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RESEARCH ARTICLE

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The impact of a crash prevention program in a large law enforcement agency

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Abstract

Background: Motor vehicle crashes (MVCs) remain a leading cause of death for US law enforcement officers. One large agency implemented a crash prevention program with standard operating policy changes, increased training, and a marketing campaign. This was a scientific evaluation of that crash prevention program.

Methods: MVC and motor vehicle injury (MVI) data for law enforcement officers were compared using an autoregressive integrated moving average (ARIMA) model. Two law enforcement agencies who had not implemented a crash prevention program were controls.

Results: After program implementation, overall, MVC rates significantly decreased 14% from 2.2 MVCs per 100 000 miles driven to 1.9 ($P = .008$). MVC rates did not decrease in the control agencies. Overall, MVI rates significantly decreased 31% from 3.4 per 100 officers to 2.1 ($P = .0002$). MVC rates did not decrease in the control agencies. MVC rates for patrol officers significantly decreased 21% from 3.1 per 100 000 miles to 2.4. MVI rates for patrol officers significantly decreased 48% from 3.2 per 100 officers to 1.6 ($P < .0001$).

Conclusions: Crash and injury rates can be reduced after implementation of a crash prevention program and the largest impacts were seen in patrol officers.

KEYWORDS
ARIMA, evaluation, law enforcement, motor vehicle crash

1 | INTRODUCTION

Motor vehicle traffic crashes (MVCs) are the leading cause of work-related death in the US. According to the most recent data from the Bureau of Labor Statistics' Census of Fatal Occupational Injuries (CFOI), transportation incidents have increased to 40% of all work-related fatalities (US Bureau of Labor Statistics, 2016).[1] To mitigate occupational driving deaths, many employers have implemented workplace programs and policies. Strategies include increasing employee seat belt use through the use of incentives and providing drivers feedback using in-vehicle monitoring systems.[2,3] While the current literature on workplace driving programs covers most industries and occupations, the law enforcement profession is notably absent.

In 2016, fatalities among law enforcement officers rose to their highest level in 5 years (National Law Enforcement Officers Memorial Fund, 2016).[4] There were 135 officers fatally injured, 39% were killed in MVCs (2016). There are insufficient national data on nonfatal MVCs; however, one state-based study found that for every officer killed in a MVC, there were approximately 234 officers injured.[5] Officers may need to drive in a more hazardous manner to respond to emergencies, which is not present for other occupations. Officers also have the additional risk of engaging in vehicle pursuits,

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which can include high speeds and hazardous driving maneuvers. In addition, officers spend a great deal of time in their car patrolling areas when not responding to calls.

Researchers have identified several reasons why officers may be at risk for MVCs. First, law enforcement shift work has been associated with sleep deficits, which can cause fatigued officers to make judgment errors and lead to increases in MVCs.[6-8] Another reason for the increased crash risk could be the multitude and complexity of technologies found in a typical patrol car. A patrol car may include technologies such as lights, sirens, radios, scanners, weapons, radar, stolen vehicle locators, video cameras, mobile data terminals, mobile devices, and facial recognition devices.[9] When officers attend to these technologies, basic driving skills diminish.[10]

Half of officer MVC fatalities involved either excessive speed or lack of a seat belt.[11] Higher speeds reduce the amount of time available to receive, process, and react to hazards and are directly associated with higher MVC fatality rates.[12-14] There is also research to suggest that officers do not wear seat belts.[15-17] One study reviewed episodes from a police reality television series and found that only 38% of officers wore seat belts in driving scenes.[18] Besides cultural norms, there may also be barriers to the wearing of seat belts.[19,20] Seat belts can get stuck in equipment belts and gun holsters and prevent quick egress from patrol cars.[19,20]

Lack of driver training may also play a role in increased risk for MVCs. One study found that only 29% of officers received any type of motor vehicle training in the prior year (NIOSH, 2014). Academy-provided driver training did not fare much better. Only 12% of officers believed that the average academy recruit had sufficient driving skills to safely operate a law enforcement vehicle (2014). While officers drive on a daily basis as part of their law enforcement duties, this does not necessarily equate to refining driving skills, practicing good habits, or getting critical feedback on their skills.[9] On-going driver training is important to driving performance, yet many agencies do not have the resources to conduct training. Despite officers' increased risk for MVCs, limited work exists on the evaluation of industry-based MVC prevention programs.

1.1 | Las Vegas Metropolitan Police Department Crash Prevention Program

Within a 1-year time span, the Las Vegas Metropolitan Police Department (LVMPD) experienced three motor vehicle fatalities and behavioral factors may have played a role (Officer Down, n.d).[21] After these deaths, the LVMPD developed a comprehensive multipronged MVC prevention program. The objective of this study was to evaluate the impact of the LVMPD crash prevention program on nonfatal MVCs and motor vehicle-related injuries (MVIs). To the best of our knowledge, this is the only scientific evaluation of an MVC prevention program in law enforcement. Since MVCs remain a leading cause of work-related death and injury for officers, the evaluation of this program could provide evidence to the law enforcement profession to implement preventive programs, as well as other public safety industries.

The primary goal of the LVMPD crash prevention program was to prevent on-duty MVC fatalities and injuries among officers. Several steps were taken to develop this program. First, focus groups were conducted with agency leadership to gain insight into officer perceptions. Second, the LVMPD researched safe driving programs, policies, and training elements from other agencies. Third, the LVMPD turned to other industries, including the United Parcel Service, for safe driving concepts that could be incorporated by a law enforcement agency. Finally, the LVMPD conducted an anonymous survey of all its officers on safe driving practices. The LVMPD MVC prevention program involved three prongs: policy changes, increased training requirements, and a progressive marketing campaign. Inherent in the program was increased accountability including a stronger consequences for not following the program and being involved in MVCs.

Table 1 displays the three prongs of the LVMPD MVC prevention program. The first prong was policy. Two new policies were developed and three existing policies were revised or emphasized. First, a policy that prevented officers from driving in excess of 20 mph over the posted speed limit when using lights and sirens was instituted. The second new policy was a supervisory check ride that required officers who transfer into new divisions or those involved in an MVC to have a supervisor monitor their on-duty driving performance before they begin or resumed work. The seat belt and texting policies were revised. Also, a re-emphasis on the training and enforcement of the intersection crossing policy was made.

The second prong was the marketing campaign titled "Belt Up." Posters with this slogan were displayed throughout the agency and in parking garages. Decals with the slogan were placed in patrol vehicles. Videos were developed which featured fellow officers who had been involved in MVCs that killed an officer or civilian. Finally, a short driving safety message was given at every shift change. The third prong was training. Training requirements were increased to require officers to pass a full emergency vehicle operations course (EVOC) annually in their first 3 years of service. After the first 3 years, officers were required to pass the EVOC course every other year. Training content was also changed to include topics on seat belt use, defensive driving, and visual horizon concepts. It is important to note that the program was not implemented at a single point in time. Rather, pieces of the program such as the policy changes occurred in 2009 and the marketing campaign was implemented in early 2010.

2 | MATERIALS AND METHODS

The methodological design used in this study is an autoregressive integrated moving average (ARIMA) model with control group. The methodological design used in this study is a robust alternative to a true experimental design when evaluating safety interventions.[22] Data from two control agencies who had not implemented a program were included. Two analyses were performed; one utilized the LVMPD's monthly MVC and MVI rates for law enforcement officers and the second compared LVMPD's data to the two control agencies.

TABLE 1 Three prongs of the Las Vegas Metropolitan Police Department MVC Prevention Program

Prong	Status	Name	Description
1. Policy	NEW	Supervisory check ride system	If an officer is involved in a crash, or transferred to a new squad, they are required to go through a supervisory check ride (supervisor rides along with officer for predetermined amount of time).
	NEW	Speed cap	Code 3 driving (responding with emergency lights and sirens) will not exceed posted speed limit by more than 20 mph with the exception of pursuit driving.
	REVISED	Seat belt	(1) Officers required to wear seat belts at all times with the exception of when the vehicle is traveling less than 15 mph.
			(2) Seat belt extenders, which were approved in the past, are not authorized.
	EMPHASIZED	Intersection crossing	Officers are required to stop at intersection crossings: (1) before entering an intersection against the traffic control device, (2) at all blind intersections, (3) at intersections where hazards are present and other drivers cannot see oncoming traffic.
	REVISED	Texting	(1) Texting and emailing are prohibited while vehicle is in motion.
			(2) Cell phones and mobile data terminals are prohibited in code 3 driving.
2. Marketing Campaign			(1) Decals placed on and in all department vehicles.
			(2) Posters placed in all briefing rooms and garage exits.
			(3) Videos featuring colleagues discussing the importance of wearing seat belts and driving safely.
			(4) Daily driving safety messages
6. Training			**(1)** First three years – pass EVOC annually
			(2) After three years, required to pass EVOC every other year

Abbreviations: EVOC, emergency vehicle operations course; MVC, motor vehicle crash.

The National Institute for Occupational Safety's Institutional Review Board approved this study.

2.1 | The LVMPD and control agencies

The LVMPD is the 11th largest municipal law enforcement agency in the US (Reaves, 2011).[23] In fiscal year 2016/2017, the LVMPD employed approximately 3115 officers. The first control agency is located in the South Central US in one of the largest US cities. The agency employs over 2500 sworn officers. The second control agency is located in a large metropolitan area in the southeastern US. The agency employs over 1800 sworn officers. The control agencies were comparable to the LVMPD on the geographic characteristics and crime level. At the time of the study, neither control agency had an MVC prevention program.

TABLE 2 Number of MVCs, MVC rate, number of MVIs, and MVI rate by year and time period for the LVMPD

Year	Number of MVCs	Number of miles driven	MVC rate per 100 000 miles driven	Number of MVIs	Number of employees	MVI rate per 100 officers
Preintervention						
2007	500	26 382 111	1.9	96	2564	3.7
2008	580	23 314 682	2.5	91	2663	3.4
2009	536	24 475 031	2.2	84	2828	3.0
Total	1616	74 171 824	2.2	271	10 832	3.4
Postintervention						
2010	474	24 719 799	1.9	70	2777	2.5
2011	434	23 247 954	1.9	65	2728	2.4
2012	423	21 969 052	1.9	52	2660	2.0
2013	435	21 658 343	2.0	42	2539	1.7
Total	1766	91 595 1489	1.9	229	10 704	2.1

Abbreviations: LVMPD, Las Vegas Metropolitan Police Department; MVC, motor vehicle crash; MVI, motor vehicle injury.

TABLE 3 Charactistics of LVMPD commissioned officers and MVCs by time period*

	Preintervention (2007-2009) Mean (SD)	2010 Mean (SD)	Postintervention (2011-2013) Mean (SD)	*P*-value
Average age of officer in MVC	34.7 (8.3)	36.4 (7.9)	38.1 (8.5)	***<.0001***
Average length of service of officer in MVC	7.3 (6.4)	8.4 (6.3)	10.5 (6.6)	***<.0001***
Sex	**n (%)**	**n (%)**	**n (%)**	.81
Male	1367 (92%)	381 (92%)	1118 (93%)	
Female	116 (8%)	35 (8%)	90 (7%)	
Unit				***.003***
Two-Man	187 (12%)	42 (9%)	102 (8%)	
One-Man	1426 (88%)	431 (91%)	1186 (92%)	
Job Title				***<.0001***
Police Officer	1220 (79%)	371 (89%)	1064 (88%)	
Sergeant	97 (6%)	35 (8%)	107 (9%)	
Lieutenant/Captain/Other	230 (15%)	12 (3%)	44 (4%)	
Shift				.21
First	68 (18%)	62 (18%)	219 (18%)	
Second	126 (34%)	116 (34%)	469 (39%)	
Third	178 (48%)	167 (48%)	518 (43%)	
No seat belt use	191 (13%)	14 (4%)	31 (3%)	***<.0001***
Civilian injury	159 (11%)	43 (15%)	109 (12%)	.21
Code 3 response (running lights & siren)	136 (8%)	31 (7%)	71 (6%)	***.009***
Pursuit-related	36 (2%)	15 (3%)	44 (3%)	.14
Call to service	305 (19%)	76 (16%)	286 (22%)	***.008***
Single car MVC	472 (29%)	143 (30%)	305 (24%)	***.001***
Collision type				***<.0001***
Head-on	110 (7%)	42 (9%)	69 (5%)	
Turning	36 (2%)	0 (0%)	0 (0%)	
Rear-end	341 (21%)	97 (22%)	273 (21%)	
Backed Into	426 (26%)	133 (30%)	373 (29%)	
Sideswipe	582 (36%)The bold and italic font indicates statistical significance at the 0.05 level	140 (31%)	494 (38%)	
Other	116 (7%)	37 (8%)	78 (6%)	
Total collisions	**1616**	**474**	**1292**	

Abbreviations: LVMPD, Las Vegas Metropolitan Police Department; MVC, motor vehicle crash.
The bold and italic font indicates statistical significance at the 0.05 level.
*Categories may not add to total due to missing data.

2.2 | Data collection and variable definitions

The two primary outcomes were nonfatal MVCs and MVIs. Data were obtained from agency administrative databases from January 1, 2007 to December 31, 2013. MVCs were defined as those crashes reported to the agency where an officer was actively driving a motor vehicle at speeds greater than 10 mph. Excluded were mechanical defects, unoccupied vehicles, parked vehicles, and MVCs occurring with speeds less than 10 mph. All MVCs regardless of fault were included. MVIs were defined as injuries obtained during an event while the patrol car was in motion and reported to the agency. Excluded were injuries occurring while the officer was outside of a moving vehicle and those occurring in immobile vehicles. MVCs and MVIs involving nonsworn employees were excluded. There were no fatal MVCs or MVIs in any agency during the study time period.

When a MVC occurred that resulted in an injury to a person or damage to a vehicle, the officer's supervisor completed a paper form based on self-report from the officer. An Excel database was prepared from these paper forms. MVIs were obtained using the

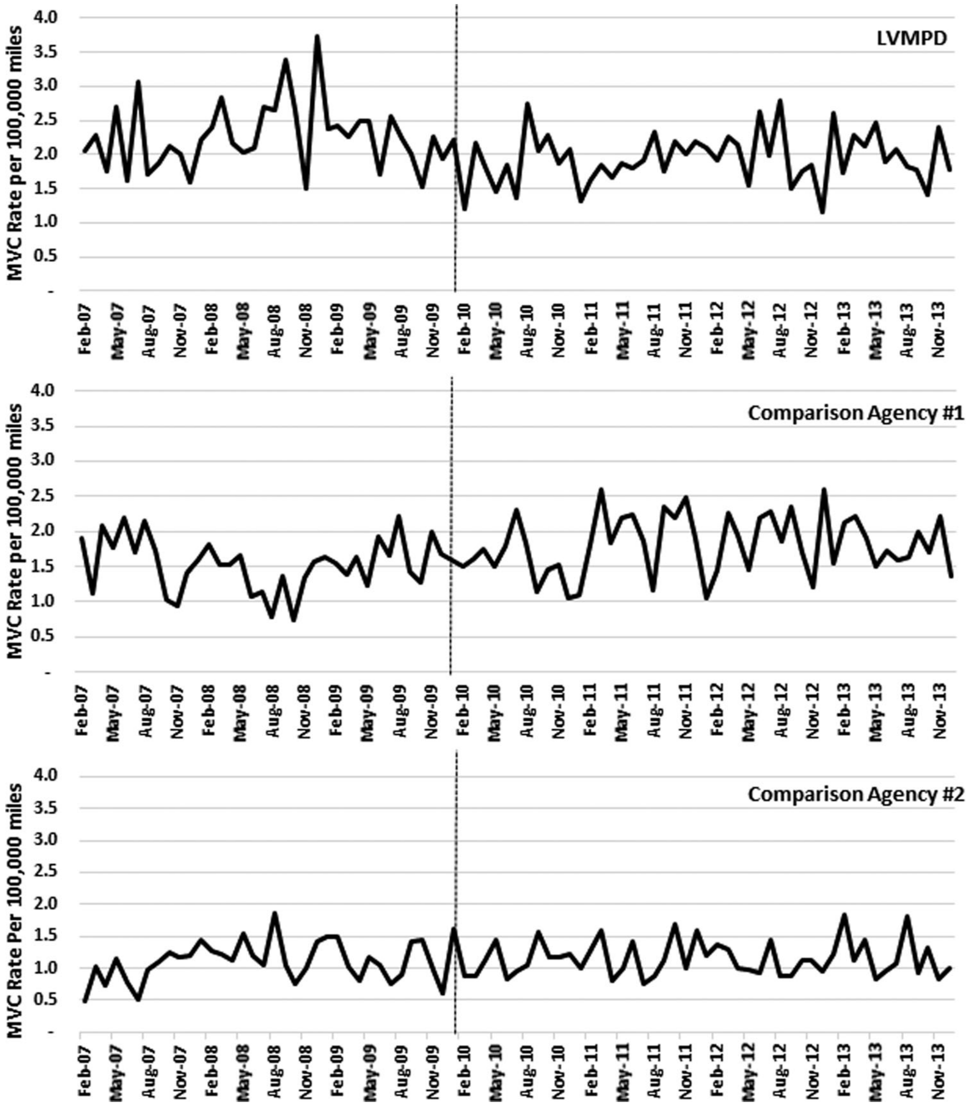

FIGURE 1 Monthly motor vehicle crash (MVC) rates for Las Vegas Metropolitan Police Department (LVMPD), control Agency#1, control Agency#2

agency-wide workers' compensation claims database, which is maintained by the LVMPD and their third party administrator (TPA). Officers verbally report on-duty injuries to their supervisor who completes an Occupational Injury, Illness, and Exposure form. Data from this form are manually entered into the TPA database. The TPA performed a database dump of all workers' compensation claims for the study period. MVIs meeting the study definition were selected using the "Motor Vehicle" cause of injury.

Agency data were also obtained for denominators used in rate calculations. LVMPD payroll data were obtained to calculate the number of commissioned officers employed in the agency during the study period. Civilians, recruits, and detention service employees were removed prior to analysis. MVI rates were defined as the number of MVIs per 1000 commissioned officers. Agency data on the number of miles driven by LVMPD officers per patrol car were obtained. Before analysis, divisions that employed only noncommissioned personnel were removed. MVC rates were defined as the number of MVCs per 100 000 miles driven.

2.3 | Data analysis

Descriptive variables were extracted from the LVMPD databases and summarized before program implementation (2007, 2008, 2009), the year of implementation (2010), and postimplementation (2011, 2012, 2013). Descriptive variables included sociodemographics of the officer, MVC characteristics, and MVI characteristics and were compared statistically using χ^2 tests.

The number of MVCs and the number of total miles driven for all officers were summed monthly for the entire study period at each agency. The number of MVIs and the number of total commissioned officers were also summed monthly. The analysis of monthly MVC and MVI rates was performed using autoregressive integrated moving average (ARIMA) techniques. ARIMA models provide an excellent fit to monthly time series data.[24] It was hypothesized that the intervention would decrease the rate of MVCs and MVIs either as a one-time decrease or as a steady monthly decrease over time. To adjust for potential serial correlation commonly found in monthly data, both

TABLE 4 ARIMA model results for MVC rates: LVMPD, control agency #1, control agency #2

Model	Serial correlation structure	Intercept	Model parameter (*P*-value)	% Change (95% CI)	AIC	SBC
LVMPD						
Constant mean	AR (2)	2.08	-	-	102.16	106.99
Constant slope	AR (2)	2.28	−0.005 (0.08)	−0.2% (−0.43%, 0.25%)[a]	101.27	108.52
Change point	**AR (2)**	**2.27**	**−0.320 (0.008)**	**−14.1% (−24.5%, −3.7%)[b]**	**97.77**	**105.03**
Control agency #1						
Constant mean	AR (1)	1.69		-	89.95	94.81
Constant slope	AR (1)	1.47	0.005 (0.02)	+0.34% (0.61%, 0.63%)[a]	86.86	94.16
Change point	**AR (1)**	**1.54**	**0.257 (0.013)**	**+16.69% (3.46%, 29.81%)[b]**	**86.52**	**93.81**
Control agency #2						
Constant mean	**None**	**1.14**	**-**	**-**	**33.21**	**35.64**
Constant slope	None	1.08	0.001 (0.36)	+0.093% (−0.13%, 0.35%)[a]	34.35	39.21
Change point	None	1.11	0.054 (0.406)	+4.86% (−6.61%, 16.36%)[b]	34.50	39.36

Abbreviations: AIC, Akaike's Information Criteria; ARIMA, autoregressive integrated moving average; CI, confidence interval; LVMPD, Las Vegas; Metropolitan Police Department; MVC, motor vehicle crash; SBC, Schwarz Bayesian criteria.
The bold font indicates the strongest fitting model-as determined by the AIC and SBC numbers.
[a]Represents percent change per month for entire study time period (2007-2013).
[b]Represents percent change from averge preintervention (2007-2009) to average postintervention (2010-2013).

moving average and autocorrelation parameters of a specific lag period were considered based on visual inspection of the autocorrelation and partial autocorrelation plots. A series sufficiently accounted for serial correlation if the χ^2 test on the residuals for white noise had a $P < .1$ for both lags 1 through 6 and lags 1 through 12. These ARIMA models assumed that the model residuals were normally distributed. Diagnostic histograms with kernel estimates of normality and qq-plots were used to assess this assumption. None of the model residuals exhibited evidence that would make the assumption of normality unreasonable.

For the ARIMA analysis, the preintervention period included 2007, 2008, and 2009. The postintervention period included 2010, 2011, 2012, and 2013 because many of the agency-level changes occurred in 2010. After modeling the serial correlation structure, three potential trend models were fit to the data.

(1) A *constant mean model* which assumed that the mean MVC and MVI rates were constant throughout the entire study time period with no significant increases or decreases. The intercept of the model (α) is assumed to be the constant mean.

(2) A *constant slope model* which assumed there was a constant linear slope throughout the entire study. This assumes the slope was the same both preintervention and postintervention. For this model, the intercept (α) is the initial rate and the parameter β represents the constant monthly change in rates. The percent change is defined as β/α and represents the monthly percent change for the entire study period.

(3) A *change point model* which assumed there was a constant rate before intervention and a different constant rate after intervention. For this model, the intercept (α) represents the preintervention rate and the parameter β represents the one time change in rate due to the intervention. The postintervention rate is estimated as $\alpha+\beta$. The change point for this model was defined as January 1, 2010. The percent change is defined as β/α and represents the percent change from to preintervention to postintervention.

All models were run using PROC ARIMA in SAS version 9.4. Seasonality was assessed by looking for significant autocorrelation or partial autocorrelation at or around lag 12. The maximum likelihood method was used to estimate all models. Determination of the best fit model was made by comparison of both the Akaike's Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC) goodness of fit tests. The model with the lowest value for both the AIC and SBC was determined to be the best fitting model for a specific series.

3 | RESULTS

3.1 | Descriptive analysis—LVMPD MVCs

Table 2 displays the number of MVCs, miles driven, MVC rate, number of MVIs, number of officers, and MVI rate by year and intervention period. In the preintervention, there were 1616 MVCs for an overall MVC rate of 2.2 per 100 000 miles. There were 1766 MVCs in the postintervention for an overall rate of 1.9 per 100 000 miles. Table 3 displays the sociodemographics of officers involved in MVCs and characteristics of those crashes by intervention period. Seat belt use in MVCs increased significantly from 87% in the preintervention to 97% during the postintervention ($P < .0001$). MVCs occurring during a code 3 response (running lights and sirens) and single vehicle crashes significantly decreased from 8% to 6% ($P = .009$) and 29% to 24% ($P = .001$), respectively. However, MVCs that occurred during a call to service significantly increased (19% to 22%, $P = .008$).

TABLE 5 Charactistics of LVMPD commissioned officer's MVIs by intervention period*

	Preintervention (2007-2009) Mean (SD)	2010 Mean (SD)	Postintervention (2011-2013) Mean (SD)	P-value
Age of officer	35.5 (8.4)	36.6 (7.1)	39.3 (8.7)	***<.0001***
Length of service	7.7 (6.6)	9.2 (5.8)	10.8 (6.7)	***<.0001***
Charge type	**n (%)**	**n (%)**	**n (%)**	
Indemnity	97 (36%)	27 (39%)	89 (56%)	***.0002***
Medical	174 (64%)	43 (61%)	70 (44%)	
Sex				.15
Male	238 (93%)	53 (86%)	134 (90%)	
Female	18 (7%)	9 (14%)	15 (10%)	
Job title				.65
Police officer	230 (90%)	57 (92%)	130 (87%)	
Sgt	20 (8%)	3 (5%)	13 (9%)	
LT./Capt/Other	5 (2%)	2 (3%)	6 (4%)	
Body part injured				**<.0001**
Arm/Hand	27 (10%)	1 (1%)	8 (5%)	
Back	31 (12%)	4 (6%)	19 (12%)	
Face/Head	10 (4%)	4 (6%)	19 (12%)	
Foot/Leg	22 (8%)	3 (4%)	7 (4%)	
Multiple	166 (62%)	56 (80%)	86 (54%)	
Other	11 (4%)	2 (3%)	20 (13%)	
Type of Injury				**<.0001**
Abrasion	21 (8%)	2 (3%)	20 (13%)	
Fracture/Crush	11 (4%)	0 (0%)	10 (6%)	
Cut	6 (2%)	0 (0%)	3 (2%)	
Sprain/Strain	91 (34%)	11 (16%)	101 (64%)	
Other	18 (7%)	8 (11%)	7 (4%)	
Multiple	124 (46%)	49 (70%)	18 (11%)	
Total	**271**	**70**	**159**	

Abbreviations: LVMPD, Las Vegas Metropolitan Police Department; MVI, motor vehicle injury.
The bold and italic font indicates statistical significance at the 0.05 level.
*Categories may not add to total due to missing data.

3.2 | Interrupted time series results—MVCs

Figure 1 displays the monthly MVC rates for the LVMPD and control agencies. Table 4 displays the results of the ARIMA models. No significant seasonality was found for any of the ARIMA models. The best fitting model for the LVMPD MVC data was the change point model. This model indicated that after the intervention (January 1, 2010), there was a significantly lower mean MVC rate than the preintervention MVC rate. MVC rates significantly decreased 14% (95% CI = −24.5% to −3.7%) from a rate of 2.2 to 1.9 per 100 000 miles ($P = .008$). The best fitting model for control agency #1 was also the change point model. However, at the point of implementation of the LVMPD program, MVC rates significantly *increased* 17% (95% CI = 3.46%-29.81%; $P = .013$). The best fitting model for control agency #2 was the constant mean model, indicating their MVC rates remained constant across the study time period.

3.3 | Descriptive analysis—LVMPD MVIs

In the preintervention, there were 271 MVIs for an overall MVI rate of 3.4 per 100 officers (Table 2). There were 229 MVIs in the 4-year postintervention period for an overall rate of 2.1 per 100 officers. Table 5 displays the sociodemographics of officers with MVIs and characteristics of those injuries. There were significant differences in the body part injured, type of injury, and claim type. MVIs involving multiple body parts decreased from 62% to 54% ($P < .0001$). Also, MVIs involving multiple types of injury such as both a sprain and an

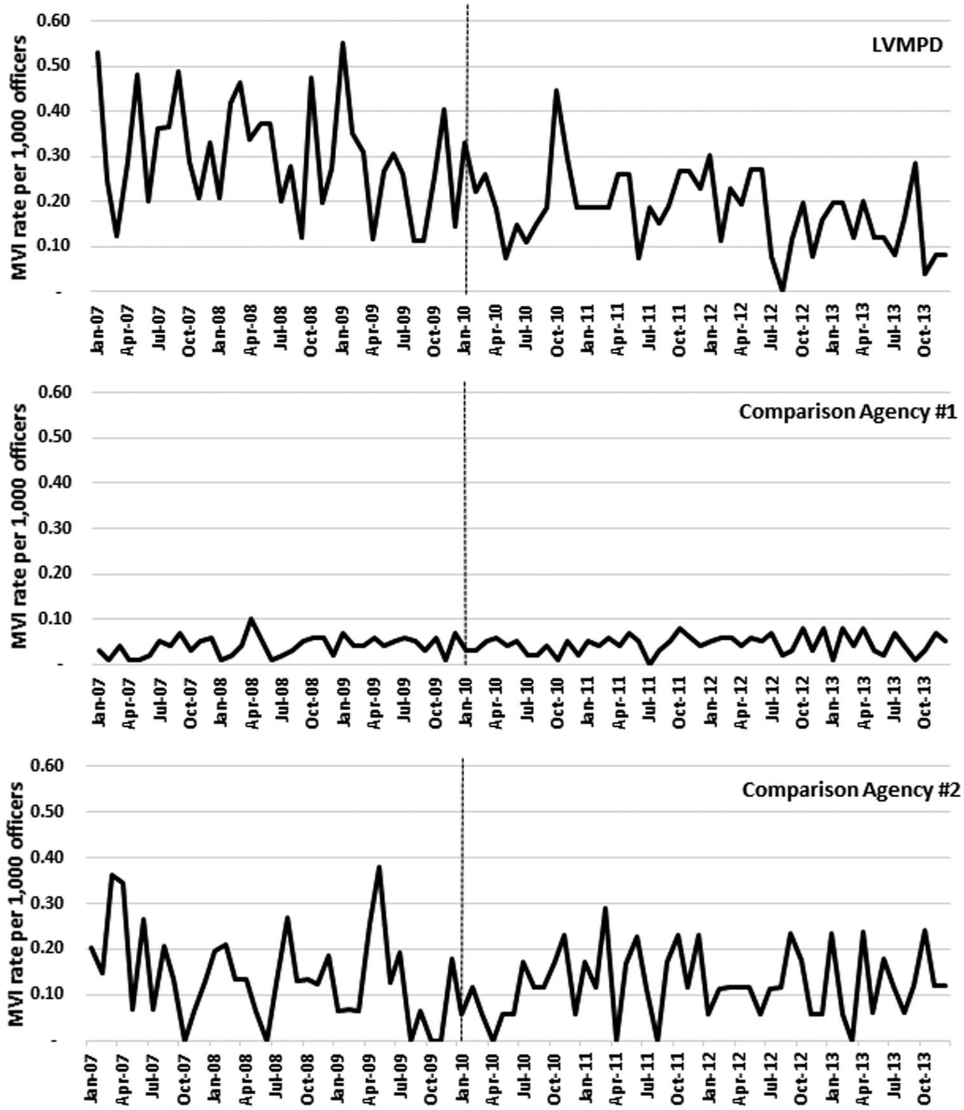

FIGURE 2 Monthly motor vehicle injury (MVI) rates for LVMPD, control agency#1, control agency#2. LVMPD, Las Vegas Metropolitan Police Department

abrasion significantly decreased from 46% to 11% ($P < .0001$). Medical only workers' compensation claims decreased from 64% in the preintervention to 44% in the postintervention ($P = .0002$).

3.4 | Interrupted time series results—MVIs

Figure 2 and Table 6 display the results for the monthly MVI rates for the LVMPD and control agencies and ARIMA models. The best fitting model for the LVMPD MVI data was the constant slope model. This model indicated that MVI rates decreased significantly 0.5% (95% CI = −0.93% to −0.33%) monthly during the entire study time period ($P < .0001$). The change point model also showed a significant decrease in MVI rates. MVI rates significantly decreased 31% (95% CI = −47.9% to −14.5%) from a rate of 3.4 per 100 officers in the preintervention to 2.1 in the postintervention ($P = .0002$). For control agency #1, the SBC was lowest for the constant mean model and the AIC was lowest for the constant slope model. The constant mean model indicates that MVI rates remained constant across the study and the constant slope model shows a monthly *increase* in MVI rates of 0.74% (95% CI = −0.03% to 1.40%). The best fitting model for control agency #2 was the constant mean model, indicating the MVI rates remained constant across the entire study time period.

3.5 | Patrol officer subanalysis

A subanalysis of LVMPD's MVC and MVI rates was conducted to determine if the MVC prevention program had a differential impact on patrol officers. An additional hypothesis was that the MVC prevention program would have a larger impact on patrol officers' MVC and MVI rates than what was seen for the overall agency. The best fitting model for the patrol officer's MVC data was the change point model (Figure 3). After the intervention, MVC rates significantly decreased 21% from a rate of 3.1 per 100 000 miles to 2.4 ($P = .002$). The best fitting model for the patrol officer's MVI data was

TABLE 6 ARIMA model results for MVI rates: LVMPD, control agency #1, control agency #2

Model	Serial correlation structure	Intercept	Model parameter (*P*-value)	% Change (95% CI)	AIC	SBC
LVMPD						
Constant mean	AR (1)	0.30	-	-	−91.04	−86.20
Constant slope	**AR (1)**	**0.41**	**−.002 (<.0001)**	**−0.5% (−0.93, −0.33)[a]**	**−102.40**	**−95.14**
Change point	AR (1)	0.36	−.113 (.0002)	−31.3% (−47.9, −14.5)[b]	−99.54	−92.28
Control agency #1						
Constant mean	AR (9)	0.34	-	-	−48.19	**−43.33**
Constant slope	AR (9)	0.27	.002 (.062)	+0.74 (−0.03, 1.40)[a]	**−49.56**	−42.27
Change point	AR (9)	0.32	.054 (.271)	+16.8 (−13.1, 46.6)[b]	−47.33	−40.04
Control agency #2						
Constant mean	**No AR**	**0.14**	-	-	**−160.88**	**−158.45**
Constant slope	No AR	0.16	−.0006 (.173)	−0.37% (−0.84, 0.15)[a]	−160.76	−155.90
Change point	No AR	0.16	−.026 (.196)	−16.77 (−42.57, 8.73)[b]	−160.58	−155.72

Abbreviations: ARIMA, autoregressive integrated moving average; LVMPD, Las Vegas Metropolitan Police Department; MVI, motor vehicle injury. The bold font indicates the strongest fitting model-as determined by the AIC and SBC numbers.
[a]Represents percent change per month for entire study time period (2007-2013).
[b]Represents percent change from averge preintervention (2007-2009) to average postintervention (2010-2013).

also the change point model (Figure 4). This model indicated that after the intervention, MVI rates significantly decreased 48% from a rate of 3.2 per 100 officers to 1.6 ($P < .0001$).

4 | DISCUSSION

Motor-vehicle–related injuries and fatalities impact officers, their families, agencies, and communities. They also introduce a large financial burden and negatively impact officer safety and wellness. The implementation of a MVC prevention program at the LVMPD was associated with lower MVC and MVI rates agency-wide during the postintervention that was not seen in two similar-sized agencies that did not implement a prevention program. More importantly, MVC and MVI rate decreases were even sharper in the primary population of interest—patrol officers. The law enforcement community has mostly directed its efforts to the dangers posed by assaults from suspects, resulting in risks posed to officers from MVCs being overlooked. However, this orientation has changed over the past few years. The recently created National Officer Safety and Wellness Group in the Department of Justice has made officer-involved MVCs one of its pillars for officer safety issues.[25] In addition, officer safety programs such as Below 100 and Destination Zero have also made efforts to increase awareness surrounding the risk of officer-involved MVCs (www.below100.org and destinationzero.org). What is still lacking are evidence-based programs that agencies can implement to reduce MVCs. The LVMPD program was the first that we are aware of to fill this gap with the creation of a program composed of pragmatic components developed by law enforcement practitioners that is now supported by empirical evidence.

However, law enforcement agencies in the US are diverse in organizational size and resources, and therefore in their capacity to implement comprehensive initiatives like the LVMPD program. The LVMPD has the staffing, facilities, and resources to support a

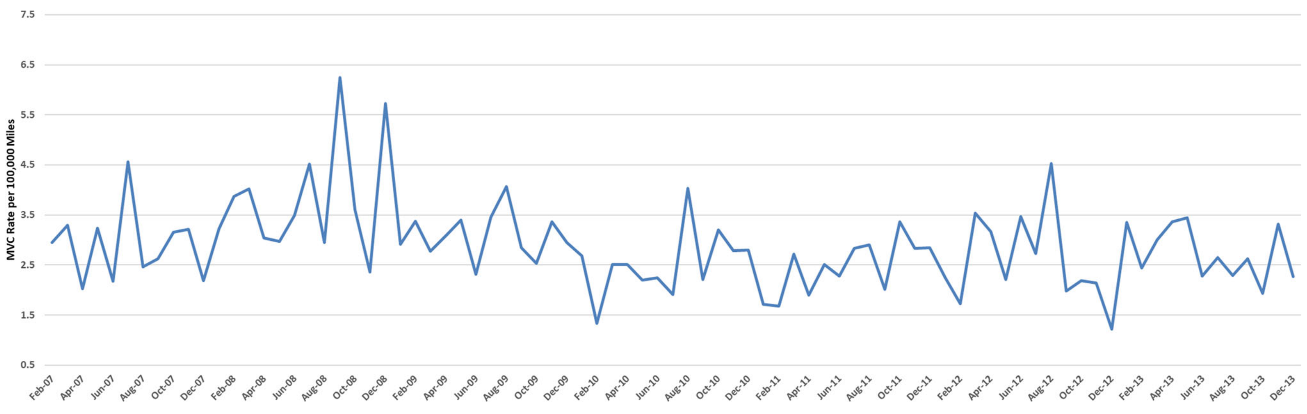

FIGURE 3 Monthly MVC rates and autoregressive integrated moving average (ARIMA) results for LVMPD patrol officers. LVMPD, Las Vegas Metropolitan Police Department; MVC, motor vehicle crash [Color figure can be viewed at wileyonlinelibrary.com]

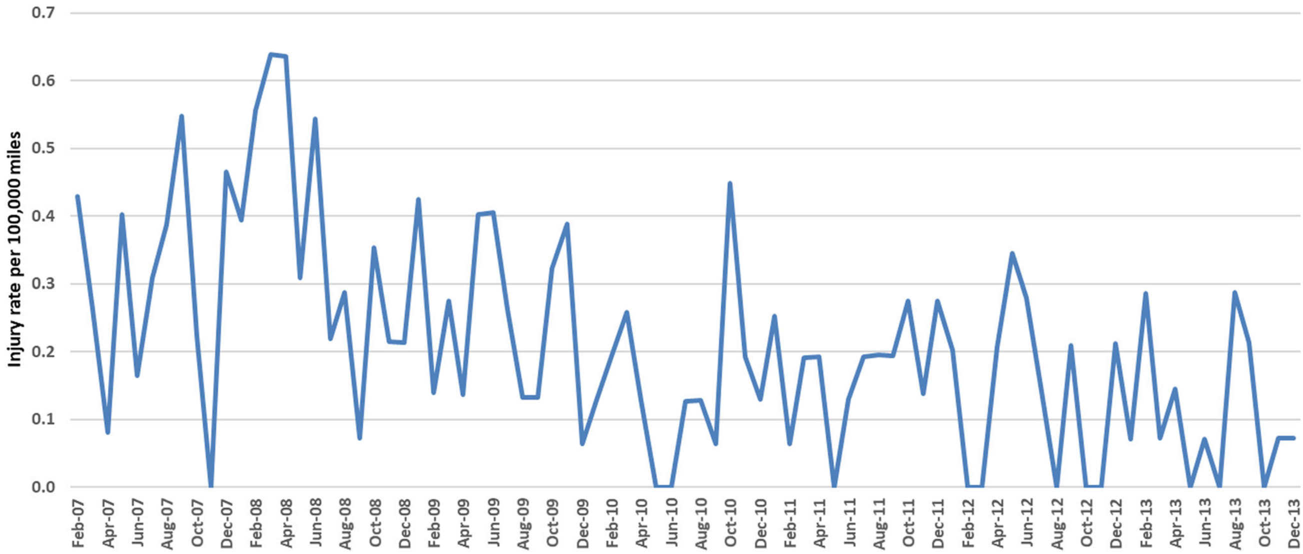

FIGURE 4 Monthly MVI rates and ARIMA results for LVMPD patrol officers. ARIMA, autoregressive integrated moving average; LVMPD, Las Vegas Metropolitan Police Department; MVI, motor vehicle injury [Color figure can be viewed at wileyonlinelibrary.com]

comprehensive driving training program on an annual or bi-annual basis. By contrast, nearly 75% of law enforcement agencies in the US have fewer than 24 officers.[26] It would be challenging for smaller agencies with fewer resources to implement the full LVMPD program. However, this program may be an important framework for the development of scalable MVC prevention programs. The LVMPD program contained components beyond training that included policy changes, accountability approaches, and cost-effective efforts to create a safety culture. The critical next step is for law enforcement agencies and researchers to evaluate individual components or combinations to enable development of scalable versions of this program and determine which components will likely have the largest impact.

While the LVMPD MVC prevention program had a positive impact on MVC and MVI rates, we must also consider that factors not controlled for in an ARIMA model could have also played a role. For example, officers may have changed their own behaviors after the loss of three officers. Another limitation was that this analysis did not control for changes in frequency or types of crime that may impact officer's crash rates or factors such as traffic density and general road safety. Also, due to the nature of the study design, it was not possible to determine which individual elements of the program had the greatest impact, so we are unable to make recommendations about specific program elements. Finally, we were unable to collect data on behavioral outcomes such as seat belt use. We were limited to self-reported seatbelt use, which is likely to have included some bias. Finally, in 2013, the final year of the postintervention period, the LVMPD switched from driving the Ford Crown Victoria's to the Ford Explorer's. This change could also account for some of the differences found in this analysis.

Another limitation of this study was our choice of January 2010 as the change point. Since the LVMPD program was implemented piecemeal throughout 2009 with no strict start date of the intervention, the choice of January 2010 is somewhat arbitrary. We made this decision based on discussions with LVMPD Leadership. We reran our ARIMA models with other potential change points and this exercise did not change our overall conclusion that the crash prevention program significantly decreased both MVCs and MVIs.

These results indicate that the LVMPD crash prevention program was effective in reducing MVCs and MVIs. The MVC rate significantly decreased from 2.2 crashes per 100 000 miles in the preintervention to 1.9 in the postintervention. The MVI rate significantly decreased 31% from a rate of 3.4 per 100 officers to 2.1. The crash prevention program appeared to have an even larger impact on the primary population of interest, patrol officers. Patrol officers' MVC rate decreased from 3.1 per 100 000 miles in the preintervention to 2.4 and their MVI rate decreased nearly 50% from 3.2 per 100 officers to 1.6. These findings were in stark comparison to the control agencies' MVC and MVI rates, where control agency #1 experienced an increasing MVC and MVI trend and control agency #2 experienced a stable MVC and MVI rate. Officers were also more likely to report wearing their seat belts in MVCs during the postintervention. MVIs in the postintervention were less likely to involve multiple body parts and multiple types of injuries, potentially indicating that the severity of injuries decreased during the postintervention. Efforts should be focused on the prevention of MVCs among officers, especially those that involve behavioral decisions. This study has shown that it is possible to change MVCs and MVIs through the implementation and enforcement of standard operating policies, education, and increased training.

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DISCLOSURE

The authors report no conflicts of interest.

DISCLOSURE BY AJIM EDITOR OF RECORD

John Meyer declares that he has no conflict of interest in the review and publication decision regarding this article.

AUTHORS' CONTRIBUTIONS

Tiesman, Rojek, Hendricks, Montgomery, and Alpert participated in the study's conception. Tiesman, Gwilliam, Rojek, and Hendricks participated in the acquisition, analysis, and data interpretation. All authors participated in the drafting of this manuscript. And all authors ensure the accuracy of these results and give final approval of this manuscript to be published.

INSTITUTION AND ETHICS APPROVAL AND INFORMED CONSENT

Human subjects approval was obtained from the NIOSH Human Subjects Review Board for this study. There was no verbal or written informed consent. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention or the Department of Justice.

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