Report #23-U0-130

NSTSCE

National Surface Transportation Safety Center for Excellence

Koper Curve Principle for Commercial Motor Vehicle (CMV) Traffic Enforcement

Stephanie Baker • Tammy Trimble

Submitted: August 15, 2023

Technology Impairment Mobility Infrastructure

Housed at the Virginia Tech Transportation Institute
3500 Transportation Research Plaza • Blacksburg, Virginia 24061

ACKNOWLEDGMENTS

The authors of this report would like to acknowledge the support of the stakeholders of the National Surface Transportation Safety Center for Excellence (NSTSCE): Zac Doerzaph from the Virginia Tech Transportation Institute; John Capp from General Motors Corporation; Terri Hallquist from the Federal Motor Carrier Safety Administration; Mike Fontaine from the Virginia Department of Transportation and the Virginia Transportation Research Council; and Melissa Miles from State Farm Insurance.

The NSTSCE stakeholders have jointly funded this research for the purpose of developing and disseminating advanced transportation safety techniques and innovations.

EXECUTIVE SUMMARY

With the goal of better understanding how to reduce commercial motor vehicle (CMV) crashes, a literature review was conducted to explore whether the "Koper Curve principle" has ever been applied to efforts aimed at reducing CMV crashes, and if so, how it was applied. In conducting the literature review, several related domains (deterrence, evidence-based policing, and high-visibility enforcement) were also considered as they apply to the use of the Koper Curve for CMV crash reduction. The literature related to the Koper Curve focused primarily on crime deterrence (e.g., robbery), not crash reduction. The literature review revealed one ongoing study that is using the Koper Curve principle toward the goal of reducing CMV crashes on specific interstate corridors (Kentucky Research Center, 2023). Two examples, from Nashville, Tennessee, and São Paulo, Brazil, showed the Koper Curve being applied to crash reduction more generally (not specific to CMVs), which may inform how the Koper Curve could be used to reduce CMV crashes.

BEST PRACTICES AND KEY TAKEAWAYS

The literature provided a few best practices and key takeaways that may be helpful to practitioners seeking to reduce crashes in high-risk corridors.

- **Use data to target behaviors leading to crashes:** The literature showed how data can be used to determine the causes of the crashes along certain roadways so that specific behavior can be targeted with high-visibility enforcement (HVE). In Nashville, these behaviors were targeted during enforcement efforts (e.g., officers focused on behaviors causing crashes such as following too closely), while in São Paolo data was used to target places (e.g., bars) and associated activities (e.g., drinking) where crashes were originating.

- **Use data to identify hot spots where crashes are occurring:** The literature showed the importance of data analysis to identify "hot spots" where crashes occur. In the Nashville study, the hot spots were roadway segments that were experiencing high crash rates. In the São Paolo study, the hot spots were where people were drinking before driving. Identifying with data where crashes occur (or in the case of São Paolo, where they originate) can help police target enforcement and save lives. The Nashville study also touched on the use of temporal analysis to identify the times when crashes were occurring (i.e., hours leading up to the evening rush hour). It is interesting to note the overlap of these two examples with the National Highway Traffic Safety Administration's HVE Toolkit described.

- **Provide instruction to officers on how to conduct HVE:** The authors of the Nashville study reported that officers were instructed to identify and conduct enforcement on the target behaviors that the data had revealed were leading to crashes. The study that is underway in Kentucky is described as providing training for enforcement on the method being used.

- **Evaluate the enforcement effort:** Both studies reviewed (Nashville and São Paolo) discussed the importance of ongoing evaluation to determine program effectiveness.

GAPS AND FUTURE RESEARCH

The primary gap discovered is that the Koper Curve is rarely used in studies dealing with crash reduction. It is typically an approach used as part of a strategy to deter crime in communities. More studies that use the Koper Curve to target areas where CMV crashes are occurring would be needed to determine if it is a useful approach for crash reduction. The literature review did identify an ongoing study (Kentucky Research Center, 2023) looking specifically at the use of the Koper Curve approach to reduce CMV crashes. The results of the study should help shed light on whether the Koper Curve is a useful approach to reducing CMV crashes on high-risk corridors. The study is documented as ending on September 30, 2023, and should be consulted by future researchers considering studies using the Koper Curve for CMV crash reduction.

Another gap in the literature was the dosage needed for the Koper Curve for crash reduction. Koper found that "the optimal length for police presence is about 14 to 15 minutes" (1995). Neither the Nashville study nor the São Paolo study used this dosage. For example, in the first Nashville experiment, the dosage applied in target areas was "two days a week for two hours each day, every three weeks" (Williams, 2020). In the São Paolo study, it is unclear how long the visits were at the locations targeted; the authors only stated that visits were "short, periodic, and non-punitive" (Sloan et al., 2020). It may be that alternative dosages of police presence are needed for crash reduction in corridors, but studies are needed to determine if the Koper Curve dosage of police presence should remain at 14–15 minutes or if it needs to be different for crash reduction.

The literature noting the use of the Koper Curve for crash reduction varied in their definitions of a hot spot. In the Nashville study, hot spots were areas where the data indicated that fatal crashes were occurring and the times they were occurring (Williams, 2020). In the São Paolo study, officers focused their efforts on "places in which fatal crashes originate" (Sloan et al., 2020), in this case bars where people may drink before driving. Clearly defining what "hot spot" means for CMV crash reduction will be important for future studies.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS AND SYMBOLS

ASEBP	American Society of Evidence-Based Policing
BIRGS	Bloomberg Philanthropies Initiative for Global Road Safety
CEBCP	Center for Evidence-Based Crime Policy
CMV	commercial motor vehicle
DUI	driving under the influence
FMCSA	Federal Motor Carrier Safety Administration
HVE	high-visibility enforcement
KTC	Kentucky Transportation Center
NHTSA	National Highway Traffic Safety Administration
NIJ	National Institutes of Justice
NSTSCE	National Surface Transportation Safety Center for Excellence
PMESP	Military Police of São Paulo State

CHAPTER 1. INTRODUCTION

BACKGROUND

Federal Motor Carrier Safety Administration (FMCSA) crash statistics indicate that rural areas, interstate highways, and work zones are problem areas, or "hot spots," where fatal crashes involving large trucks are more likely to occur. In 2020, approximately 54% of large truck crashes occurred in rural areas, 27% on interstate highways, and 13% on rural interstate highways (FMCSA, 2023). Additionally, large trucks were involved in 26% of work-zone crashes and 15% of work-zone injury crashes.

Crash statistics also show that there are "hot times," as well as hot spots, for crashes. In 2020, 37% of all fatal crashes, 24% of all injury crashes, and 20% of all property-damage-only crashes occur between 6:00 p.m. and 6:00 a.m. (FMCSA, 2023). Eighty-two percent of truck-involved fatal crashes and 87% of truck-involved non-fatal crashes happened on the weekdays (Monday through Friday).

National Surface Transportation Safety Center for Excellence (NSTSCE) researchers have looked at commercial motor vehicle (CMV) crash risk by time of day and have also found windows of time when crashes peak. Camden et al. (2020) assessed CMV crash risk using carrier-owned crash and electronic logging device data. More specifically, their study used the Hours-of-Service Rules Impact Analysis dataset "to evaluate crash risk as a function of time of day (in hour bins), daytime vs. nighttime, and morning rush hour vs. evening rush hour." Results showed that "crash rates for overall, preventable, injury, and fatal crashes were highest in the early morning hours between 4:00 a.m. and 6:00 a.m. Additionally, overall crash rates were significantly higher at 6:00 a.m. and 11:00 p.m., compared to several other hours" (Camden et al., 2020).

Given such data, transportation safety research has recently been placing more emphasis on strategies to mitigate hot spot crashes across all vehicle classes. One potential solution is to apply the Koper Curve principle from law enforcement, which postulates that with an optimal dosage of police presence at hot spot locations, police can improve their efforts at deterring crime in those locations (Koper, 1995).

OBJECTIVE

With the goal of better understanding how to reduce CMV crashes, a literature review was conducted to explore if the Koper Curve principle has been applied to reducing CMV crashes, and if so, how it was being applied.

APPROACH

This review identified and summarized approaches and best practices related to the implementation of the Koper Curve principle to reducing CMV crashes in identified high-crash corridors. The literature revealed one ongoing study that is using the Koper Curve principle toward the goal of reducing CMV crashes on specific interstate corridors (Kentucky Research Center, 2023). A couple of examples show the Koper Curve being applied to crash reduction more generally (not specific to CMVs), which may inform how the Koper Curve could be used to reduce CMV crashes.

CHAPTER 2. METHODS

The review considered several related domains (deterrence, evidence-based policing, and high-visibility enforcement) as they apply to the use of the Koper Curve for CMV crash reduction. Each of these domains is briefly described. In lieu of finding literature on the reduction of CMV crashes, researchers tried to identify literature related to the use of the Koper Curve for crash reduction more broadly. Based on the literature findings, best practices, key takeaways, gaps in the literature, and possible future research are documented.

IDENTIFICATION OF STUDIES

The literature review was performed with a series of keyword searches using Google Scholar, the Virginia Tech Library database, and the Transportation Research International Documentation database. The review included published peer-reviewed research articles, scholarly books, and practitioner magazines and publications. The initial searches were conducted between February and March 2023. The keyword searches used to identify potentially relevant literature included the following:

- Koper curve AND vehicle crash reduction
- Koper curve AND evidence-based policing AND vehicle crash reduction*
- Koper curve AND high-visibility enforcement AND vehicle crash reduction*
- Koper curve AND psychological deterrence AND vehicle crash reduction*
- Koper curve AND traffic enforcement
- Koper curve AND interstate
- Koper curve AND traffic corridor
- Koper curve AND commercial motor vehicle

A few of the keyword searches, noted here with an asterisk, were not found in the Virginia Tech Library search and had to be done without including "vehicle crash reduction" in the search term. In these cases, for instance, the search was simply "Koper curve AND high-visibility enforcement." In April 2023, researchers performed an additional limited scan on Google of "Koper Curve AND Commercial Motor Vehicle Crashes" and "Koper Curve AND Motor Vehicle Crashes" and identified a couple of additional sources.

An Excel workbook was created of the abstracts identified during the search. Once abstracts were in the workbook, they were reviewed for relevance. If relevance was unclear based on the abstract, the full article or chapter was scanned. Over 70 abstracts or their equivalent (e.g., executive summaries) were reviewed, but few dealt with studies where the Koper Curve had been used for crash reduction in general, and none dealt with the use of the Koper Curve for CMV crash reduction. One source was identified that described an ongoing study looking at the use of the Koper Curve for CMV crash reduction (Kentucky Research Center, 2023). Most of the sources identified used the Koper Curve in relation to crime deterrence (e.g., robbery, gun violence, auto theft) not in relation to crash reduction along high-risk corridors.

It should be noted that a few abstracts were not accessible through the various databases. In those cases, the research team requested the source through Virginia Tech's Interlibrary Loan system. All but one was secured via this way. The article that was unavailable did not seem relevant based on the abstract, so no further attempt was made to obtain it.

CHAPTER 3. CONTEXT

The aim of the literature review was to identify and summarize approaches and best practices related to the implementation of the Koper Curve principle to reducing crashes, especially CMV crashes, in identified high-crash corridors. The review considered several related domains (evidence-based policing, high-visibility enforcement [HVE], and deterrence) as they apply to the use of the Koper Curve for crash reduction. The Koper Curve and each of these related domains is described here.

KOPER CURVE

The "Koper Curve" principle is named after Christopher Koper, a professor in the Department of Criminology, Law and Society at George Mason University and the Principal Fellow of George Mason's Center for Evidence-Based Crime Policy (CEBCP). Koper assessed data from a 1-year study in Minneapolis looking at high-crime locations and found that "police can maximize crime and disorder reduction at hot spots by making proactive, medium-length stops at these locations on a random, intermittent basis" (1995). This length of time in a hot spot led to "significantly more residual deterrence than is generated by simply driving through a hot spot." The optimal dosage of police presence was found to be about 14–15 minutes. After that timeframe, the incremental benefit of police presence appeared to lessen. By finding an optimal dosage of presence, which came to be known as the Koper Curve principle, "police can maximize deterrence and perhaps minimize the amount of unnecessary time spent at hot spots."

The focus of Koper's study was on crime reduction, not crash reduction. Hot spots were operationalized as "a cluster of addresses which together produced 20 or more hard crime calls (e.g., robbery, rape, burglary) and 20 or more soft crime calls (e.g., disturbances, prostitution)" over the study period (Koper, 1995). The hot spots were in public areas and had boundaries such as not being longer than a standard linear street block. This type of hot spot definition is different from what would be needed for CMV crash reduction in high-risk corridors.

DETERRENCE

The Koper Curve is an approach that applies police presence at hot spots to deter crime. Koper, as mentioned earlier, found an optimal dosage of police presence that can reduce or deter crime and disorder at hot spots (1995). Deterrence is described by the National Institute of Justice (NIJ) as "the crime prevention effects of the threat of punishment – a theory of choice in which individuals balance the benefits and costs of crime" (2016). The NIJ goes on to discuss how police deter criminal behavior when they cause someone to believe they are more likely to be caught and punished. They describe how "strategies that use the police as 'sentinels,' such as hot spots policing, are particularly effective."

The National Policing Institute discusses deterrence in relation to the use of the Koper Curve and provides guidance to law enforcement agencies about the Koper Curve in a one-page guidance, "5 Things You Need to Know about Hot Spots Policing & the 'Koper Curve' Theory" (2015). The Koper Curve is explained as a tool to maximize and extend deterrence. The guidance sheet states that the Koper Curve "suggests that random 10–15-minute patrols at least every two hours in hot spots optimized deterrence."

EVIDENCE-BASED POLICING

The American Society of Evidence-Based Policing (ASEBP) discusses the concept of evidence-based policing and how scientific evidence should be used to guide and evaluate how policing is done: “By rigorously studying everything we do, we can more accurately determine what works, what does not, and what is promising when it comes to our core functions of preventing crime and disorder” (2023).

The ASEBP alludes to the Koper Curve principle by noting that studies have shown if an officer is put at a hot spot, defined as a “micro-place where crime is greatest,” for 15 minutes that there will be a residual deterrent effect on crime (2023). They describe how using data to inform the location of hot spots can help police allocate resources wisely. Even though the Koper Curve is not specifically called out, this approach is being shared as an aspect of evidence-based policing.

HIGH-VISIBILITY ENFORCEMENT

HVE is another concept that overlays the Koper Curve in that it is a “strategy that focuses on police presence in a hot spot” (College of Policing, 2023). The National Highway Traffic Safety Administration (NHTSA, n.d.) in their HVE Toolkit discusses HVE in relation to traffic safety. NHTSA defines HVE as “a universal traffic safety approach designed to create deterrence and change unlawful traffic behaviors. HVE combines highly visible and proactive law enforcement targeting a specific traffic safety issue. Law enforcement efforts are combined with visibility elements and a publicity strategy to educate the public and promote voluntary compliance with the law.”

NHTSA’s HVE Toolkit touches on patrol presence. It suggests the use of waves, specifically “increased enforcement of a specific traffic violation in a targeted location for a short period of time that occurs periodically” (NHTSA, n.d.). The toolkit provides two examples of how these waves could be implemented: speed enforcement waves and DWI waves. In speed enforcement waves, patrols are conducted several times a month for a few hours and occur immediately after rush hour when motorists are attempting to make up lost time due to traffic congestion. In DWI waves, patrols are conducted two weekends in one month from 10 p.m. to 2 a.m. DWI waves can also target special events such as festivals or sporting events.

While the patrol presence periods (e.g., a few hours several times a month after rush hour) are different than the Koper Curve suggestion (i.e., 14–15-minute stops on a random, intermittent basis), the guidance is worth noting. Police presence to deter unsafe driving behaviors may be different than the police presence needed to deter the types of crimes (e.g., robbery) that Koper referred to in his study. Yet the goal is the same, to deter crime or, in this case, unsafe driving behaviors. As the NHTSA Toolkit states, “the goal of HVE is to make the motoring public aware of your enforcement efforts and create deterrence” (n.d.).

CHAPTER 4. FINDINGS

Through this literature review, researchers looked at sources to see how the Koper Curve was defined, the mention of related theories of interest such as evidence-based policing and HVE, and how the Koper Curve was being applied to crash reduction in corridors. Best practices and key takeaways for law enforcement related to the Koper Curve were also considered, as well as gaps in the literature where future research may be needed.

None of the sources reviewed were specific to the application of the Koper Curve to the reduction of CMV crashes on high-risk corridors. Yet, researchers did find reference to a study that is underway (i.e., active July 1, 2021–September 30, 2023). The study is being conducted by Jennifer Walton and David Leddy of the Kentucky Transportation Center (KTC). The grant description is in line with the focus of this literature review: the application of the Koper Curve to CMV crash reduction. This study should be very helpful in understanding if the use of the Koper Curve approach helps reduce CMV crashes on interstate corridors. The description of the proposed study reads:

> ***Abstract RSF 114, Koper Curve Philosophy:*** *The Kentucky Transportation Cabinet and the Kentucky State Police are partnering with the Kentucky Transportation Center to study the effects and reliability of a national enforcement model called the "Koper Curve" theory. The goal of this method is to create the perception of a significant enforcement presence by utilizing short bursts of roving patrols. The goal of the project is to reduce commercial motor vehicle crashes on specific interstate corridors. KTC will assist KSP with training enforcement on this method and will help to prepare an activity sheet for officers to track their activity. KTC will analyze crash and inspection data against the activity sheets and prepare a final report summarizing the benefits of this type of enforcement* (Kentucky Research Center, 2023).

Most of the studies found through the literature review involved the Koper Curve being applied to deter crime. The literature review also identified a few studies that mentioned the Koper Curve and crash reduction more generally. One study was from Nashville, Tennessee, and the other from São Paolo, Brazil. A summary of each study and the key takeaways follows.

METRO NASHVILLE POLICE DEPARTMENT

The Metro Nashville Police Department was "struggling with high numbers of motor vehicle crashes that were straining limited resources" (Williams, 2020). To address the issue, the Department used traffic crash data to develop a plan to reduce crashes in target areas. Two HVE interventions were conducted in 2017 and 2019 with the goal of reducing "harms associated with crashes and improving policing outcomes."

In Experiment 1, the pilot, crash data was used to identify hot spots (roadway segment) and times where crashes were happening and HVE would be targeted. For instance, "temporal analysis showed that crashes were more likely in the hours leading up to the evening rush hour" (Williams, 2020). The department also used data to assess the factors that were contributing to the crashes. The contributing factors included following too closely and failing to maintain the lane, which were believed to be potentially caused by driver distractions, as well as speeding (Williams, 2020).

The department combined HVE with the Koper Curve approach. Williams stated that “based on the previous identification of corridors with high numbers of crashes and the associated temporal analysis, the Koper method was applied to target the driving behaviors associated with crashes” (2020). The study did not use the 15-minute dosage suggested in the Koper study. Instead, the “HVE plan hypothesized that enforcement ‘waves’ could have an ideal dosage to reduce crashes.” The optimal dosage of enforcement in the target areas was determined to be “two days a week for two hours each day, every three weeks.”

During HVE, officers were “given specific instructions to seek out and enforce only those violations that correlated to the contributing factors discovered in the data analysis” (Williams, 2020). The pilot experiment resulted in a 33% reduction in crashes over the 3-month intervention period, which was posited to correlate to a decrease of more than 26 man-hours per month in time spent on crashes.

Experiment 2 was an expansion of the original pilot and approach. As in the pilot, hot-spot areas were identified along roadway segments. The dosage schedule was expanded to cover 6 weeks at these hot spots (Williams, 2020).

The larger experiment differed from the pilot in a few ways. One key difference was that “specific contributing factors for each hot spot were not examined” and instead “officers were asked to focus on the same violations across every hot spot” (Williams, 2020). These violations were the same as in Experiment 1. Another difference was that Experiment 1 focused enforcement waves at times when violations were highest, while Experiment 2 had waves occurring over different time periods since data analysis had shown that over the larger study area “crash likelihood spanned several hours.”

The results of Experiment 2 were mixed. Overall, there was a 22.56% reduction in crashes, yet crash reduction varied by hot spot, and in one location crashes increased over the study period (Williams, 2020). The author notes that the location where crashes increased had particularly challenging roadway characteristics for enforcement (i.e., narrow, congested). The researchers stated that “mixed results point to the reality that not all hot spots are the same and that targeted enforcement based on the specific characteristics of each hot spot is more effective in curtailing motor vehicle incidents.”

The Metro Nashville Police Department used data to determine the locations, times, and types of behaviors that were leading to crashes and then applied HVE waves to those target areas. The authors stated that moving forward, “we hope to institutionalize the practice of data analysis, HVE waves in hot spots, and evaluation so we can proactively impact driving behaviors in the city” (Williams, 2020). They go on to summarize that “the best outcomes in traffic enforcement can be seen when you make traffic stops in the right places, at the right times, and for the right reasons.”

One aspect of the study that may need to be researched further was the dosage of HVE being applied to reduce crashes in the hot spots. The study did not implement the Koper Curve dosage (i.e., 14–15-minute stops on a random, intermittent basis). For instance, in Experiment 1, the optimal dosage of HVE was "two days a week for two hours each day, every three weeks" (Williams, 2020). Further research could be done on what the ideal dosage of enforcement should be for HVE on high-crash corridors.

SÃO PAULO, BRAZIL

The Bloomberg Philanthropies Initiative for Global Road Safety (BIRGS) reports that "nearly 90 percent of the 1.35 million annual traffic-related deaths are concentrated in low- and middle-income countries" (Sloan et al., 2020). The Military Police of São Paulo State (PMESP) has been working with the International Association of Chiefs of Police and BIRGS to use evidence-based policing practices to reduce fatal crashes and injuries in São Paulo, Brazil, where there was an increase between 2006 and 2019 in vehicles on the roadway "accompanied by a large number of traffic fatalities" (Sloan et al., 2020).

The PMESP has faced the challenge of "understanding the causal factors contributing to traffic fatalities in their jurisdiction" (Sloan et al., 2020). In 2019, the PMESP updated their crash reporting forms to include possible causes of fatal crashes so that police can "proactively focus their law enforcement efforts on places and associated activities where fatal crashes originate, not just where they end." This included focusing on "known areas of alcohol consumption (e.g., roadways with a high concentration of bars) as well as conducting checkpoints to detect drivers operating vehicles under the influence of alcohol."

Through the Educational Initiative on Safe Driving, officers from PMESP visit bars and restaurants to "raise awareness of the risks associated with driving under the influence (DUI) of alcohol" (Sloan et al., 2020). PMESP officers share information on the dangers and legal consequences of drinking and driving and offer people a passive breathalyzer test to inform them if their blood alcohol content is above the legal limit. This education is done in tandem with DUI checkpoints near the locations (e.g., bars) where the educational program is conducted, and Sloan et al. describe how "supplementing educational initiatives with enforcement is critical to enhancing the deterrent effect."

This approach is described as a usage of the Koper Curve method of hot-spot patrolling. Sloan et al. (2020) explain "this strategy is grounded in research showing that short, periodic, non-punitive visits, intended to leave reverberating impact in target areas (i.e., hot spots), are an effective and efficient means of controlling crime and disorder." The hot spots in this instance are places (e.g., bars) and associated behaviors (i.e., drinking) where fatal crashes originate. The article did not state the time dosage at these hot spots, only that they were short visits.

The PMESP supplements these efforts with social media for community outreach and engagement with the idea that drawing attention to "successful enforcement operations" can "help enhance deterrent effects" (Sloan et al., 2020). The PMESP also has a motorcycle safety education program that educates motorcyclists on safety issues (e.g., utilizing proper braking techniques) while also alerting them to equipment violations. These combined education and enforcement activities are "intended to strengthen perceptions of officer presence and targeted enforcement activity, which deters community members from engaging in unsafe driving habits associated with serious and fatal vehicle crashes."

The authors report that these initiatives (i.e., non-punitive interactions combined with enforcement operations) have led to a decrease in traffic deaths (Sloan et al., 2020). Johns Hopkins University also conducted a study and observed “a gradual decrease in the number of drunk drivers on São Paulo’s roadways from 2015-2019” (Sloan et al., 2020). The PMESP plans to monitor and evaluate the “effectiveness of these interventions in reducing traffic fatalities” with the hope of conducting them in other areas to reduce crashes and save lives.

While the authors described aspects of this initiative as being based on the Koper Curve, some key aspects of the Koper Curve approach are missing. There is no mention of dosage time (i.e., 14–15 minutes) other than “short” visits, and the hot spots are not locations where crashes are occurring but locations determined to be areas where people engage in behaviors that lead to fatal crashes (i.e., a bar where someone may drink before driving).

Though the study did not use the Koper Curve approach to target hot spots where crashes are occurring, the initiative may be interesting to consider for future CMV studies since it was shown to result in a reduction in fatalities and drunk drivers. For instance, studies could consider conducting social media campaigns and/or educational programs to alert CMV drivers to the specific types of crashes or risk factors leading to crashes prior to locations where data shows those crashes are occurring. For instance, a truck stop located ahead of a high-crash corridor could be targeted for safety messaging or short-term educational programming about the causes of CMV crashes in the upcoming high-risk corridor.

Light vehicle drivers could also be informed about specific causes of CMV crashes along corridors they are traveling and how to safely share the road with CMVs in those locations through social media campaigns in nearby communities or at rest areas ahead of such corridors. NSTSCE researchers currently conduct educational outreach programming on how to Share the Road with Trucks, primarily with novice drivers, to inform students about behaviors that lead to CMV crashes (e.g., cutting off trucks, driving in truck blind spots). More focused educational programming and/or social media campaigns could be conducted in communities near high-crash corridors informing people who may regularly drive in those areas about the causes of the CMV crashes in the corridor and how to avoid such crashes.

These educational and outreach efforts could be conducted in tandem with targeted enforcement of the behaviors that are leading to CMV crashes in high-risk corridors.

CHAPTER 5. CONCLUSIONS

There were only a few examples found in this literature review of the Koper Curve being used to reduce crashes, and no examples were found of it being used to reduce CMV crashes. The literature found related to the Koper Curve focused primarily on crime deterrence (e.g., robbery), not traffic crashes. This finding supports a statement by Corsaro et al. (2012) that "research within criminology and criminal justice has provided scarce attention regarding the impact of police-driven strategies to reduce the harms associated with traffic crashes, despite the obvious role of criminal justice officials in regulating traffic patterns." However, the literature review did reveal a few key takeaways, as well as gaps that could be explored through future research.

KEY TAKEAWAYS

The literature provided a few best practices and key takeaways that may be helpful to practitioners seeking to reduce crashes in high-risk corridors.

- **Use data to target behaviors leading to crashes:** The literature showed how data can be used to determine the causes of the crashes along certain roadways so that specific behavior can be targeted with HVE efforts. In Nashville, these behaviors were targeted during enforcement efforts (e.g., officers focused on behaviors causing crashes such as following too closely), while in São Paolo data was used to target places (e.g., bars) and associated activities (e.g., drinking) where crashes were originating.

- **Use data to identify hot spots where crashes are occurring:** The literature showed the importance of data analysis to identify "hot spots" where crashes occur. In the Nashville study, the hot spots were roadway segments that were experiencing high crash rates. In the São Paolo study, the hot spots were where people were drinking before driving. Identifying with data where crashes occur (or in the case of São Paolo, where they originate) can help police target enforcement and save lives. The Nashville study also touched on the use of temporal analysis to identify the times when crashes were occurring (i.e., hours leading up to the evening rush hour). It is interesting to note the overlap of these two examples with NHTSA's HVE Toolkit described earlier in the literature review.

- **Provide instruction to officers on how to conduct the HVE:** The authors of the Nashville study reported that officers were instructed to identify and conduct enforcement on the target behaviors that the data had revealed were leading to crashes. The study that is underway in Kentucky is described as providing training for enforcement on the method being used.

- **Evaluate the enforcement effort:** Both studies reviewed (Nashville and São Paolo) discussed the importance of ongoing evaluation to determine program effectiveness.

GAPS AND FUTURE RESEARCH

The primary gap discovered through this literature review is that the Koper Curve is rarely used in studies dealing with crash reduction. It is typically an approach used as part of a strategy to deter crime in communities. More studies that use the Koper Curve to target areas where CMV crashes are occurring would be needed to determine if it is a useful approach for crash reduction. The literature review did identify an ongoing study (Kentucky Research Center, 2023) looking specifically at the use of the Koper Curve approach to reduce CMV crashes. The results of the study should help shed light on whether the Koper Curve is a useful approach to reducing CMV crashes on high-risk corridors. The study is documented as ending on September 30, 2023, and should be consulted by future researchers considering studies using the Koper Curve for CMV crash reduction.

Another gap in the literature was the dosage needed for the Koper Curve for crash reduction. Koper found that "the optimal length for police presence is about 14 to 15 minutes" (1995). Neither the Nashville study nor the São Paolo study used this dosage. For example, in the first Nashville experiment, the dosage applied in target areas was "two days a week for two hours each day, every three weeks" (Williams, 2020). In the São Paolo study, it is unclear how long the visits were at the locations targeted; the authors only stated that visits were "short, periodic, and non-punitive" (Sloan et al., 2020). It may be that alternative dosages of police presence are needed for crash reduction in corridors, but studies are needed to determine if the Koper Curve dosage of police presence should remain at 14–15 minutes or if it needs to be different for crash reduction.

The literature noting the use of the Koper Curve for crash reduction varied in the definition of a hot spot. In the Nashville study, hot spots were areas where the data indicated that fatal crashes were occurring and the times they were occurring (Williams, 2020). In the São Paolo study, officers focused their efforts on "places in which fatal crashes originate" (Sloan et al., 2020), in this case bars where people may drink before driving. Clearly defining what "hot spot" means for CMV crash reduction will be important for future studies.

REFERENCES

American Society of Evidence Based Policing. (2023). *What is EBP?* https://www.americansebp.org/what_is_ebp.php

Camden, M. C., Soccolich, S. A., Hickman, J. S., Rossi-Alvarez, A., & Hanowski, R. J. (2020). *Commercial motor vehicle crash risk by time of day*. National Surface Transportation Safety Center for Excellence. http://hdl.handle.net/10919/100876

College of Policing. (2023). *Hot spots policing.* https://www.college.police.uk/guidance/hot-spots-policing

Corsaro, N., Gerard, D. W., Engel, R. S., & Eck, J. E. (2012). Not by accident: An analytical approach to traffic crash harm reduction. *Journal of Criminal Justice*, *40*(6), 502-514.

Federal Motor Carrier Safety Administration. (2023, March). *Large truck and bus crash facts 2020*. https://www.fmcsa.dot.gov/safety/data-and-statistics/large-truck-and-bus-crash-facts-2020#A3

Kentucky Research Center. (2023). *RSF 114, Koper Curve philosophy grants and contacts details*. https://scholars.uky.edu/en/projects/rsf-114-koper-curve-philosophy

Koper, C. S. (1995). Just enough police presence: Reducing crime and disorderly behavior by optimizing patrol time in crime hot spots. *Justice Quarterly, 12*(4), 649-672

National Highway Traffic Safety Administration. (n.d.) *High visibility enforcement (HVE) toolkit*. https://www.nhtsa.gov/enforcement-justice-services/high-visibility-enforcement-hve-toolkit#:~:text=High%20Visibility%20Enforcement%20%28HVE%29%20is%20a%20universal%20traffic,public%20and%20promote%20voluntary%20compliance%20with%20the%20law.

National Institute of Justice. (2016). *Five things about deterrence*. https://nij.ojp.gov/topics/articles/five-things-about-deterrence#:~:text=Police%20deter%20crime%20by%20increasing%20the%20perception%20that,such%20as%20hot%20spots%20policing%2C%20are%20particularly%20effective.

National Policing Institute. (2015). *5 things you need to know about hot spots policing & the "Koper Curve" theory*. https://www.policinginstitute.org/publication/5-things-you-need-to-know-about-hot-spots-policing-the-koper-curve-theory/

Sloan, M., Clary, K., & Oliveria P. (2020, Fall). How police in Sao Paulo, Brazil, are using data and science to reduce fatal vehicle crashes. *Translational Criminology*, 10-12.

Williams, J. (2020). *Effect of high-visibility enforcement on motor vehicle crashes*. https://www.ojp.gov/pdffiles1/nij/254779.pdf