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FINAL ACTIVITY REPORT

An Evaluation of Oleoresin Capsicum (O.C.) Use by Law Enforcement Agencies: Impact on Injuries to Officers and Suspects

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Overview of the Study

This report describes a two-year study to collect and analyze data on injuries to suspects resulting from police use of force and to officers from assaults occurring in the line of duty. Information from multiple sources was abstracted from hard copy and electronic data maintained by the North Carolina Highway Patrol, the Winston Salem Police Department, and the Charlotte-Mecklenburg Police Department.

Study Sites

Charlotte-Mecklenburg Police Department (CMPD)

Characteristics: Charlotte is a city of more than 600,000 people, in the county of Mecklenburg. The CMPD is the result of the consolidation of the Charlotte Police Department and the Mecklenburg County Police Department at the end of 1993. There are 1200- 1300 sworn officers serving the service area in 12 Police Districts – Adam 1, 2, 3; Baker 1, 2, 3; Charlie 1, 2, 3; and David 1, 2, 3. However, because we wanted data before and after OC Spray implementation, we restricted the analysis to the Adam, Baker and Charlie districts.

OC Spray: OC Spray was first issued in Fall 1994 but was stopped due to an in-custody death after OC Spray use. OC Spray was re-issued in January 1995. It is standard procedure to apply saline solution to persons whose eyes are sprayed with OC after the suspect is detained. Sworn officers carry both the ASP (collapsible baton) and OC spray (stream). Collapsible batons were provided first in 1994.

Winston Salem Police Department (WSPD)

Characteristics: The city of Winston-Salem is home to approximately 170,000 people. The city is divided into four sectors geographically, each with eight to 10 beats for police patrols, plus a special operations unit that includes a tactical team, a motorcycle squad, and crime prevention efforts. Approximately 250 officers are in the field, including special operations, in squads of 40. The remaining approximately 200 officers are distributed among investigative services, development and training, and administration.

OC Spray: The WSPD first issued OC Spray to officers in March 1993, and OC Spray was fully implemented on June 16, 1993. During this training and implementation period, a mix of mace and OC was being carried. All new employees are exposed to OC and all sworn personnel take a direct (15-16%) or indirect (85%) spray during a five hour training program. Recruits receive about the same amount of training on OC although it is integrated into their defensive tactics training.It is standard procedure to apply saline solution to persons whose eyes are sprayed with OC after the suspect is detained.

North Carolina State Highway Patrol (SHP)

Characteristics: The SHP was created in 1929 by the North Carolina General Assembly, and is currently the largest law enforcement agency in North Carolina. The SHP has troops, A – H, which patrol the state by geographic region, in addition to the Interstate, or "I", Troop, the Governor's Security Detail, the Training Center, and Headquarters. Each of the A-H troops has district offices that serve the counties within each troop's region. The state of North Carolina has an area of 48,479 square miles, and a population of over 7 million people.

OC Spray: OC use began in 1992 in Raleigh and other pilot areas (Fayetteville and Greensboro). About 100 troopers were trained in the use of OC (there were fewer than 58 districts at this time). By 1993, the entire state was covered by trained officers. The authorized force of the Highway Patrol is 1380 troopers. Each trooper is sprayed during OC training.

Description of the Data

Injuries to Officers

Information on officer injuries from the SHP came from a record review of SHP Workers' Compensation and Medical Only Claims files. The Workers' Compensation and Medical Only Claims records of the State Highway Patrol were reviewed and the following data abstracted: Date of Incident, County of Incident, Injury sustained by trooper, trooper gender and age at time of incident, and action performed when the injury took place (e.g., arrest, chase). Records in which the injury was a result of a motor vehicle crash or actions unrelated to an arrest were not abstracted. We also had the number of Workers' Compensation Claims filed per year in the SHP document, Activities in Review, for 1988 - 1997. The number of cases found from the record review was consistently less than the number of cases reported in the Activities in Review for each year.

For the CMPD and the WSPD, we collected injury information on officers and suspects. The CMPD Use of Force Database contains information on all uses of force by CMPD Officers. The information contained in the database that is relevant to officer injuries is: date, time and location of incident; reason for arrest; officer demographics; weapons used by the officer; injuries to the officer; subject demographics; subject impairment status; weapons used by the subject. For injuries to officers, we also had a record review of files where injuries to officers were noted in the database - files where there was an injury to officer were pulled, and injury to officer reports including narratives were photocopied

and sent to us. These reports gave more detail on the circumstances surrounding the injury and the severity of the injury.

For WSPD, we used their Injury Database 1990 – 1998. The injury database included information on each incident where a citizen, officer, or both were injured. The information included the date of the incident, who was injured, the type of injury, and the circumstances surrounding the injury. However, the database did not have information on the patrol sector where the incident occurred.

Injuries to Suspects

We do not have information on injuries to suspects of the SHP. However, starting in 1997 the assault on patrol member information is included in a SHP Use of Force/Assault electronic database that has information on the incident; demographics, injury type and severity, and display and/or use of weapon(s) of the trooper and offender. The database also includes information on whether the offender was intoxicated and the mode of intoxication, and charges preferred against the offender.

The information on injuries to suspects in the CMPD Use of Force database is: file number; date, time and location of incident; reason for arrest; weapons used by the officer; subject demographics; subject impairment status; weapons used by the subject; injuries to the subject; charges filed against the subject.

For WSPD, we used their Injury Database 1990 – 1998. The injury database included information on each incident where a citizen, officer, or both were injured. The information included the date of the incident, who was injured, the type of injury, and the circumstances surrounding the injury.

OC Spray Information

We did not have OC Spray information for SHP prior to 1997. However, in the electronic database there is information on OC spray display and usage by SHP troopers.

We supplemented the details on CMPD use of force incidents with record reviews of files where OC Spray use was noted in the database. Files where OC Spray use was noted were pulled, and OC Spray reports including narratives were photocopied and sent to us. These reports gave detail on the distance from which OC was sprayed, the number and duration of sprays, time to OC effectiveness, time to subject recovery post-OC spray, and post-OC spray care.

Information on OC Spray use in WSPD came from their OC Spray Detail Report, January 1994 to May 1998. The OC Spray Detail Report listed the details for each OC Spray use by WSPD officer between January 1, 1994 and May 28, 1998. The report indicated the date of each incident, whether an associated complaint was filed, details which led to OC Spray use and whether or not OC Spray was effective, post-OC exposure follow-up on-scene (e.g., treatment with saline) and additional follow-up,

whether or not there was a post-OC injury and whether or not the person sprayed was hospitalized.

WSPD does have additional information on OC use on a OC Aerosol Use Supplement which has the following information for each OC Spray use: suspect behavior, discharge distance and amount, suspect area targeted for OC spray, exposure reaction time, physical reaction, whether additional force was used, restraint and decontamination method, medical assistance, vision recovery, whether or not the suspect was wearing eye or sun glasses or contact lenses, time to general recovery, respiratory condition, alcohol or drug use, and whether or not injury was sustained during arrest. This supplement was recently revised and is not currently in an electronic form.

Use of Excessive Force Complaints

We received from the SHP yearly counts of Use of Force Litigations filed against members of the SHP from 1975 to 1998. Each count is the number of the lawsuits filed in that year.

For CMPD, we obtained the History of Excessive Force (Offense Code _28A) for 1995 – 1998. The document contained detailed reports giving date complaint received, brief allegation, board findings, and action taken. For 1990 – 1994 we had a yearly count of Excessive Force complaints.

We used the Rule of Conduct Violation Summary Report, January 1990 – April 1999 for WSPD. For the total period, and by year, the report indicated the number of each type of rule of conduct violations by status (e.g., exonerated, sustained, pending). The type of Rule of Conduct Violations consistent with information from the other law enforcement agencies was "Use of Force" Rule.

Arrest/Use of Force Data

Yearly total arrest counts for the SHP came from the Activities in Review 1988 – 1997. Activities in Review are books that the SHP Research and Planning Unit prepare. These books contain summary statistics of the SHP activities and operations by year, including: enforcement activities, and number of personnel and number of arrests by Troop. Monthly estimates were based on assuming that arrests were proportionally distributed among a troop's districts and the pattern of arrests by month could be reasonably estimated by using the monthly pattern for each troop from 1997 to 1998.

In addition, we have the total number of Charges made from January 1994 to September 1998 by quarter and by type of charge (eg. Alcohol/ Drugs, Resisting/Delaying/ Obstructing Arrest). We also have this information broken down by Troop. We also have the number of duty hours worked by Highway Patrol Members of ranks Trooper, Sergeant, or First Sergeant from January 1994 to September 1998 by quarter. We also have this information broken down by Troop.

For CMPD data, we estimated the monthly counts of arrest per unit. CMPD sent us the yearly counts of total number of arrests by unit for 1990 to 1998. We estimated the monthly counts of arrests by using the monthly percentage of uses of force.

The data for WSPD came in the form of monthly counts of criminal arrests given to us by the law enforcement organization. Due to data purging, the counts for 1993 through September 1995 only included the more serious criminal arrests, but October 1995 – December 1998 counts included all criminal arrests. We also had counts of Criminal Arrests from the Informational Report on Pepper Spray (below) for 1993 to 1997. Using these two pieces of information, we estimated the total monthly count of criminal arrests for January 1993 to September 1995. The report also included the monthly count of Traffic Arrests for 1996 to 1998, however we did not have comparable information on the count of Traffic Arrests prior to 1996.

Other Supplementary Data Sources

Assault on State Highway Patrol Members Reports are issued quarterly, and indicate the date, troop and county of assault. They have demographic and limited impairment information about the assailant and type of weapon used by assailant. The assignment the patrol member was engaged in when assaulted is also specified (e.g. Arresting DWI). We had these reports for 1978 – 1998. The reports before Third Quarter 1994 have information on injury to patrol member, and charges preferred against assailant.

The WSPD Informational Report on Pepper Spray was a result of a Pepper Spray Discussion Group formed by the Public Safety Committee of the Board of Aldermen of the City of Winston-Salem on November 10, 1997. The document had statistics on the usage of OC Spray by WSPD from 1993 to 1997, demographics of persons sprayed with OC Spray, policies of WSPD regarding OC Spray and other information.

Analytical Method

This evaluation uses a quasi-experimental before-and-after analysis of the monthly count of injured suspects and officers resulting from the use of force in three jurisdictions in North Carolina. The analytical approach chosen in this report involves the use of Poisson regression, a methodology appropriate for the analysis of dependent variables that take on only non-negative integer values such as 1,2,3..... The Poisson loglinear model belongs to a class of generalized linear models. Parameters are estimated using SAS with a Poisson probability distribution and a log link function. An iterative reweighted least squares algorithm is used to derive the maximum likelihood estimators. The Poisson models to be estimated take on the form:

$$\log \lambda_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik}.$$ [1]

A common problem with the use of Poisson regression is the existence of overdispersion. This occurs when the equality of dependent variable means and variances, a basic assumption of Poisson regression, is violated.[2] Overdispersion does not bias coefficients,

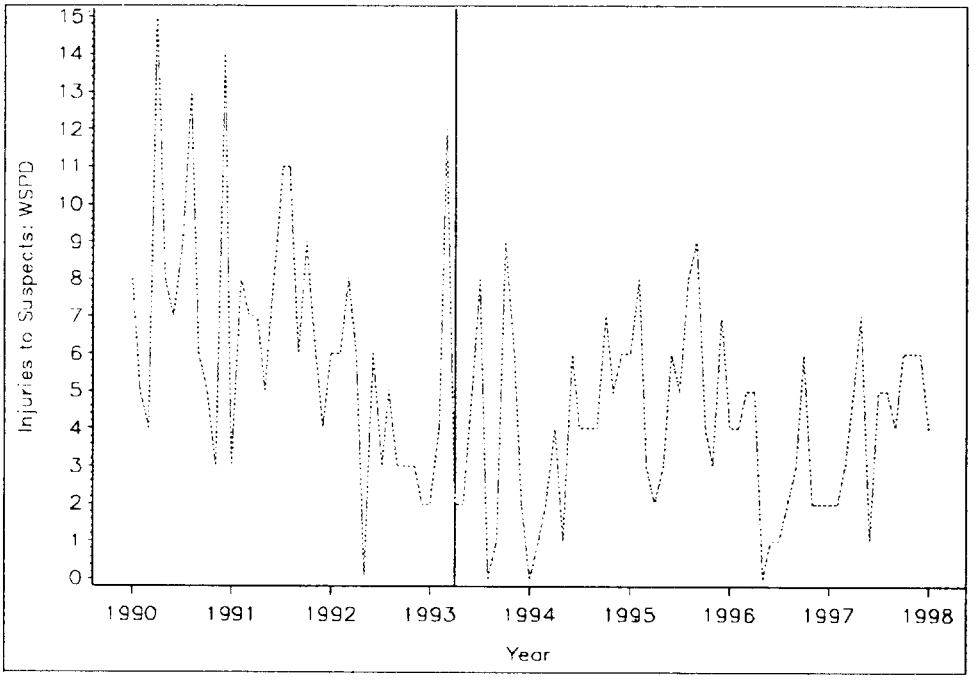
but does lead to liberal estimates of standard errors and chi-square statistics. In the event that overdispersion is identified, a correction (Agresti 1996, p.92)[3] will be used.

Results

Injuries to Suspects

Winston Salem Police Department: Figure 1 displays the time series of monthly counts of suspects injured by law enforcement officers of the Winston Salem Police Department. The time series of injury counts extends from January 1990 to December 1998 and includes monthly counts totaling 566 injuries. While some Winston Salem police officers began to use OC spray in March 1993, few incidents involving OC were reported until the following month. Therefore, the dating of implementation was set at April 1993 for the following analyses.

Figure 1. Time Series of Monthly Counts of Injured Suspects: Winston Salem Police Department



The time series is characterized by a substantial decline in counts of injuries between 1990 and 1993 with a large spike in numbers (12 injured suspects) occurring during March 1993. The post implementation period experienced erratic variations in counts of suspects injured.

Table 1 presents the unadjusted Poisson regression coefficients for an analysis of predictors of counts of suspects injured by Winston Salem police officers. Each coefficient is exponentiated and represents the average change in monthly counts of injured suspects resulting from a 1-unit change in an explanatory variable. Coefficients less than 1 indicate a diminution in the estimated average number of injured suspects per month while coefficients greater than 1 indicate that increasing values of the variable yield a greater number of average monthly injured suspects.

Table 1. Results of a Bivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Suspects: Winston Salem Police Department

Variable	Regression Coefficient	95% CI	*p* value*
Trend	0.9933	0.9898-0.9968	0.0002
OC Spray			
Yes	0.7094	0.5742-0.8762	0.0014
No	1 (referent)		
Month			
January	0.6863	0.3861-1.2199	0.20
February	0.9608	0.5688-1.6229	0.88
March	1.0196	0.6083-1.7090	0.94
April	1.0589	0.6347-1.7663	0.83
May	0.6079	0.3346-1.1041	0.10
June	0.8628	0.5031-1.4793	0.59
July	1.0196	0.6083-1.7089	0.94
August	1.1176	0.6744-1.8522	0.67
September	0.8235	0.4770-1.4218	0.49
October	1.1568	0.7009-1.9094	0.57
November	0.7843	0.4509-1.3642	0.39
December	1.0 (referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Three types of parameters were tested. A variable measured as a sequential count of months from 1 to 108 was used to estimate an upward or downward trend in counts of injured suspects over the time series. A binary (0-1) variable was included to measure differences in the average number of injured suspects before and after issuance of OC spray to officers. Months of the year were also coded to estimate seasonality in the monthly counts.

An examination of bivariate associations indicates that there is a slight downward trend in monthly counts of injured suspects. The indicator variable measuring the timing of implementation of OC spray is also significantly associated with monthly injury counts with 30 percent fewer average suspects injured per month in the post implementation

period compared to the pre OC period. Average counts of injured suspects did not display seasonality by month with no significant effects identified.

Table 2 presents adjusted coefficients for a Poisson regression model representing the time series of monthly counts of suspects injured through uses of force by Winston Salem police officers. The model fits a continuous variable for trend and a binary variable measuring the timing of OC implementation in Winston Salem.

Table 2. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Suspects: Winston Salem Police Department

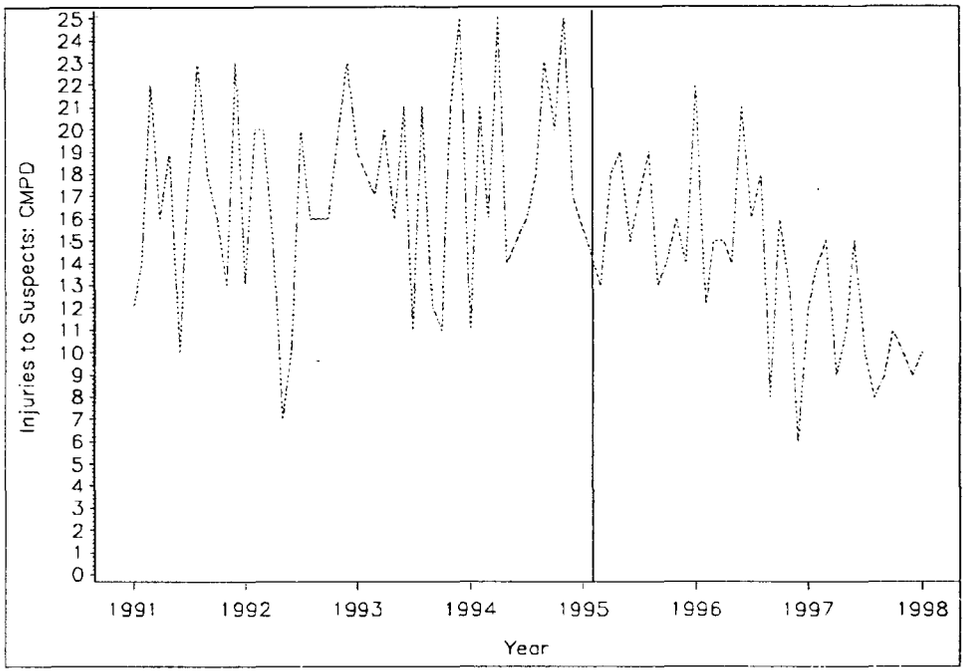
Variable	Regression Coefficient	95% CI	*p* value*
Trend	0.994714	0.9901-0.9992	0.02
Pepper Spray			
Yes	0.8748	0.6687-0.8690	0.33
No	1 (referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Controlling on the influence of trend in the time series of monthly counts, the effect of OC spray implementation drops substantially and no longer achieves significance.

Charlotte-Mecklenburg Police Department: Figure 2 displays the time series of monthly counts of suspects injured by law enforcement officers of the Charlotte-Mecklenburg Police Department. The time series extends over the seven-year period from January 1991 through December 1998. OC training in the Charlotte-Mecklenburg Police Department took place over several months during the first half of 1994. Based upon use of force data, however, only 8 incidents involving OC spray occurred prior to February 1995. During that month 19 incidents of use of force involving OC spray took place. For the following analyses the implementation of OC spray has been set at February 1995 in accordance with usage statistics.

Figure 2. Time Series of Monthly Counts of Injured Suspects: Charlotte-Mecklenburg Police Department



The time series is characterized by an overall upward trend in injuries from 1991 through the winter months of 1994 and a significant downward trend in injuries in the post implementation period. In the period prior to implementation of OC spray, an average of 16.2 suspects were injured through police use of force. During the post implementation period, only 12.5 suspects were injured on average each month. Through their use of force, Charlotte-Mecklenburg officers injured an average of 16.9 suspects monthly in the 12 months preceding the use of OC spray. In the 12 months subsequent to equipping officers with OC spray the average number of injured suspects each month declined to 14.9.

Table 3 presents the unadjusted Poisson regression coefficients for an analysis of predictors of the time series of counts of injured suspects.

Table 3. Results of a Bivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Suspects: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value*
Trend	.995809	1.0010-.9939	<0.0001
Pepper Spray			
Yes	.7913	0.7147-0.8762	0.001
No	1 (referent)		
Month			
January	.9921	0.7754-1.2693	0.96
February	1.1024	0.8670-1.4016	0.54
March	1.007	0.7885-1.2883	0.96
April	1.2036	0.8016-1.3073	0.88
May	.8819	0.6841-1.1370	0.45
June	.9527	0.7428-1.2221	0.77
July	1	0.7819-1.2789	1.00
August	1.0473	0.8212-1.3355	0.77
September	.8898	0.6906-1.1465	0.48
October	.9842	0.7689-1.2600	0.92
November	1.0157	0.7950-1.2978	0.92
December	1 (referent)		
Use of Force	1.0188	1.0143-1.0231	<0.0001

The trend variable is sequentially numbered from 1 (January 1990) to 96 (December 1998) and is entered into the model to measure the direction of the trend in monthly counts. Counts over the eight-year time period declined overall. Monthly counts of injured suspects also declined subsequent to the introduction of pepper spray into the officer's armamentarium. The unadjusted coefficient represents an estimated 20 percent reduction in the average number of injured suspects per month after OC was issued and used by Charlotte-Mecklenburg officers. A series of dichotomous variables representing month of the year was tested to determine if a pattern of seasonality could be detected in the data. Nonsignificant coefficients for month variables indicate that the monthly count of injured suspects does not exhibit seasonality.

Table 4 presents adjusted coefficients for a Poisson regression model representing the time series of monthly counts of suspects injured through uses of force by Charlotte-Mecklenburg police officers. The model includes effects for trend, officer availability of OC spray, and an interaction of trend and OC availability. The trend/OC interaction term is included in order to model the downward slope of monthly counts of injured suspects subsequent to the introduction of OC spray.

Table 4. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Suspects: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value*
Trend	1.004912	1.0001-1.009646	0.05
Pepper Spray			
Yes	2.2522	1.4594-3.4757	0.004
No	1 (referent)		
Trend x OC Spray	0.9825	0.9752-0.9898	<.0001

The fit of the data to the model is deemed adequate with a deviance score of 100.84 (df=92) and Pearson Chi-Square Value of 100.2 (df=92). Comparing degrees of freedom with the deviance measure also indicates low levels of dispersion in the model. Both trend and OC spray exert a positive effect on the count of monthly suspect injuries while the interaction term is shown to diminish the count of injured suspects. The net effect of these coefficients is to yield an increasing estimate of the total count of injured suspects for each month prior to implementing pepper spray. The estimate is highest for month 49 (19.58), which is December 1994, one month before OC spray was used in the field by Charlotte-Mecklenburg police officers. This trend is reversed in months subsequent to the implementation of OC spray. At month 61 (January 1996) the estimated count of suspect injuries is 18 percent less than the count 12 months previous.

Table 5 presents the results of a Poisson regression model that introduces a control variable for the count of uses of force into the above model. Coefficients for trend and OC are no longer significant when use of force is included in the model.

Table 5. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Suspects: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value
Trend	1.003	0.9982-1.0077	0.22
Pepper Spray			
Yes	1.3163	0.8253-2.0807	0.25
No	1 (referent)		
Use of Force	1.0153	1.0101-1.0205	<.0001
Trend x OC Spray	.9926	0.9846-1.0006	0.07

Table 6 presents the results of analyses to further explicate the relationship between OC spray, use of force, and suspect injuries. The dependent variable, the monthly count of use of force by officers of the Charlotte-Mecklenburg Police Department, displayed a similar pattern of increase prior to the introduction of OC spray and decline thereafter. Based upon these results it seems evident that OC spray did not directly result in declines in injuries to suspects. Rather, the introduction of OC spray resulted in a significant drop in uses of force, thereby yielding a decline in injuries to suspects.

Table 6. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Uses of Force: Charlotte-Mecklenburg Police Department

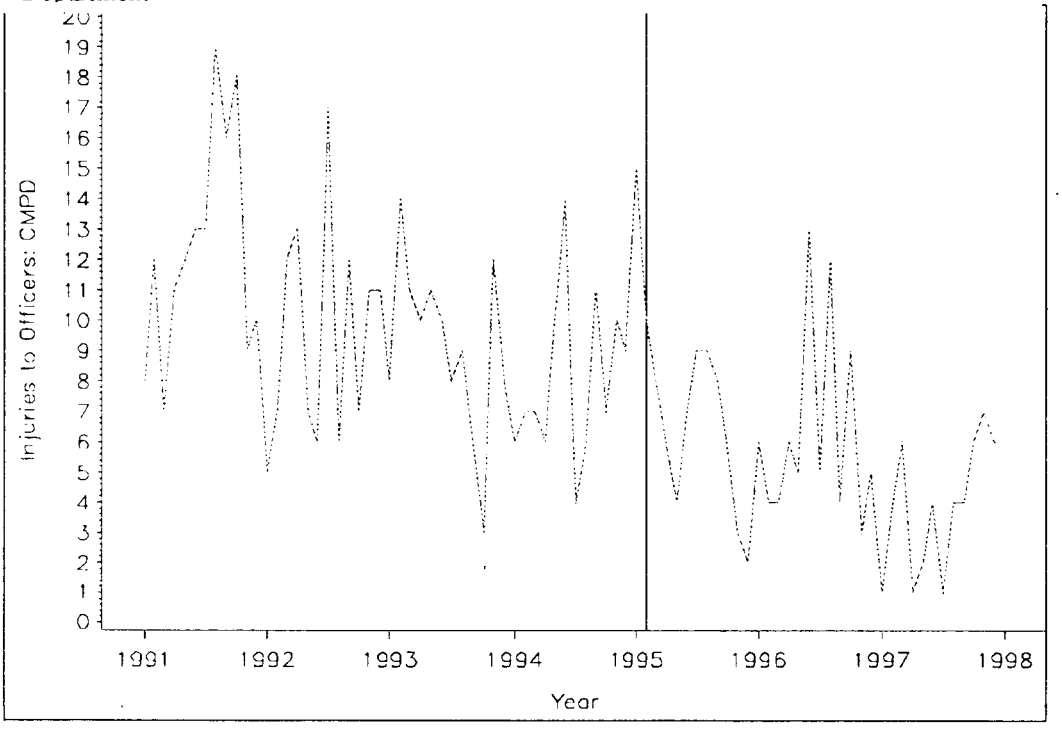
Variable	Regression Coefficient	95% CI	*p* value
Trend	1.0023	0.9982-1.0063	0.27
Pepper Spray			
Yes	2.0711	1.4488-2.9609	<.001
No	1 (referent)		
Trend x OC Spray	0.9862	0.9802-0.9923	<.0001

*χ^2 values and corresponding *p* values corrected for overdispersion

Injuries to Officers

Charlotte-Mecklenburg Police Department: Figure 3 displays the time series of monthly counts of officers injured while using force to subdue suspects. The time series extends over the seven-year period from January 1991 through December 1998.

Figure 3. Time Series of Monthly Counts of Injured Officers: Charlotte-Mecklenburg Police Department



Monthly counts of injured officers declined monotonically over the seven-year period with the largest monthly count of officers injured recorded in mid 1991 (19 officers) and the lowest monthly count recorded in 1997 (1 officer). Table 7 presents the unadjusted Poisson regression coefficients for an analysis of predictors of the time series of counts of injured officers in the Charlotte-Mecklenburg Police Department.

Table 7. Results of a Bivariate Poisson Time Series Analysis of the Counts of Monthly Injured Officers: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value
Trend	0.9885	0.9858-0.9911	<.001
Pepper Spray			
Yes	0.5450	0.4681-0.6344	<.001
No	1 (referent)		
Month			
January	0.9822	0.6770-1.4249	0.92
February	1.0714	0.7444-1.5422	0.71
March	1.1072	0.7714-1.5890	0.58
April	1.0179	0.7039-1.47182	0.93
May	1.1072	0.7714-1.5890	0.58
June	1.3036	0.9202-1.8465	0.14
July	1.0536	0.7309-1.5186	0.78
August	1.2678	0.8932-1.7997	0.18
September	1.1250	0.7849-1.6124	0.52
October	1.0714	0.7444-1.5422	0.71
November	1.0536	0.7309-1.5186	0.77
December	1 (referent)		
Use of Force	1.021528	1.0153-1.0279	<.0001

The significant downward trend in injuries to officers over the time span of 1991-1998 is evidenced in the trend coefficient of the bivariate model (0.9885). For each additional month, the number of officers injured is estimated to decline by slightly more than 1 percent. The count of injured officers was significantly (45 %) lower subsequent to the introduction of OC spray to the Charlotte-Mecklenburg Police Department than after its implementation. Months with larger counts of use of force tended to have higher numbers of injured officers. Every additional use of force is associated with a 2 percent increase in the monthly count of officers injured.

Table 8 presents adjusted coefficients for a Poisson regression model representing the time series of monthly counts of officers injured through uses of force. The initial multivariate model includes effects for trend and OC spray. After controlling for the influence of trend, the introduction of OC spray is seen to have a nonsignificant influence on the monthly counts of officers injured. The effect of an OC spray by trend interaction was tested (not shown here) and also found to be nonsignificant.

Table 8. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injured Officers: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value
Intercept	12.2154	10.5129-14.1951	<.0001
Trend	0.9912	0.9861-0.9964	0.0009
Pepper Spray			
Yes	0.8323	0.6210-1.115	0.22
No	1 (referent)		

Table 9 presents the Poisson regression model that incorporates an effect for the monthly count of uses of force. Each additional use of force during the month is estimated to increase the count of injured officers by 1.4 percent. This model fits the data well (deviance = 104.5, df=92) and shows little indication of overdispersion.

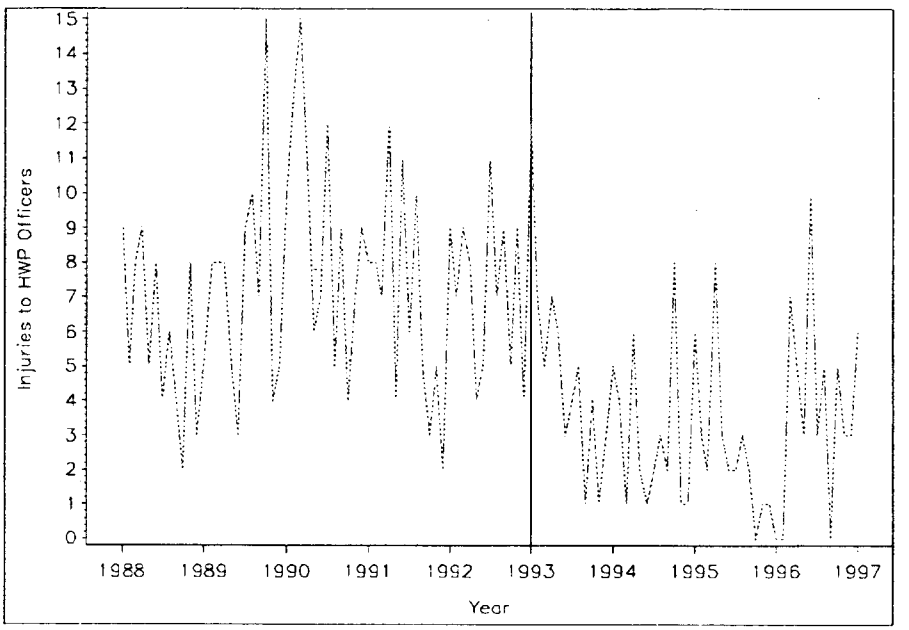
Table 9. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injured Officers: Charlotte-Mecklenburg Police Department

Variable	Regression Coefficient	95% CI	*p* value
Intercept	5.890259	4.006-8.6616	<.001
Trend	0.992627	0.9875-0.9978	0.005
Pepper Spray			
Yes	0.8504	0.6411-1.1280	0.26
No	1 (referent)		
Use of Force	1.013997	1.0073-1.0208	<.001

Based upon these models, the introduction of pepper spray cannot conclusively be linked to declines in the monthly count of injuries to officers resulting from use of force in the Charlotte-Mecklenburg Police Department.

North Carolina State Highway Patrol: Figure 4 displays the time series of monthly counts of Highway Patrol officers injured while using force to subdue suspects. The time series extends over the ten-year period from January 1988 through December 1997. During that time period 653 officers reported receiving injuries while using force.

Figure 4. Time Series of Counts of Highway Patrol Officers Injured by Suspects



The time series displays a substantial decline in counts of injured officers corresponding to the implementation of OC spray. During 1992, 87 officers were injured while only 58 were injured in 1993. This represents a decline of 33 percent over the one-year period.

Table 10 presents the unadjusted Poisson regression coefficients for an analysis of predictors of the time series of monthly counts of injured North Carolina Highway Patrol officers. The overall trend in counts is negative with an estimated 1 percent decline in officers injured for every month over the time span. Almost 50 percent fewer officers were injured subsequent to the issuance of OC spray.

The count of arrests issued is a measure of the exposure of highway patrol officers to the risks of injury from use of force. The count of arrests has been reduced by a factor of 1000 to allow printable values of the exponentiated regression coefficients. Each additional 1,000 citations yields a 1% increase in the number of injuries to officers.

Dummy variables for calendar months were used to capture seasonality in the counts of officer injuries. Officers were significantly more likely to be injured in the months of January through April than other months of the year. A dummy variable was created to more parsimoniously model the elevated risk of injuries in the first four months of the year. On average, injuries to officers were 51 percent higher during these months than during the remainder of the year.

Table 10. Results of a Bivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Officers: North Carolina Highway Patrol

Variable	Regression Coefficient	95% CI	*p* value*
Trend	0.991338	0.9891-0.9936	<.0001
Pepper Spray			
Yes	0.5046	0.4681-0.6344	<.001
No	1 (referent)		
Count of Citations Issued	1.00441	0.9988-1.0100	<.0001
Month			
January	2.121238	1.6717-3.7742	0.01
February	1.787825	1.5176-3.2356	0.05
March	2.151575	1.4531-3.8232	0.009
April	2.454443	1.7067-4.3124	0.001
May	1.30304	1.0797-2.4503	0.41
June	1.545427	1.2014-2.8431	0.16
July	1.666624	1.4076-3.0395	0.09
August	1.727197	1.3098-3.1374	0.07
September	1.242468	1.1724-2.3518	0.51
October	1.48483	1.0467-2.7450	0.21
November	1.30304	1.0467-2.4503	0.41
December	1.0 (Referent)		
Month Collapsed			
Jan, Feb, Mar, Apr	1.510741	1.2214-1.8705	.0001
Other months	1.0 (Referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

An initial multivariate model (not shown here) was tested that fit effects for trend and OC spray. After controlling for the influence of trend, the introduction of OC spray exerted a nonsignificant influence on the monthly counts of officers injured. A second model tested the effect of an OC spray by trend interaction (not shown here). The interaction was also found to be nonsignificant.

Table 11. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Police Officers: North Carolina Highway Patrol

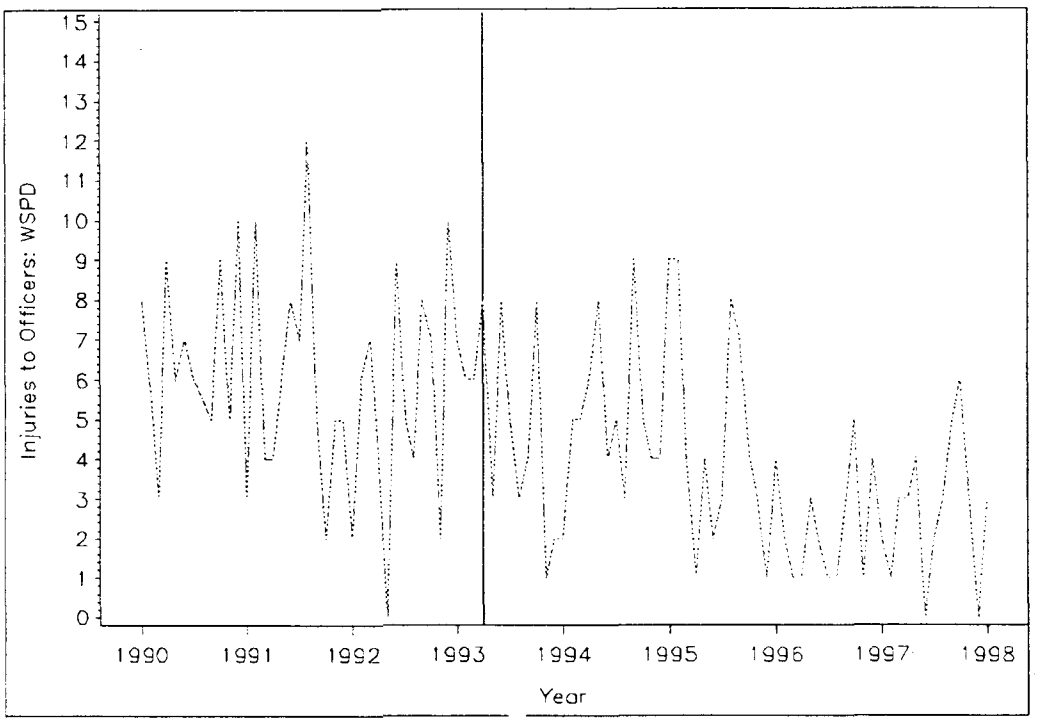
Variable	Regression Coefficient	95% CI	*p* value*
Trend	1.0006	.9954-1.006	.82
Pepper Spray			
Yes	0.48612	.3365-.7024	.0001
No	1.0 (Referent)		
Month Collapsed			
Jan, Feb, Mar, Apr	1.5163	1.2618-1.8225	<.0001
Other months	1.0 (Referent)		

*$\hat{\chi}$ values and corresponding *p* values corrected for overdispersion

Table 11 presents the results of a model that included seasonality of injuries to Highway Patrol officers. The addition of the seasonality effect detrended the time series of monthly counts. OC spray was issued at the beginning of this four-month cycle (January 1993). Officer injuries due to assault declined substantially subsequent to the issuance of OC spray. Due to an indication of moderate overdispersion, standard errors and χ^2 values were corrected.

Winston Salem Police Department: Figure 5 displays the time series of monthly counts of Winston Salem police officers injured in the line of duty by assault. The time series of injury counts extends from January 1990 to December 1998 and includes monthly counts totaling 507 injuries. Comparable to the suspect analysis above, OC spray is dated to April 1993.

Figure 5. Time Series of Counts of Winston Salem Police Officers Injured by Suspects



The pre OC period was characterized by two upward trends in monthly counts of officers injured with August 1991 ending the first trend (12 cases) and December 1992 (10 cases) the second. The post implementation period was characterized by an initial decline, subsequent rise in counts, and a relatively stable period of low counts beginning in December 1995.

Table 12 presents the unadjusted Poisson regression coefficients for an analysis of predictors of the time series of monthly counts of injured Winston Salem police officers. The count of injuries tended to decline overall during the eight-year period by approximately 1 percent per month. The bivariate relationship between the implementation of OC spray and officer injuries is highly significant and indicative of a protective effect on officer safety. Seasonality in the monthly count of officers injured was indicated from the high effect parameters evidenced in August through October. A binary variable capturing the elevated number of injured officers during these months was tested and found to be highly significant. Numbers were 32 percent higher in August through October than in other months.

Table 12. Results of a Bivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Police Officers: Winston Salem Police Department

Variable	Regression Coefficient	95% CI	*p* value*
Trend	0.9908	1.0015-0.9937	<.001
Pepper Spray			
Yes	0.6092	0.5118-0.7252	<.001
No	1 (referent)		
Month			
January	1.052639	0.6752-1.6410	0.86
February	1.28943	0.8442-1.9697	0.38
March	1.078963	0.6939-1.6775	0.80
April	1.026341	0.6565-1.6043	0.93
May	1.0	0.6379-1.5677	1.00
June	1.078963	0.6939-1.6775	0.80
July	0.947337	0.6006-1.4945	0.86
August	1.421056	0.9384-2.1520	0.21
September	1.263139	0.8253-1.9332	0.28
October	1.394729	0.9195-2.1155	0.12
November	0.789465	0.4891-1.2742	0.33
December	1.0 (Referent)		
Month Collapsed			
Aug, Sep, Oct	1.3210	1.0936-1.5957	0.004
Other months	1.0 (Referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Adjusted coefficients for a Poisson regression model representing the time series of monthly counts of injured Winston Salem police officers are displayed in Table 13. The model includes parameters for trend, OC spray, and month of the year. Controlling on seasonality and trend, the issuance of OC spray to Winston Salem officers had a negligible effect on the average monthly count of injured officers.

Table 13. Results of a Multivariate Poisson Time Series Analysis of the Counts of Monthly Injuries to Police Officers: Winston Salem Police Department

Variable	Regression Coefficient	95% CI	*p* value*
Trend	0.99104	0.9857-0.9963	0.004
Pepper Spray			
Yes	0.971416	0.7003-1.3476	0.88
No	1 (referent)		
Month Collapsed			
Aug, Sep, Oct	1.363698	1.1275-1.6478	0.005
Other months	1.0 (Referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Excessive Use of Force Complaints

North Carolina State Highway Patrol: The North Carolina State Highway Patrol was the only institution that provided a sufficiently long time series of excessive use of force complaints to examine an association with the issuance of OC spray to officers.

Figure 6. Time Series of Excessive Use of Force Complaints: North Carolina State Highway Patrol

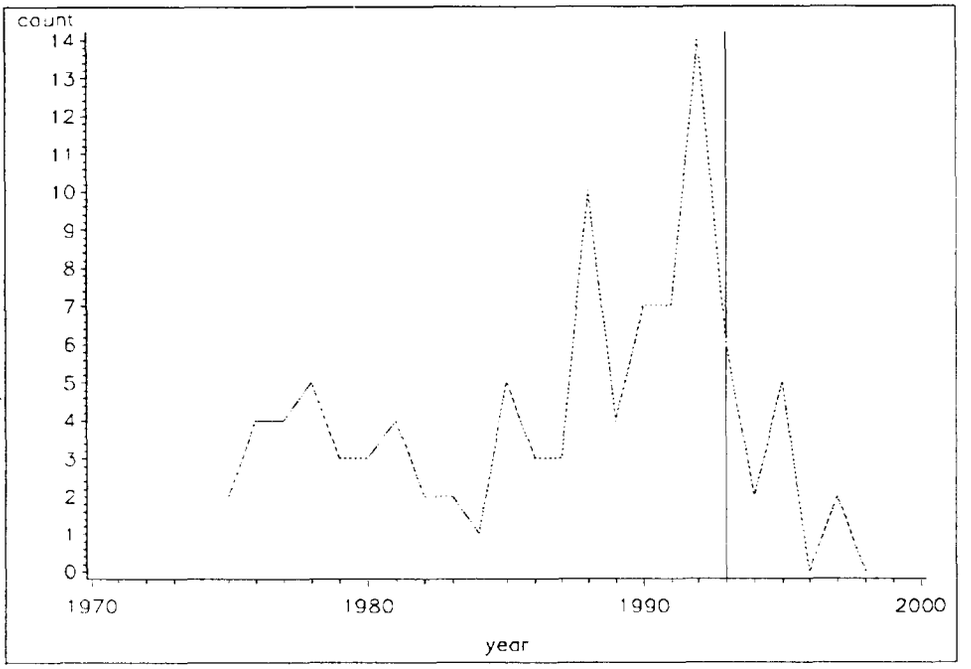


Figure 6 presents a time series of annual counts of excessive use of force complaints filed against North Carolina State Highway Patrol officers. There were a total of 94 complaints filed over the 23 year period from 1975-1998. The time series is characterized by a substantial rise in excessive use of force complaints beginning in 1984 culminating in a high of 14 complaints in 1992. Complaints dropped sharply in 1993 coinciding with the issuance of OC spray to Highway Patrol officers.

Table 14 displays the results of two bivariate Poisson regression models predicting the overall trend in the count of annual excessive use of force complaints and a binary variable coded 0 for years 1975-1992 and 1 for 1993-1998. Both Poisson regressions models are nonsignificant.

Table 14. Results of a Bivariate Poisson Time Series Analysis of the Counts of Excessive Use of Force Complaints: NC State Highway Patrol

Variable	Regression Coefficient	95% CI	*p* value*
Trend	1.008536	0.053-0.9647	0.71
Pepper Spray			
Yes	0.542157	0.2201-0.2359	0.15
No	1 (referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Table 15 displays the results of a multivariate model using trend and OC spay as the two predictor variables. The trend variable indicates that for each additional year, excessive use of force complaints are estimated to have increased by 7 percent over the time series. Based upon this model, there were 75 percent fewer excessive use of force complaints in the post OC spray period than prior to implementation.

Table 15. Results of a Multivariate Poisson Time Series Analysis of the Counts of Excessive Use of Force Complaints: NC State Highway Patrol

Variable	Regression Coefficient	95% CI	*p* value*
Trend	1.071758	1.0149-1.1318	0.01
Pepper Spray			
Yes	0.249799	0.1013-0.6156	0.003
No	1 (referent)		

*χ^2 values and corresponding *p* values corrected for overdispersion

Conclusions and Limitations

Based upon changes in counts of injuries, the findings of this study indicate that the issuance of OC spray was associated with declines in the number of injured NC Highway Patrol officers per month and declines in the monthly counts of suspects injured by uses of force by the Charlotte-Mecklenburg Police Department. Further, declines in excessive use of force complaints lodged against officers of the State Highway Patrol were associated with the implementation of OC spray in that jurisdiction. While OC spray could have been implicated in changing counts of suspects or officers injured in other study sites, available data did not provide sufficient evidence to make those claims.

There were several limitations of the retrospective cross agency approach that this study has taken.

1. Protocols for identification of officer and suspect injury differed considerably across each agency and over the time frame of this study. Systems in place in the North Carolina Highway Patrol and the Winston Salem Police Department in the early part of the decade were primarily text based requiring officers to describe the circumstances leading up to injuries. Variability of articulation as well as recall may have resulted in more or less detail added to narrative accounts that could be used to classify cases.

2. Injuries captured in one system might have been overlooked in others. The NC State Highway Patrol only included reports of cases that were filed with Worker's Compensation. Cases identified in Winston Salem and Charlotte were not limited to those requiring medical attention and/or loss of work. Where available, details of seriousness were captured from the agency data files.

3. Availability of data at each site differed, being largely determined by the level of computer use and sophistication of programming and software. This necessitated the analysis of each agency separately by suspect injuries, officer injuries, and excessive use of force counts.

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