

EVIDENCE BRIEF

Effectiveness of Enforcement Strategies on Road Safety Outcomes



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Key Messages

- The burden of injury due to motor vehicle collisions in Ontario is currently high, despite the ability to prevent dangerous driving behaviours; a common cause of injuries and fatalities.
- Understanding the effectiveness of enforcement strategies, one of the three E's of injury prevention interventions (enforcement, education and engineering) is an integral part of informing a program of public health for road safety.
- Despite the need for further research on certain enforcement strategies such as those specific to occupational settings such as emergency services, enforcement interventions focused on reducing speed, alcohol consumption, and increasing helmet use provide consistent evidence of their positive effect on decreasing motor vehicle collisions, injuries, and fatalities.

Issue and Research Question

As of 2019, the age-standardized rate of emergency department (ED) visits for injuries due to motor vehicle collisions (MVCs) in Ontario was 597.5 per 100,000 population (95%CI= 593.5-601.5).¹ This rate has decreased over time where the rate in 2003 was 683.6 per 100,000 (95%CI= 679.0-688.3);¹ however, there is much work to be done to support a Safe Systems and Vision Zero approach to road safety that includes zero deaths and severe injuries on our roads.² In 2019, Transport Canada reported that 25.6% of fatalities and 10.3% of serious injuries occurred where drivers were not wearing seatbelts.³ Distracted driving, speeding, and impaired driving contributed to 21.7%, 23.0%, and 15.2% of all fatal collisions in 2019, respectively.³ These data emphasize the need for a public health approach to reduce collisions including the need for evidence on the effectiveness of interventions to reduce negative road safety outcomes.⁴ Further, research in this area suggests population level intervention is successful at reducing fatal MVC outcomes, particularly in children and youth.⁵ This evidence brief will aim to understand how effective enforcement strategies are in preventing negative road safety outcomes.

Methods

A literature review was conducted to identify and synthesize the existing evidence on enforcement-based road safety interventions across all populations and any geographic region. Systematic searches were conducted in May 2021 in order to identify all relevant evidence. Public Health Ontario Library Services conducted a search in MEDLINE, Embase, PsycINFO, Global Health, CINAHL, SocINDEX, and Cochrane Database for Systematic Reviews using relevant vocabulary and subject headings. All database results were integrated and duplicates were removed. The search strategy is available upon request.

English-language peer-reviewed articles were eligible for inclusion if they examined the effect of an enforcement-based road safety intervention and were published within the last five years. Papers were excluded if they did not have a MVC or collision pathway outcome, did not include reproducible search methods, were not review-level articles, or did not include an enforcement intervention.

One reviewer (SS) screened all of the titles and abstracts and a second reviewer screened a random selection of titles and abstracts (SR). Full-text versions of all articles for inclusion were reviewed by two reviewers. One reviewer (SS) then performed a data extraction for the included articles and categorized the content according to intervention. A random selection of articles were chosen by the second reviewer (SR) to identify any discrepancies in data extraction.

The Health Evidence Quality Assessment Tool for Review Articles was used to conduct a quality appraisal for each included review.⁶ The two reviewers appraised each paper individually and any discrepancies were discussed to reach a consensus (SS, SR).

Main Findings

The literature search identified 923 articles, from which 18 met the inclusion criteria. One was a review of reviews, ten were systematic reviews,⁷⁻¹⁶ three were meta-analyses,¹⁷⁻¹⁹ two were both systematic reviews and meta-analyses,^{20,21} one was a systematic review and metasummary,²² and one was a mixed-methods review.²³ The quality appraisal found that nine of the articles were determined to be of strong quality,^{7,8,11-13,20-22,24} five were moderate,^{9,10,14,15,18} and four were weak.^{16,17,19,23} The findings below are organized by intervention type.

Dangerous Driving Policies

SPEED REDUCTION POLICIES

Three systematic reviews, two meta-analyses, and one systematic review and metasummary examined speed reduction interventions.^{7,9,15,17,18,22} The findings below suggested that reducing speed by implementing speed cameras, speed limits and creating 20 mile per hour (mph) speed zones were effective at reducing vehicle speed, injuries and fatalities due to MVCs. Increasing fixed penalties (i.e., traffic fine amounts) was also associated with a decreased incidence of MVCs and fatalities. Although these strategies are effective on their own, utilizing various speed management strategies at once can yield the greatest positive effects on road safety outcomes.

Sadeghi-Bazargani et al. conducted a review that assessed the effects of speed management interventions.¹⁵ Implementing speed cameras were found to be effective in reducing vehicle speed and reducing the incidence of person-injured collisions by 4% to 51%.¹⁵ Employing various speed management strategies was reported to reduce injuries and fatalities due to MVCs by 8% to 65% and 11% to 71%, respectively.¹⁵ The authors suggested that integrating speed management strategies with other road safety interventions would yield the greatest benefits for road safety.¹⁵

A meta-analysis examined the effect of increasing fixed penalties for speeding. Elvik et al. determined that as fixed penalties increased from zero to \$600 USD, the number of traffic fatalities changed from a 10% increase to a 25% reduction with a small decrease (5-10%) in the number of MVCs.¹⁸ Once fatalities were reduced by 25%, additional increases in fixed penalties did not result in further reductions in the number of fatalities.¹⁸

A systematic review conducted by Araujo et al. examined the effect of prevention interventions for motorcycle collisions and MVCs in general.⁷ One specific intervention focused on the installation of 20mph (~30kmh) speed limit signs in urban areas.⁷ Reductions of 32.6% and 39.1% in the total number of injuries and fatal motorcycle collisions were reported, respectively.⁷ Similarly, Cairns et al. conducted a review specifically on the effect of 20mph zones (traffic calming measures such as speed bumps and mini roundabouts) and 20mph speed limits.⁹ The authors reported that 20mph limits and zones were effective at reducing MVC collisions and related injuries, as well as traffic speed.⁹ Twenty mile per hour speed limits were associated with a 25% reduction in the number of traffic collisions in the area the intervention was introduced.⁹ These speed reduction zones were found to result in a 45% decrease in the number of injuries among road users.⁹

A systematic review and metasummary conducted by Staton et al. examined the effect of multiple collision prevention initiatives on MVCs, injuries, and fatalities in low and middle-income countries.²² One of these initiatives included increased legislation on speed limits (lower limits and/or higher traffic violation fines) which was found to have no statistically significant effect on collision incidence.²² One primary study in this review found that the introduction of speed humps in two residential areas of South Africa was associated with a decrease in serious pedestrian MVCs by 23% and 33% and fatal pedestrian MVCs by 50% and 68%.²²

A meta-analysis conducted by Castillo-Manzano et al. examined the incidence of MVC fatalities after adopting higher speed limits in the United States.¹⁷ The number of fatalities increased by 0.214 (fixed-effects model summary effect estimation [FEM]; $I^2 = 0.664$) when the higher speed limits were applied to rural interstates and by 0.002 (FEM; $I^2 = 0.894$) when applied statewide.¹⁷ There were no changes reported in the incidence of fatalities in states that did not raise speed limits.¹⁷ However, when reporting on the fatality rate, the authors cited a decrease in the rate of fatalities with statewide

increases to speed limits (FEM; $I^2 = 0.910$).¹⁷ It is important to recognize that this meta-analysis scored low on the quality appraisal and the findings are inconsistent with the reviews of higher quality appraisal scores, below.

DRIVER MOBILE PHONE USE POLICIES

Implementing stricter laws that penalise mobile phone use while driving may be effective at reducing motor vehicle related fatalities.

Olsson et al. conducted a systematic review in which legislation penalising mobile phone use while driving was evaluated to determine its effect on the number and rate of fatal or serious MVCs and the prevalence of mobile phone use while driving.¹² The authors reported that introducing hand-held bans (HHBs; restriction of any electronic device use that occupies one or more of the driver's hands) was found to decrease the prevalence of mobile phone conversations while driving by 2.8% [95% Confidence Interval (CI) = 1.4, 4.3], but increased hand-held device manipulation by 1.2% [95% CI = 0.5, 2.0].¹² Introducing text-messaging bans was associated with a 1.4% [95% CI = 0.7, 2.2] decrease in hand-held device manipulation. Based on these results, the authors concluded that text-messaging bans and hand-held bans may reduce the prevalence of mobile phone use and thereby reduce MVC fatalities.¹²

ALCOHOL CONSUMPTION AND DRIVING POLICIES

Four systematic reviews, one meta-analysis, one review of reviews, and one systematic review and metasummary examined alcohol consumption and driving interventions.^{7,11,13,16,19,22,24}

The majority of reviews included in this section reported that legislating the reduction of blood alcohol content (BAC) in motor vehicle drivers across various geographical populations was associated with reductions in road traffic fatalities and/or injuries. There was some evidence indicating that other alcohol-related policies (e.g.; alcohol sales restriction) could yield positive effects on road safety outcomes; however, literature in this area are less conclusive than evidence on modifying the legal BAC limit.

A review by Siegfried, et al. examined various alcohol control policies including pricing policies, drink-driving policies and countermeasures, and implementation of legislation limiting the availability of alcohol.²⁴ The authors found that injuries decreased when setting a legal BAC limit was combined with other alcohol control interventions.²⁴ Enforcing the BAC limit (use of breathalysers by police officers) led to a decrease in overall driver BAC.²⁴ Compulsory alcohol testing of occupational drivers was found to reduce fatalities by 80% in truck drivers and by 41% in other drivers.²⁴

Staton et al. reported that legislation that reduced the legal BAC limit was associated with a 16% to 33% reduction in head injuries among motorcyclists.²² The review conducted by Araujo et al. included studies that also examined the effect of increasing penalties related to BAC and/or reducing the legal BAC limit for motorcyclists.⁷ Greater penalties were associated with a significant decrease in the risk of MVCs in urban regions (Risk Ratio (RR) = 0.83; CI 95% = 0.77, 0.90) and rural regions (RR = 0.71; CI 95% = 0.64, 0.78).⁷ When laws limiting BAC to 0.08 g/dl were implemented, the risk of mortality among motorcyclists decreased (adjusted RR = 0.87; CI 95% = 0.79, 0.95).⁷

Fell et al. sought to determine whether lowering the legal BAC limit was associated with any changes in drink-driving and/or fatal and non-fatal alcohol-related collisions.¹⁹ The meta-analysis found that implementing this legislation led to a 5% decrease (standard deviation [SD] = 2.6) in non-fatal alcohol-related collisions.¹⁹ In particular, laws that reduced the legal BAC limit from 0.1 to 0.08 g/dl were associated with a 9.2% (SD = 4.5) decrease in the rate of fatal collisions related to alcohol.¹⁹ Laws that

reduced the legal BAC limit to 0.05 g/dl or lower were associated with a decrease in the rate of fatal alcohol-related crashes by 11.1% (SD = 5.5).¹⁹ This meta-analysis scored a 3 out of 10 on the Health Evidence Quality Appraisal Tool and; therefore, the findings should be reviewed with other higher quality reviews included in this section.¹⁹

Another review examined policy interventions enacted by Chile's national government from 2000 to 2015, related to reducing alcohol consumption and/or alcohol-related harms in 2012 (a reduction of BAC limits from 0.05-0.1 g/dl to 0.03-0.08 g/dl).¹³ One study reported a 32% reduction in alcohol-related collisions per week (26 fewer alcohol-related collisions per week; 95% CI = 36.9; 15.2) and a decrease in the monthly rate of alcohol-related collisions.¹³ Another study evaluated various alcohol policy changes, other than the BAC limit reduction in 2012 (such as preventative community and/or health services' action; restriction of alcohol sales, pricing, and marketing; public intoxication bans; reducing illicit/informally produced alcohol; rehabilitation) and reported that alcohol-attributable deaths increased by 19.3% per year between 2000 and 2006 [95% CI = 7.3; 32.7], and then decreased by 9.5% per year from the beginning of 2006 until the end of 2015 [95% CI = -14.3; -4.5].¹³

Sanchez-Ramirez et al. conducted a review that examined the effect of extending or restricting the number of hours/days available for alcohol sales on alcohol related harms including MVCs, fatalities, injuries, and hospitalizations, among others.¹⁶ Extending alcohol trading time was found to have conflicting results on MVCs.¹⁶ For example, a study conducted in Australia found that extending alcohol trading time by one hour was associated with a 47% increase in MVCs, whereas in the UK, extending trading hours resulted in a 12.8% decrease in collisions.¹⁶ In Canada, extending alcohol trading hours was found to have no effect on MVC-related injuries.¹⁶ However, it is important to recognize that this article scored low on the quality appraisal. Lefio et al. conducted a review that evaluated the effect of regulatory policies on alcohol consumption among drivers in both occupational and general populations.¹¹ When beer taxes increased 1%, alcohol-related MVC fatalities decreased by 0.37% per 100,000 population.¹¹ These findings were not consistent among all studies included in the review; as one study reported that an alcohol sales ban on Sundays led to an increased number of MVCs.¹¹ Implementing police sobriety checkpoints; however, was associated with a 14.0% to 16.7% reduction in the number of fatal crashes ($p < 0.05$) and increasing the legal BAC limit by 0.01 g/dL led to an increased rate of monthly deaths per US state by 0.228 times ($p < 0.05$).¹¹

Police Enforcement/Presence

One systematic review and one systematic review with metasummary examined the effectiveness of increasing police enforcement or presence on MVC outcomes and found that increasing enforcement was found to reduce road traffic fatalities and injuries.

The two reviews conducted by Azami-Aghdash et al. and Staton et al. examined the effect of general police presence/enforcement program on MVCs.^{8,22} Staton et al. reported that increasing police presence on four major roads in Uganda resulted in a 17% reduction in the number of road traffic fatalities.²² The only study included in the review by Azami-Aghdash et al. that examined the effect of police enforcement and prevention programs and found a 12% decrease in the odds of fatal injuries (OR= 0.83, 95% CI = 0.82, 0.85) and a 32% decrease in the odds of non-fatal injuries (OR= 0.68, 95% CI = 0.67, 0.68) in Iran.⁸

Helmet Use Legislation for Motorcycles and Bicycles

Three systematic reviews, one systematic review and meta-analysis, and one systematic review and metasummary evaluated the effects of helmet use legislation on MVC outcomes.^{7,10,14,20,22}

Helmet laws appear to be effective in reducing the incidence of injuries (particularly head injuries), fatalities, and MVCs among motorcyclists and bicyclists. Universal laws (i.e., those that apply to the whole population), appear to be more effective at preventing negative road safety outcomes compared to partial laws (i.e., those that apply only to a portion of the population).

Among motorcyclists, mandatory helmet laws were found to decrease the number of fatalities, particularly in low to middle income countries.²² Partial helmet laws (e.g., those under the age of 18 years) and universal helmet laws were examined by Araujo et al. and were reported to result in statistically significant reductions (20-40%) in the occurrence of craniocerebral trauma and road traffic fatalities among motorcyclists.⁷

Specifically in the United States, Peng, et al. found that universal helmet laws were more effective than partial helmet laws on reducing fatal and non-fatal injuries.¹⁴ Universal helmet laws were found to be associated with a higher prevalence of helmet use, lower rates of injury, and a decreased number of fatal and non-fatal injuries.¹⁴ However, no difference was found between partial helmet laws and the absence of helmet laws specifically among young motorcyclists.¹⁴ Universal helmet laws led to increased helmet use among younger motorcyclists, decreased the number of fatal injuries and fatalities, but increased the risk of neck injuries.¹⁴ Among this population, the incidence of hospitalizations due to non-fatal head injuries arising from motorcycle-related collisions decreased, while the overall hospitalization rates for motorcycle-related collisions increased.¹⁴

For bicyclists, Hoyer et al. examined both universal and partial helmet legislation and found that the reduction of serious head injuries for all cyclists was greater (-55%; 95% CI = [-78, -8]) than the reduction of injuries with unspecified levels of severity (-20%; 95% CI = [-27; -13]).²⁰ Hoyer et al. also found that the effectiveness of universal helmet legislation was greater in comparison to age-restricted laws.²⁰ The authors found that in general, helmeted cyclists experienced fewer and less severe collisions.²⁰ However, helmeted cyclists tend to cycle more on average, implying that more experienced cyclists may demonstrate safer cycling behaviour.²⁰ Du, R. conducted an in-depth review on the effect of various helmet policies and their effect on the incidence of TBI and helmet use among both cyclists and motorcyclists 25 years of age or younger.¹⁰ Most studies included in the review support mandatory helmet use legislation as it has been found to decrease injuries and fatalities related to bicycling collisions.¹⁰ The severity of these injuries also decreased immediately after enacting the legislation.¹⁰ The authors also found that universal bicycle and motorcycle helmet laws as well as geographically encompassing laws were reported to be of more benefit to children and adolescents when compared to age-restricted helmet laws or region-restricted legislation.¹⁰

Provisional/Graduated Driver's Licensing Policies

One review and meta-analysis, one systematic review and one mixed methods review examined the effectiveness of graduated drivers licensing (GDL) on road safety outcomes. Graduated licensing programs refer to two levels of restriction for beginner drivers that include a learner's permit and then an intermediate license that allows teens to drive alone with certain restrictions that prevent high risk driving conditions.²¹ Despite one study scoring low on the quality appraisal, studies found that GDL programs reduce the incidence and severity of MVCs.

A review and meta-analysis conducted by Salam et al. examined the effectiveness of GDL programs and found a 19% decrease (RR = 0.81; 95% CI: 0.75-0.88) in the incidence of MVCs.²¹ Further, Azami-Aghdash et al. reported that the severity and crude number of traffic injuries reduced significantly in response to provisional driver's licensing in Iran.⁸ One year prior to the introduction of graduate driver licensing,

22.8% of total MVCs were related to drivers under 23 years of age.⁸ In the first and second year after implementing the intervention, this proportion reduced to 15.5% and 16.1% respectively, among drivers that held a restricted driver's license ($p < 0.001$).⁸

Finally, Bui et al. examined changes in the frequency, risk, and/or severity of vehicle incidents among emergency service workers in the United States.²³ This review scored fairly low on the quality appraisal but found that GDL for this population was estimated to reduce overall road traffic incidents by 50%.²³ Although the quality of this article is weak, its general findings (positive effect of graduated driver's licensing) is consistent with other reviews that assessed similar interventions and scored higher on the quality appraisal.

Seatbelt Use Policies

Two reviews examined the effect of seatbelt use legislation on negative road safety outcomes.^{8,22} Legislation mandating the use of seatbelts among drivers and passengers of motor vehicles were found to be effective at preventing MVC, injuries, and the severity of injuries.

Azami-Aghdash et al. found that mandating seatbelt use in Iran led to a reduced number and severity of MVCs by 9.7% [95% CI = 9.6, 9.9] and 11.4% [95% CI = 11.3, 11.6] in the first and second years respectively, post legislation.⁸ Staton et al. focused its review among the general population in low and middle-income countries and evaluated the effects of mandatory seatbelt legislation when combined with helmet and mobile phone use legislation.²² The authors reported that this legislation led to a 17.7% to 33.0% reduction in emergency department visits related to MVCs.²² The average length of hospitalizations also decreased by 14.7%.²²

Occupational-Specific Policies

There were two systematic reviews that examined the effectiveness of occupational-specific policies on road safety outcomes.^{11,23} Each review examined several interventions; however, both were found to be associated with a decreased collision incidence among employees.

Since crash risk is generally elevated when emergency service workers perform a response protocol, Bui et al. examined policies to modify these protocols and found that reducing the use of unnecessary emergency lights and sirens resulted in a 10-78% crash reduction among fire service responders.²³ Lefio, et al. examined the effect of compliance reviews in the freight and shipping industry on negative road safety outcomes.¹¹ The authors found that on average, the number of collisions increased by 19.2% (95% CI = [13.3, 25.1]) annually until the compliance review was introduced among truck drivers.¹¹

Discussion and Conclusions

The aim of this evidence brief was to summarize the existing scientific evidence on the effectiveness of enforcement policies on reducing negative road safety outcomes. A number of policies were evaluated in the included reviews from speed reduction and alcohol policies, to helmet legislation for both motorcycle and bicycle use. Some reviews; however, included several strategies which presented difficulty in summarizing results by policy type.

Overall, the majority of reviews included in this brief report a reduction of negative road safety outcomes with the implementation of enforcement strategies. Speed reduction, driver mobile phone use restrictions, BAC limits, sobriety checkpoints, universal helmet use, and specific occupational-related policies demonstrated reductions in average speed, MVCs, injury severity and fatalities.

Four of the six studies that examined speed reduction strategies demonstrated positive results on negative road safety outcomes. One review that examined several speed interventions reported that increased legislation on speed limits (i.e., lower limits and/or higher traffic violation fines) had no statistically significant effect on collision incidence;²² another review that scored low on the quality appraisal reported mixed results when implementing speed increases in the United States.¹⁷ One high quality study evaluated the effect of penalising mobile phone use while driving and the findings suggested that the intervention is effective at reducing mobile phone use while driving, as well as MVC-related fatalities.

Five of the seven reviews that examined the effect of alcohol policies on drink driving were found to have positive effects on reducing driver BAC, collision incidence, injuries, and fatalities. Two reviews scored low on the quality appraisal which included the review reporting conflicting results. This review reported that modification to the hours/days available for purchasing alcohol was associated with a reduced incidence of MVCs; however, the results presented did not support the authors' conclusion as a reduction in collision incidence was not always observed across studies. One of the higher scoring reviews examined the effect of increasing alcohol taxes but was unable to find conclusive evidence to support its effectiveness on preventing collisions. The study was able to support the effectiveness of the BAC policy as well as the implementation of sobriety checkpoints on preventing alcohol-related fatalities due to collisions.

Several articles examined the effect of helmet use legislation on negative road safety outcomes. The findings suggest that universal helmet laws are more effective than partial helmet laws at decreasing road traffic injuries and fatalities among motorcyclists. This is likely a result of increased helmet use among this population. Similar positive results were found when universal helmet laws were applied to cyclists. Results showed that cyclists experienced fewer and less severe collisions and a reduced incidence of head injuries once the legislation was implemented.

It was difficult to summarize the results of reviews reporting on the effectiveness of occupational-specific enforcement strategies on road safety. This was due to the number of interventions included in each review; however, both reviews report decreases in collision incidence among employees with implementation of enforcement strategies.

Implications for Practice

The results presented in this evidence brief are consistent across multiple reviews and the majority of results were reported from articles of moderate or strong quality. This enables practitioners to inform programs of public health for road safety with evidence on effective enforcement interventions available to reduce negative road safety outcomes. Speed reduction policies, alcohol consumption policies, and helmet use legislation provided the most significant evidence of a positive effect on decreasing MVCs, injuries, and/or fatalities. Although further research on certain enforcement strategies in occupational-specific interventions is warranted to support their implementation in various jurisdictions and among different populations, this brief provides a summary of evidence to support a program of public health in road safety. Motor vehicle collisions, injuries and fatalities can decrease if effective policies, supported by scientific evidence are applied in Ontario.

Strengths & Limitations

The purpose of this evidence brief was to investigate a research question in a timely manner to help inform decision making. The evidence brief presents key findings, based on a systematic search of the best available evidence near the time of publication, as well as systematic screening and extraction of the data from that evidence. It does not report the same level of detail as a full systematic review. Every attempt has been made to incorporate the highest level of evidence on the topic. There may be relevant individual studies that are not included; however, it is important to consider at the time of use of this brief whether individual studies would alter the conclusions drawn from the document.

There are several strengths to this review. First, this is the first summary of evidence on the effectiveness of enforcement strategies on collision outcomes. Practitioners in public health have cited the need for summaries of evidence to be used in a program of public health for road safety.⁴ Second, many of the studies included in this review scored high on the quality appraisal, thus increasing our confidence in reporting results. There are; however, limitations to this review. First, four studies scored low on the Health Evidence Quality Appraisal Tool. This was primarily due to the author's absence of completing quality appraisal, limiting our ability to determine methodological quality of the studies included. Further, of the reviews that reported the results of a quality appraisal, they most often were conducted by only one reviewer. Any discrepancies in the quality appraisal between two potential reviewers was; therefore, missed which may have resulted in an incorrect level of quality reported by the author(s). The four studies that scored weak on the quality appraisal were included in the findings of this evidence brief, but indicated as such. The findings of these studies were reviewed alongside with findings from similar, higher-quality studies in this brief to contribute to a fulsome understanding of the level and quality of evidence in this area.

Second, many of the included reviews did not consider study design in pooling or summarizing results. For instance, results of randomized controlled trials and cohort studies were often combined in several systematic reviews. This limits the ability to compare variability among individual study results. Third, there was a relatively small amount of literature on evaluating legislation specific to seat belt use. This is likely due to the time restrictions placed on our literature search (i.e., the last five years).

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