studies and research findings are continuously presented and documented but not easily accessible by all transportation practitioners. Therefore, Transport Canada identified a need for a document that synthesized the safety impacts of various traffic operations and control strategies.

The objective of this project was to assemble state of the art information from approximately the last ten years of research on the safety benefits of traffic engineering improvements. The final product would be a reference document providing, as much as possible, Canadian research information on the safety impacts of traffic control and operations that are most useful to transportation practitioners and other transportation professionals.

As traffic operations and engineering is a vast topic, a Technical Advisory Team of provincial and municipal transportation engineering professionals from across Canada assisted in developing a list of relevant topics for inclusion in the Synthesis. The topics selected were: intersection control, traffic signs, pavement markings, pedestrian safety, bicycle safety, legislation and enforcement, turn lanes, and traffic calming. The information contained in the document was found from conventional literature searches of known databases, Internet searches using appropriate key words, and personal contact with Canadian academic and road safety practitioners. Only studies that reported on crash occurrence, crash severity, or crash surrogates with a proven correlation to crashes were taken into consideration. The research studies were appraised according to how the sites were selected for evaluation, the treatment used, and the study methodology.

This Synthesis provides transportation professionals with a tool to help them make better decisions regarding the safety impacts of their traffic control treatments thereby contributing to the goal of Canada's Road Safety Vision – to make Canada's roads the safest in the world.

Introduction

Background

Traffic safety is an active area of research in Canada and abroad. There are many studies that have been conducted and countless research reports produced yet many transportation practitioners may not have knowledge of the research, or have access to the information. Furthermore, for those that have access it is very time consuming and may even seem impossible

to keep track of research, read through the reports, critically appraise them, and decide if they are relevant to their own study area. Understanding all the constraints of any particular study is also a challenging task as there are different methods and procedures used in conducting safety studies and different statistical techniques used to analyze the results.

Safety impacts of specific traffic countermeasures play a significant role in the decision making process when traffic professionals implement traffic improvements or modifications. In 1999, safety information for roadway elements was included under the sections entitled "Explicit Consideration of Safety" in the Geometric Design Guide for Canadian Roads(2). However, in the realm of traffic control and operations safety there is a limited amount of guidance available from the Manual of Uniform Traffic Control Devices (MUTCD)(3). The MUTCD is a collection of traffic control devices with little information on their safety benefits or how they should be used to improve safety. Therefore, Transport Canada recognized a need to produce a synthesis of safety related to traffic operations containing safety impact information on specific traffic operations and control strategies in order to assist practitioners.

Objective

The objective of this project was to gather state of the art safety information, from approximately the last ten years, focusing on areas related to traffic control and traffic operations and synthesize the findings into one document. Geometric design considerations were only included if they were routinely the subject matter for traffic operations professionals. Additional goals included the following:

- Collect research studies that report on crash occurrence, crash severity, or crash surrogates with a proven correlation to crashes
- As much as possible, synthesize Canadian research using Canadian datasets
- Promote evidence-based road safety (EBRS)
- Help Canada achieve its objective of making Canada's roads the safest in the world

The end product would be a reference document catering to practitioners and other transportation professionals in selecting traffic countermeasures and would provide safety information to the users of the MUTCD(3).

Project Procedure

Technical Advisory Team (TAT)

Qualified professionals from across Canada who specialize in the area of traffic operations, control, and safety were identified and asked to assist in the development of the Synthesis. These individuals were advised of the objective of the project and what their role would be. The responsibilities of the TAT were:

- To provide input on traffic operational control issues that are of most concern to them and their colleagues

- To forward any reports, documents, and literature that they may have, or identify sources of this information

- To provide data that they may have collected on a particular topic of interest

- To review the synthesis and offer comments.

The complete advisory team consisted of nine traffic specialists: four from municipal governments; four from provincial governments; and one national representative.

Subject Areas

A preliminary list of subject areas, which were felt to be most relevant to traffic engineers, and the most useful and important to practicing transportation professionals was prepared. This list was reviewed by the TAT who added missing subject areas, and prioritized the list according to need. With the input from the TAT, the subject areas identified were thought to be those issues that were of most interest to Canadian practitioners. The list of topics was also dependent on the amount of information available on the specific subject.

Safety impact information was synthesized in the following chapters:

- Intersection control including signalization, all-way stop control, intersection control beacons, traffic signal design and operation, advance warning flashers, signal clearance timing, signal coordination, traffic signal timing, and night-time flash

- Traffic signs including horizontal curve signing and marking, close-following warning signs, and restricted visibility signing

- Pavement markings including edgelines and transverse markings

- Pedestrian safety including marked crosswalks, pedestrian refuge islands and split pedestrian cross-overs, flashing beacons with supplementary signs, “Turning Traffic Must Yield to Pedestrians” signs, and school zone traffic control

- Bicycle safety including advanced stop lines for cyclists

- Legislation and enforcement including speed limits, speed display boards, curbside parking, and one-way streets

- Turn lanes including left-turn lanes, two-way left turn lanes, and right-turn lanes

- Traffic calming including speed humps and transverse rumble strips

Metrics

The most common metric used to measure road safety is motor vehicle crash (MVC) occurrence and severity. But since MVCs are rare and random events, relying solely on them would be limiting. Many evaluation studies use crash surrogates to determine the effectiveness of specific road safety countermeasures. Crash surrogates are substitute measures that are representative of crashes or crash severity but occur with greater frequency. It was decided that studies based on surrogates would be included in the Synthesis as long as there was reasonable evidence that the surrogate correlated with crash occurrence or severity. For example, since there was an absence of explicit research that linked stop sign compliance to crash occurrence or severity, it was not considered a valid surrogate to be included in this report. The two surrogates that did show definite links to MVC occurrence or severity were operating speed and traffic conflicts.

Currently, the science of road safety uses two different methods to measure the safety impacts of a traffic operation which may be found in several of the traffic studies synthesized in the document. They are Safety Performance Functions (SPFs) and Collision Modification Factors (CMFs).

A SPF is a crash prediction model that determines the relationship between the amount of traffic and the collision frequency per unit of time for a specific section of road or intersection to estimate the long-term crash frequency of a facility. It helps determine if a sites' safety performance is better or worse than expected. When they are developed for two different locations that have similar characteristics but differ in only one aspect, the difference in performance is assumed to be caused by this differing aspect. For example, if you have two intersections that are both similar except one of the intersections has a red light camera installed, the difference in the safety performance would be assumed to be caused by the red light camera. An additional section was included in the synthesis that provides information to practitioners on how to use SPFs.

CMF are usually developed for before-after studies and are multipliers used to estimate the safety impact of implemented countermeasures. It is calculated by dividing the expected collision frequency without the countermeasure implemented by the expected collision frequency with the countermeasure. If the CMF is less than one, there is a safety benefit; if the CMF is greater than one, there will be an increase in crashes. For example, a traffic operation countermeasure with a CMF of 0.60 would be expected to reduce crashes by 40%.

Literature Review and Critical Appraisal

This project required a state of the art review on the relationship of traffic control and traffic operation measures to collision causation and severity. The chapters found in the Synthesis formed the basis of the search. As much as possible Canadian information was synthesized but American documents and international experiences were also used as supplemental information. The search included published and unpublished documents from the last 10 years but did not exclude studies completed more than 10 years ago if they were found to be relevant to the research priorities.

Overall, the literature synthesized in this document was found by conventional literature searches of known databases, Internet searches using appropriate key words, and personal contact with Canadian academics and road safety practitioners. Other sources included information from magazines, journals, newsletters, booklets, brochures, conference proceedings and reports.

All identified literature related to the subject areas was critically evaluated to determine the validity of the research findings. In particular, the sample size, the length of the evaluation period, the site selection methodology, and the statistical evaluation methodology used.

Since research in the traffic safety field is continuously emerging and this document represents the conventional wisdom on the safety impacts of specific traffic operations at the time of authoring, a critical appraisal tool was developed and included in the Synthesis. This tool may be used to help critically appraise other research, and supplement the information contained in the Synthesis. By having each study in the Synthesis critically appraised, the users of the Synthesis could judge whether the safety impacts identified are reliable and/or applicable to their particular situation.

Study Methodologies

The studies included in the Synthesis used different statistical techniques each having their own strengths and weaknesses. Four of the most common techniques are described below:

Naïve Before-after Study

This is a simple comparison of the number of crashes or crash rates before and after treatment. The difficulties with this method are that traffic and other causal factors might change from before implementation to after which would not be accounted for. Also, if a number of countermeasures were implemented together, it is impossible to quantify the individual effects. Furthermore, regression-to-the-mean effects are not taken into consideration.

Before-after Study with a Control Group

In a before-after study with a control group, a group of untreated sights are used to account for the unrelated effects. It is assumed that any change in the crash record in this control group would have also occurred in the treatment group if no treatment were applied. Although this method is an improvement from the naïve before-after study, it still does not account for regression-to-the-mean effects.

Cross-sectional Study

This method involves the study of two different groups of sites that vary only by the feature of interest. Safety impacts are determined by comparing the crash records between both groups of sites. The difficulty in this is finding sites that are very similar in all aspects besides the feature of interest.

Empirical Bayes (EB) Techniques

The EB technique is a before-after study that uses advanced statistics to increase the accuracy of estimates and correct for the regression-to-the-mean bias. It combines collision records with safety information from sites similar to the one under investigation. SPF are combined with site-specific crash data in the before and after periods to determine the safety impacts.

Cautions in Using Information

Practitioners must be cautious when relying on results of studies from other jurisdictions. There are several reasons why results would not be valid from one jurisdiction to another.

Collision reporting methods vary between jurisdictions. For example, the maximum elapsed time in which a death must occur following a collision to be considered a traffic fatality is not the same in all provinces. Most provinces use 30 days but other provinces use 8 days or even 12 months. Also, jurisdictions define "intersection collision" in varying ways. Some jurisdictions define it as any crash that occurs within 30 m from an intersection. In other jurisdictions, this number may be as high as 250 m. Furthermore, some provinces only record specific information on fatal and non-fatal injury collisions but not on property damage only collisions.

Other variations between jurisdictions include mandatory graduated licensing laws, fleets, rules of the road, and traffic design standards. These should all be taken into consideration when deciding whether a research study is valid for a specific situation or not.

Problems Encountered

In developing this Synthesis, a few problems were encountered that affected the content of the document. Firstly, there were not as many studies done by practitioners as previously thought. It was expected that the volume of published Canadian research would be relatively small. However, it was also expected that practitioners would have been undertaking safety evaluations for their own purposes, although not publishing the results. What was found was that practitioners are faced with daily pressures and many jurisdictions do not have the human and financial resources to evaluate every traffic safety countermeasure implemented on their roads. This unfortunately, results in a lack of Canadian information available.

Another shortfall was the use of statistical techniques in published evaluation studies that did not account for regression-to-the-mean. This shortcoming could overestimate the safety benefits, limit the credibility of the conclusions, and provide misleading information to practitioners.

While reviewing all of the studies, it was found that not all of the information to critically appraise the study could be found in the published material. For example, all the results of a study would be included except site selection procedures, which is a very important consideration when determining the validity of the statistical results.

In response to the above-noted shortcomings, it was deemed appropriate by the project team to include in the Synthesis a section on reporting on road safety research. Essentially, this is a short appendix to the Synthesis that reminds individuals of the necessary elements of a research report.

Evidence-Based Road Safety

Since there is a lack of good quality (Canadian) information on the safety impacts of traffic operations and control strategies, it is difficult for traffic professionals to practice evidence-based road safety (EBRS) within the traffic operations environment.

EBRS is defined as *the conscientious and judicious use of current best evidence in providing road safety for individuals, facilities, and transportation systems.* The practice of EBRS is the integration of the best available information on global safety research with the experience and knowledge of the individual practitioner respecting community values and local policy. The end result of practicing EBRS is informed decision-making respecting road safety matters, where the safety effects of the selected actions and strategies are known, and are compatible with community values.

Global safety research within traffic operations is fractured and relatively sparse, making it difficult for local practitioners to make informed safety decisions. The Synthesis is intended to consolidate some of the known research, and to provide practitioners with better/more information with which to make operations and control decisions.

Conclusions

Traffic operations professionals make countless decisions respecting the safety of the road system (or elements of the system) daily. Safety research is continuous, and the ability for these individuals to keep abreast of the conventional wisdom in this area is daunting. Many of these professionals either do not know about, or do not have access to, the latest research results.

Transport Canada has recognized this information gap exists for practitioners and has responded by preparing a Synthesis of Safety for Traffic Operations.

The Synthesis provides transportation professionals with a tool to help them make better decisions regarding the safety impacts of their traffic control treatments thereby contributing to the goal of Canada's Road Safety Vision – to make Canada's roads the safest in the world.

Recommendations

Based on the fact that it was difficult to critically appraise every study found as a result of the lack of information included in the research reports, it is recommended that there be a uniform process of reporting safety information including the documentation of evaluation studies completed. Perhaps, better safety analysis training for practitioners is needed to overcome this obstacle.

References

1. Forbes G; Synthesis of Safety for Traffic Operations: Final Report; Intus Road Safety Engineering Inc. for Transport Canada; Burlington, ON; March 2003

2. Transportation Association of Canada; Geometric Design Guide for Canadian Roads; 1999 Edition; September 1999

3. Transportation Association of Canada; Manual of Uniform Traffic Control Devices for Canada; Fourth Edition; September 1998