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Evidence Synthesis on Key Metrics for Enhanced Enforcement to Address Behavioral Risk Factors for Road Safety

Key Findings

- Increasing the dose of enforcement and ensuring sustained and highly intensive operations[1] generally improves road safety by reducing the occurrence of risky behaviors and improves safety.
- Speeding countermeasures drawing on negative reinforcement (such as high levels of detection) combined with public awareness campaigns are effective deterrent methods.[2]
- Recent and increased exposure to drink driving enforcement increases the perceived risk of detection for drink driving (such as high visibility random breath testing (RBT) checkpoints testing large volumes of drivers).[2]
- The following key metrics* for enhanced enforcement for each behavioral risk factor were identified:
  - Frequency/periodicity of enforcement, e.g., the number of breath tests performed per month during high alcohol hours (8pm to 4am).[1]
  - Visibility of the enforced activity/intervention, e.g., visibility of drink driving enforcement[2], combination of overt and covert[3] enforcement for speeding. (Note: the visibility of speed enforcement is unlikely to be an effective speed deterrent outside of the enforcement site.)[4]
  - Compliance with established standards, e.g., enforcing from as close to the speed limits as possible.[4]
  - Public perception, e.g., randomness and predictability of a drink driving checkpoint location, perceived awareness of speed enforcement activity, and perceived risk of being apprehended.[4,5]
  - Penalties issued, e.g., the number of demerit/penalty points/fines/citations issued for violation of a seat-belt law.[6]
  - Location of the enforced activity/intervention, e.g., random and unpredictable speed enforcement sites, as well as speed enforcement at specific high-risk intersections, school zones and/or crash hotspots.[3]
  - Trained police personnel/human resource (HR) capacity, e.g., availability of trained police officers to report fatal and serious injury crashes.[1]
- There are a lack of studies investigating enhanced enforcement for non-compliance of helmet use, compared with other behavioral risk factors (i.e., drink driving, non-compliance with seat-belt use, and speeding) related to road traffic injuries (RTIs). However, given the effectiveness of enhanced enforcement on other behavioral risk factors, it is likely that the same effect will be seen for helmet use.

Recommendations

- Implement enhanced enforcement efforts coordinated with targeted public awareness programs.[4]
- Conduct further research related to the key metrics for enhanced enforcement, such as:
  - the frequency of use of road safety enforcement techniques, such as penalties, checkpoints, and speed cameras that can ensure sustainable impact of the planned interventions.[3,4]
  - the impact of the amount of time spent by police officers on target roads and dosage (i.e., the volume of breath tests and speed infringements issued), particularly random breath testing during hours when alcohol consumption is likely higher. [1,4,7]
  - the impact of the visible and covert speed enforcement measures on perceived risk of being apprehended for speeding and actual speeding behavior.[3,4]
  - the context of application of the key metrics, such as the blood alcohol content (BAC) limit set across different countries, duration of the intervention, time of day (day versus night), and location of the specified intervention (an urban versus a rural setting), can inform road safety policy decisions tailored to the settings in which they are implemented.[1,2]

*In this report, 'key metrics' indicates those that broadly describe enhanced enforcement of interventions addressing behavioral risk factors for road traffic injuries.

The Problem

Accounting for over 50 million disabilities and 1.19 million annual fatalities worldwide[8], RTIs and fatalities have recurrently been represented as a pandemic in several studies.[9-11] While RTIs are a significant public health concern for high-income countries (HICs) and low- and lower-middle-income countries (LMICs), road traffic fatalities are disproportionately higher in LMICs at 93%.[7,11] Behavioral risk factors, such as drink driving, non-compliance with seat-belt and helmet use, and speeding, have been directly attributed to a substantial surge in the severity of RTIs and related fatalities globally.[5,12,13] While enhanced enforcement measures have been implemented and found to be effective in preventing risky road behaviors in both HICs and LMICs, clarification about the meaning of 'enhanced enforcement' and key metrics to assess it are lacking.

What we already know

Below is a list of common enforcement techniques that have been employed to prevent risky road behaviors and/or RTIs. It is worth noting that the literature does not have any examples recommending enhanced enforcement for non- compliance with helmet use. However, it can be deduced that enhanced enforcement is likely to increase compliance with helmet use.

- Drink driving
  - Issuing citations for driving while intoxicated
  - Random breath testing and sobriety checkpoints for checking BAC levels conducted during high alcohol hours
  - Long-term and mandatory license suspension[5]
- Non-compliance with seat-belt use
  - Penalty point systems
  - Enforcement of primary law*, particularly in the United States (U.S.)
  - Issuing citations
- Speeding
  - Issuing citations
  - Speed cameras

*"Primary law, within the U.S. allows police officers to pull over a vehicle and issue a traffic citation if they observe an occupant not wearing a seat-belt."[12]

Aim of the Review

This review aimed to identify key metrics for enhanced enforcement of interventions targeting behavioral risk factors, including drink driving, non-compliance with seat-belt use, and speeding, that can be used to quantitatively measure the interventions' impact on road traffic fatalities and RTIs and further leverage the data to compare their effectiveness across geographies. There were very few studies that specifically used the term "enhanced enforcement" to suggest that there was an increase in either the deployed police force or the number of hours of routine checks. This review attempted to highlight those key examples to promote further deliberation on defining and distinguishing "enhanced enforcement."

This review included articles that discussed enhanced enforcement of interventions targeting road safety risk factors related to drink driving, non-compliance with seat-belt use, or speeding, or a combination of these, and evidence on the effectiveness of enhanced enforcement. Evidence on enhanced enforcement techniques were included, such as fines, citations, automated citations, traffic convictions, driver's license disqualifications, education, and awareness of risk factors and/or interventions (related to policing only), and enhanced policing. There was no limitation on the vehicle type or geography. This review excluded studies that were not in English, that included only educational or environmental interventions, or were opinion pieces.

Summary of Evidence

The majority (81%) of the studies focused on interventions to reduce RTIs associated with one type of behavioral risk factor (i.e., drink driving, non-compliance with seat-belt use, and speeding) as opposed to multiple behavioral risk factors. After careful analysis, categories of key enforcement metrics were identified, as illustrated in the table below.

Key metrics for enhanced enforcement for each high-risk road safety behaviors

KEY METRICS	KEY PARAMETERS (GENERAL†)	KEY PARAMETERS FOR DRINK DRIVING	KEY PARAMETERS FOR SEAT-BELT USE	KEY PARAMETERS FOR SPEEDING
Frequency/ periodicity of enforcement	Frequency of enforcement checkpoints (per week/ per month)	The number of breath tests performed per month and the subsequent number of drivers apprehended	Frequency of observations in a day for seat-belt compliance	1. On-view stopping of offenders (i.e., stopping every 6th/25th/100th offender) 2. Frequency of speed measurements in a day
	Periodicity of the enforcement activity (e.g., duration of the operations at the checkpoint sites)	The randomness and intensity of testing	Number of months the trained observers were active (i.e., length of the seat-belt violation observations)	1. Amount of time spent by police officers on target roads 2. Periodicity/length of the presence of speeding warning signs 3. Amount of enforcement sites

†In this report, 'key parameters (general)' are those that provide specific details on enhanced enforcement of interventions addressing behavioral risk factors for road traffic injuries. However, these are generic parameters and are not specific to any behavioral risk factor.

KEY METRICS	KEY PARAMETERS (GENERAL†)	KEY PARAMETERS FOR DRINK DRIVING	KEY PARAMETERS FOR SEAT-BELT USE	KEY PARAMETERS FOR SPEEDING
Visibility of the enforced activity/ intervention	1. Number of high-visibility road checkpoints 2. Number of enforcement checkpoints-both overt and covert (for speeding)	Number of high-visibility random breath testing checkpoints at high traffic count road sites		Covert and overt speed enforcement
Compliance with established standards	Enforcement of established standards			Enforcing from as close to the speed limits as possible
Public perception	Number of repeated locations and timing for enforcement activities	1. Predictability of a checkpoint location/ the enforcement intervention 2. Increased public awareness level of drivers about the enforcement activity	Level of awareness among drivers of citations issued for traffic violations detected through camera enforcement	1. Perception among drivers of the probability of being apprehended due to hidden cameras or the risk of getting a ticket when speeding past a speed camera 2. Definition of the appropriate speed limit, especially on arterial and residential sites 3. Increased public awareness level of drivers about enforcement activity
Penalties issued	Issuance of citations/ fines	Increase in fines (higher penalties for higher BAC levels)	1. Issuance of penalties, e.g., for traffic citations/fines/ increase in fixed fines for violation of seat-belt law 2. Number of demerit/ penalty points applicable for violation of seat-belt law 3. Amount of fine issued for violation of seat-belt law	Amount of fine issued for mild to severe speeding offenses

KEY METRICS	KEY PARAMETERS (GENERAL†)	KEY PARAMETERS FOR DRINK DRIVING	KEY PARAMETERS FOR SEAT-BELT USE	KEY PARAMETERS FOR SPEEDING
Location of the enforced activity/ intervention	Locations including both: 1. Target sites (i.e., at high volume sites/ beltways/arterials/ crash hotspots) 2. Randomly chosen sites	Randomly chosen sites with operational differences in urban vs rural areas		1. Choice of specific target sites where camera operation is restricted (i.e., open roads/100 km/h speed limit roads) 2. Location of static police cars (i.e., at high volume sites/ residential streets/ arterials/freeways/ crash hotspots) 3. Random and unpredictable enforcement location
Trained police personnel/HR capacity	Number of trained police officers involved	Availability of trained police officers to conduct RBTs and to operate and report deviations using passive alcohol sensors		Availability of trained police officers specifically for reporting road collisions

Summary of evidence for each behavioral risk factor

I. Drink Driving

Geography - Studies were largely from the U.S. and Australia, followed by Europe, New Zealand, Spain, and Canada.

Types of Enhanced Enforcement

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Reducing the BAC legal limit	1. In Minnesota (U.S.), the recidivism rate for both first- time and repeat offenders with BAC levels ≥ 0.2% was lower in 1998 (6.7% vs. 7.3%) compared with 1997 (8% vs. 9%).[14] 2. First-time driving while intoxicated (DWI) offenders with BACs ≥ 0.2% exhibited recidivism rates that were approximately 1.5 percentage points lower compared with the "comparison" group of offenders with BACs ranging from 0.17% to 0.19%.[14] 3. By 1986, fatality and fatal crash rates in Oklahoma were about one-third lower than before the enactment of the Administrative per se law* in 1983.[15] 4. Reducing the maximum legal BAC limit from 0.08% to 0.05% in Australia decreased drink driving at BAC limits of above 0.15% by 41% and that of BAC limits between 0.10% and 0.15% by 90%.[16] **Law permitting automatic license revocation if a police officer was refused the right to administer a blood alcohol test of a suspected drunk driver.*	An estimated 947 lives could have been saved if the entire U.S. had enacted a BAC legal limit of 0.08%* in 2000.[17] **Of note, the current legal BAC limit in all states in the U.S. is 0.08%, except Utah which has a BAC limit of 0.05%.[18]*

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Random Breath Testing (RBT)	1. RBT that is highly publicized, highly visible, and used frequently can reduce fatal drink driving crashes by approximately 20%.[19] 2. In New South Wales, Australia, RBT reduced alcohol-related fatalities by 36% for more than four years.[20]	Allows for greater number of drivers to be tested (high volume testing), per hour of enforcement activity, therefore, allows for efficient use of resources. It is important to conduct RBTs during high alcohol use hours (e.g., 8pm to 4am).[1] The impact of RBT persists for at least two weeks.[1]
Sobriety checkpoints‡	States with at least monthly sobriety checks had 41% less self-reported drink driving. No significant association was found between having an open container law and drink driving. However, states that actively conducted open container enforcement, regardless of having a law, had 18% less instances of drink driving.[21]	Checkpoints can have fewer officers and be conducted for shorter periods of time while preserving effectiveness.[22,23] This is useful in low-resource settings and/or rural communities.[22] It is important to conduct checkpoints during high alcohol use hours (e.g., 8pm to 4am).[1]
Driving license revocation	As a result of the administrative per se law in Oklahoma (U.S.), there was roughly a 5% decrease in fatality and fatal crash rates during the nine-month period in 1983.[24]	

‡Random breath tests are more efficient compared to sobriety checkpoints since these tests are done randomly, whereas sobriety checkpoints require the police to establish that a driver is under the influence of alcohol before a breath test can be administered.[18]

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Breath analyzer ignition interlock* **Ignition interlock requires a breath sample with a BAC level under the legal limit, otherwise the vehicle will not start for a pre-designated time period, typically 30 minutes.*	Eighteen percent recidivism was observed for the interlock group compared with 25% for the non-interlock group. The non-interlock group was twice as likely to have another conviction within three years compared with the interlock group.[25]	
Combination of interventions		
a) Community-level (targeting specific populations) package of high-visibility interventions including random roadside driving under the influence (DUI)/sobriety checkpoints, saturation patrols, and undercover operations to reduce service of alcohol to intoxicated patrons in bars	These interventions resulted in about 310 fewer crashes in a three-year post-intervention period.[26]	When taking into consideration the cost of an alcohol-related crash and total cost of the interventions, the benefit-cost ratio was $27 for every $1 spent.[26]

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
b) Compulsory breath testing (CBT), zero alcohol tolerance for youth, media blitzes, and booze buses* **"CBT required two officers to take each driver who appeared to be over the limit by sniffer test to the police station where they performed evidentiary breath testing and processing before returning." This pulled officers away from checkpoints after catching a few drunk drivers, shutting down the checkpoints. In the "booze bus" initiative, police officers delivered drunk drivers to a "booze bus" where a dedicated team tested and processed them, freeing up officers to maintain checkpoints.*[27]	In New Zealand, there was nearly a 50% reduction in night-time serious and fatal crashes as a result of three key interventions: • CBT introduction and zero tolerance for youth - ~22% • Expanded media campaign - ~14% • Booze bus initiative - ~18%[27]	

II. Seat-belt Use

Geography - Studies were largely from the U.S., followed by Italy, Turkey, Vietnam, Canada, Australia, Israel, Finland, New Zealand, Kuwait, and the United Kingdom (U.K.).

Types of Enhanced Enforcement

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Primary enforcement versus secondary enforcement of laws* **"Primary law, within the U.S. allows police officers to pull over a vehicle and issue a traffic citation if they observe an occupant not wearing a seat-belt."* *"Secondary enforcement for seat- belt laws require law enforcement officers to have some other reason for stopping a vehicle before citing a driver or passenger for not using a seat-belt."*[27]	1. In the U.S., 47 states and the District of Columbia changed from secondary to primary enforcement resulted in the greatest average increase in seat-belt use—from 56% to 83%—between 1991 and 2003.[13] 2. Primary enforcement was associated with a 7% reduction in annual fatality rates of passenger vehicle drivers in one year.[13] 3. Another U.S.-based study found the change from secondary to primary seat-belt enforcement would prevent roughly 696 deaths per year.[28]	1. This intervention is less costly compared with other, less effective interventions, such as educational strategies.[29,30] 2. Incentives to enforce law on routine shifts, such as awards or grants for police officers, are useful, particularly in rural areas, to encourage higher prioritization of seat-belt use enforcement.[31]
Combination of interventions		
Demerit points system, in combination with a media campaign	In Italy, there was a significant increase in seat-belt use of 52% among drivers, 42% among front-seat passengers, and 121% among rear-seat passengers, after one year of implementation.[6]	

III. Speeding

Geography - Studies were largely from the U.S. and the U.K., followed by Norway, Iran, Thailand, New Zealand, Spain, Belgium, Australia, Canada, Hong Kong, Saudi Arabia, and the Netherlands.

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Checkpoints – stopping every 6th offender	Enforcing checkpoints at a higher intensity level (stopping every 6th offender rather than every 25th) resulted in a reduction of 3.5 km/h in the average driving speed, and its perceived probability impacted drivers' behavior in the Netherlands (in 1993).[32]	Increasing the intensity level of speeding checkpoints is more effective in reducing speed than maintaining enforcement activities at a constant, low level.[32] It is important to include both overt and covert speed enforcement to reduce the "kangaroo effect"[§].
Automated enforcement: Speed cameras	1. In Australia, high levels of speed camera ticketing were associated with a statistically significant reduction (41%) of fatal crash outcomes.[33] 2. At camera sites in England, crashes decreased by 19% and fatal and serious crashes decreased by 44% (1998-2001).[34]	1. These effects are higher at speed camera zones and less effective further away due to limitations of the "halo effect," wherein a camera only influences behavior for a certain distance before drivers resume their previous speeding pattern. Thus, there is a need to install more speed cameras to offset this.[35,36] 2. Covert camera systems with immediate feedback are more effective than overt ones.[37]
Automated enforcement: Automated section speed control *(Also called average speed enforcement, time over distance cameras, trajectory control, and point-to-point speed enforcement, this mechanism measures the average speed over a designated section of a road.)*	1. In Belgium, average speed decreased by 5.8 km/h.[38] 2. In Saudi Arabia, average speed reduced by 15 km/h at camera position.[39]	There are limitations to this intervention due to the "halo effect."[35,39]
Automated enforcement: Automated photo enforcement	In the U.S., this was effective in school zones, resulting in a decrease in motorist speeding and a reduced rate of speeding violations by roughly 50%.[40]	

[§]The kangaroo effect describes drivers who slow on seeing visible speed enforcement and then speed up after passing visible enforcement.

INTERVENTIONS	EVIDENCE OF EFFECTIVENESS	CONSIDERATIONS FOR IMPLEMENTATION
Automated enforcement: Automated speed control cameras on an arterial road within the city	After six months of implementation in Khon Kaen City, Thailand, average vehicle speed reduced by 10%, while traffic crashes decreased by 6% and vehicle fatalities decreased by 34%.[41]	In developing cities and LMICs, low rates of enforcement arise from factors such as resource constraints. The positive impacts from this intervention in Khon Kaen City suggest the feasibility of using automated speed control cameras in such settings.[41]
Presence of police	When assessing enforcement methods in the capital and a small city within Saudi Arabia, the presence of state police cars was associated with a reduction of 10 km/h in average speed.[39]	

IV. Multiple Risk Factors

Geography - Studies were largely from Australia, World Health Organization, Sub-Saharan Africa and Southeast Asia regions, and Israel, followed by the U.S., China, Uganda, Thailand, Latin America, the Caribbean, the Middle East, Asia, Norway, Iran, Greece, and Kuwait.

RISK FACTORS	INTERVENTIONS	EVIDENCE OF EFFECTIVENESS
Drink driving and seat-belt use	Highly publicized law enforcement programs including: passive alcohol sensors, checkpoints, and seat-belt use observations.[42]	Highly publicized law enforcement programs significantly reduced injury-causing crashes (by 24%) and late-night crashes (by 23%).[42]
Drink driving, seat-belt use, speeding	The Random Road Watch traffic policing program in Queensland, Australia used an explicit resource management technique to randomly schedule police enforcement.[43]	The Random Road Watch traffic policing program resulted in a 15% decrease in fatal crashes. The program was cost effective with benefit-cost ratio of $55 (Australian dollar) for every $1 spent.[43]

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