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Authors

Kearney, Thomas
Hiatt, Patricia
Birdsall, Elisabeth
[et al.](#)

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PEPPER SPRAY INJURY SEVERITY: TEN-YEAR CASE EXPERIENCE OF A POISON CONTROL SYSTEM

Thomas Kearney, PharmD, Patricia Hiatt, BS, Elisabeth Birdsall, PharmD, Craig Smollin, MD

ABSTRACT

Background. Pepper spray is a common lacrimator used by law enforcement and the public to subdue individuals and for self-defense. The risk factors for severe injury due to pepper spray exposure are not well documented and there is a lack of guidelines to identify patients that require transport and medical evaluation in an emergency department. **Objective.** The aim of this study was to determine the prevalence of and circumstances associated with symptoms suggestive of tissue injury beyond transient irritation in persons exposed to pepper spray. **Methods.** We reviewed all human exposures to pepper spray reported to a poison control system between 2002 and 2011. Cases were differentiated into 2 outcome groups: minor or self-limiting symptoms versus those with more severe symptoms suggestive of tissue injury that warranted a medical evaluation. A comparison of the variables between the outcome groups was performed using odds ratios (ORs), 95% confidence intervals (CIs), and associated *P* values. **Results.** A total of 4,544 cases were identified and 3,671 met the inclusion criteria. Of these, 249 cases (6.8%) were found to have more severe symptoms that warranted a medical evaluation. There were no reported deaths. The cases with more severe symptoms most commonly involved the ocular (53.8%), respiratory (31.7%), and dermal (17.7%) organ systems. Factors with largest independent associations with more severe outcomes were use for law enforcement training (OR, 7.39; 95% CI, 2.98–18.28), direct intentional exposure for purposeful use to incapacitate (OR, 3.02; 95% CI, 1.80–5.06), and for law enforcement on individual target suspects or crowd control (OR, 2.45; 95% CI, 1.42–4.23). **Conclusions.** There was a low 1 in 15 potential risk for more severe adverse health effects in persons exposed to pepper spray that warranted a medical evaluation.

The risk was highest when used for training of law enforcement personnel and involved severe ocular symptoms. This suggests that routine use of pepper spray for training of law enforcement or military personnel be reconsidered. Protective goggles may be an option when direct spraying into the face of trainees. Transport for medical evaluation should be considered for exposed persons that manifest persistent ocular or respiratory symptoms. **Key words:** capsaicin; tear gas; pepper spray; eye injury; respiratory injury

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INTRODUCTION

Pepper sprays that contain oleoresin capsicum (OC) are used as lacrimators as a nonlethal method to subdue delirious or violent individuals by law enforcement agencies and as riot control agents in an aerosolized delivery system to disable individuals by causing intense irritation of mucous membranes of the eyes, nose, throat, lungs, and skin.^{1–3} They are also used as an animal repellent and are available over the counter to the general public for self-defense.

Oleoresin capsicum is a mixture of more than 100 compounds obtained from the extraction of the fruit of chili peppers from *Capsicum species*.⁴ The principal constituent capsaicin is noted for its irritant properties. The primary mechanism of action is believed to be via stimulation of sensory nerves mediated by the release of neural modulators such as substance P.⁵

The use of OC-containing products has overtaken other lacrimators, such as chloroacetophenone (CN) and orthochlorobenzamalonitrile (CS), due to a perceived safer health profile.⁶ However, the long-term health consequences and risk factors for humans exposed to pepper spray are poorly understood. There may be a risk of serious adverse events requiring medical care in exposures to pepper spray products. Case reports and epidemiologic studies have identified an association between pepper spray exposures and ocular injuries (i.e., corneal erosions, abrasions, and ulcers), pulmonary edema and bronchospasm, and deaths.^{7–17} The prevalence of serious medical outcomes and requirement for medical evaluation in pepper spray exposures has ranged from 2.7 to 15%.^{6,10,14,15}

We reviewed human exposures to pepper spray reported to the California Poison Control System with the goal to determine the severity of pepper spray-related adverse health events. The prevalence of symptoms suggestive of tissue injury beyond transient

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Address correspondence to Thomas Kearney, University of California, San Francisco, UCSF Box 1369, San Francisco, CA 94143-1369, USA. e-mail: pccck@calpoison.org

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irritation in persons exposed to pepper spray was a particular interest. This provides emergency response personnel the risk factors for identifying the more consequential medical outcomes, by organ system, associated with pepper spray exposure. Furthermore, this study could serve as the basis for triage guidelines for transport of pepper spray exposure cases to emergency departments.

METHODS

Study Design and Case Inclusion

The California Poison Control System (CPCS) has served the state since 1997 and has an archived case database of all poison exposures reported to its 24/7 hotline service. It serves a population of more than 35 million and manages more than 200,000 exposures each year. The poison control system provides treatment advice and referral assistance to the public as well as to health-care professionals through four highly integrated sites operating under a single administration. Poison control center services are available to all residents through a toll-free emergency hotline, 24 hours a day, 365 days a year. Each reported poisoning case is entered prospectively into a clinical database (Visual Dotlab[®]) by trained poison center specialists (Specialist in Poison Information). The specialists are licensed pharmacists or nurses with special training in clinical toxicology. They are individually certified by the American Association of Poison Control Centers after passing a standardized national examination. For each case the specialists enter specific product, symptom, treatment, and outcome codes according to American Association of Poison Control Center criteria. The initial and follow-up notes are also entered into a text field constituting a time-stamped case narrative, which can be reviewed in its entirety.

A retrospective chart review of the CPCS electronic database was conducted for pepper spray exposure consultations provided between October 1, 2002 and September 30, 2011. The study was approved by the University of California San Francisco institutional review board.

Eligible cases involved all humans aged 6 years or greater who were exposed to pepper spray. Most exposures involved aerosolization but nonaerosolized cases, involving exposure to a leaking container or other spill, were included. Young children less than 6 years of age were excluded from this analysis since most of these involved nonaerosolized inconsequential exposures (e.g., lick or taste of container) and were generally reported to have minimal symptoms. For all cases meeting the inclusion criteria we read the entire case narratives with time sequences to ensure accurate coding of symptoms, outcomes, and treatments.

Data Analysis and Coding

Cases meeting the inclusion criteria were analyzed and aggregated as a cohort within a 10-year time period. The review period was chosen to provide a sufficient sample size and represent recent trends. Data fields of interest included: patient demographics (age/gender), reason or circumstance of use or exposure, intended use of product, route of exposure, symptoms/types of adverse health effects experienced, management site (e.g., non-health-care facility vs. health-care facility), and outcome. Outcomes were dichotomized by the investigators as minor or self-limiting symptoms (cases with transient symptoms as is typical of exposure) vs. those with more severe symptoms that warranted medical evaluation following a review of the time-sequenced case narratives and based on a priori criteria with the case definitions below. Case definitions were developed from the approved triage criteria utilized by the poison control center and medical compendia *Tintinalli's Emergency Medicine*¹⁸ and *Current Diagnosis & Treatment in Pulmonary Medicine*.¹⁹

Case Definitions

Minor outcomes were cases with symptoms defined as self-limiting effects and symptoms; dermal/skin effects include erythema, swelling, pain, and itching (prolonged pain of several hours may be expected in persons not adequately decontaminated); ocular effects include initial pain, tearing, and redness; respiratory effects include initial cough and choking, throat irritation (suggestive of upper airway irritation); and gastrointestinal effects include nausea and vomiting.

Cases were deemed as more severe outcome and where medical evaluation was needed if they had symptoms that suggested more significant tissue injury that may require specific medical care beyond field decontamination. Examples of symptoms, diagnostic findings, or care rendered for cases assigned to the more severe group were as follows: (1) dermal/skin symptoms included rash and/or blisters suggestive of a persistent dermatitis and/or dermal second degree burn; (2) ocular symptoms included persistent pain (more than an hour beyond the completion of a sufficient eye irrigation), blurred vision, foreign body sensation, photophobia, discharge or exudate, or periorbital swelling (symptoms suggestive of a possible corneal abrasion, iritis, or ocular infection); and (3) respiratory symptoms included shortness of breath, chest tightness, or wheezing (suggestive of bronchial and/or lower airway irritation or injury). Cases with documented abnormal ocular (e.g., slit lamp) examinations and diagnosis, as well as administered ocular therapies (e.g., ophthalmic antibiotics

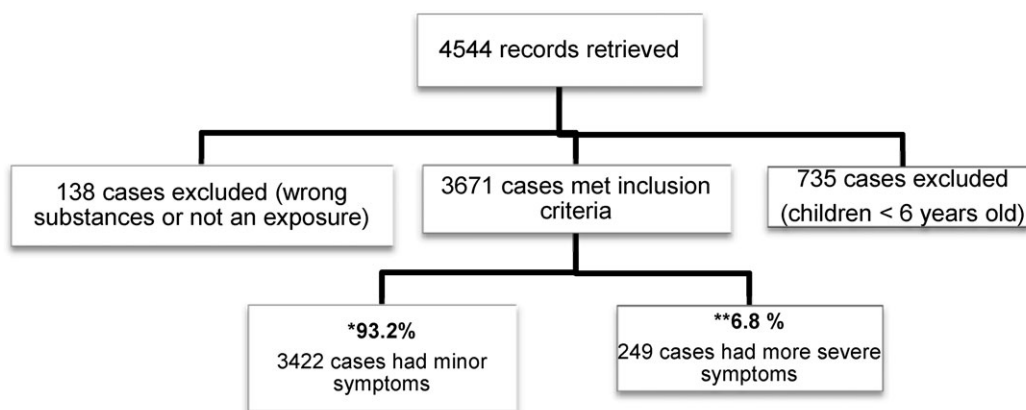


FIGURE 1. Algorithm for outcome of California Poison Control System cases of exposure to pepper spray. *Minor symptoms defined as self-limiting and transient; **moderate symptoms defined as suggests that medical evaluation is warranted.

or steroids) were noted. Cases that had documented histories of asthma, abnormal physical or pulmonary function examinations, as well as administered respiratory therapies (e.g., bronchodilators) were also noted.

The circumstances (intent, individual responsible, and type of product), routes of exposure, symptoms by organ system, and other specific medical therapies provided were coded for all cases. The circumstance codes were grouped and defined as follows: (1) unintentional direct is an accidental exposure but the person was sprayed directly; (2) intentional direct is a purposeful exposure such as law enforcement to subdue a suspect or by an individual to incapacitate another when threatened or during a training exercise; (3) indirect is an environmental exposure such as walking into area where pepper spray released; (4) direct unknown is a direct contact with spray, but the intent is unknown. Codes for the product type and intended use were (1) self-defense (public); (2) animal repellent; (3) law enforcement with use on an individual victim as target and crowd control, and (4) law enforcement with use for training of personnel.

Statistical Analysis

We used standard statistical tests to analyze the comparative demographics between the groups for gender and age. Means and standard deviations were calculated for continuous variables. Normally distributed variables were compared by a *t* test and categorical variables by χ^2 . Associations between exposure characteristics and moderate symptoms were analyzed by univariate analysis to determine odds ratios (ORs), 95% confidence intervals (CIs), and associated *p* values. The significance threshold was $p \leq 0.05$ in all tests. Data were analyzed using Microsoft Excel 2010 (version 14.0.6123.5001).

RESULTS

A total of 4,544 cases were identified and 3,671 met the inclusion criteria. Figure 1 is an algorithm of cases reviewed and provides a summary of reasons for exclusion of cases and the final outcomes for included cases. No deaths were reported and 249 cases (6.8%) had more severe symptoms. Table 1 summarizes the comparative demographics (age and gender) between the two groups. In both groups, minor or self-limiting symptoms and those with more severe symptoms, 51 and 55% of exposures involved males, respectively. The average age of individuals in the minor symptoms group was 24 years (range, 6–94) and in the more severe symptoms group, 23 years (range, 7–45). The differences between the group ages were not statistically significant ($p = 0.79$).

Table 2 summarizes the comparative circumstances and routes of exposures for cases in the minor or self-limiting symptoms vs. more severe symptoms group. The common reasons for and circumstances of exposure for all cases included indirect exposure, such as contact with sprayed animal or in a room where spray was discharged (24%); unintentional direct spray, such as accidental discharge (19.4%); and intentional direct spray, such as use by law enforcement or for self-defense (7.2%). The most common known intended

TABLE 1. Comparative demographics of 3,671 pepper spray exposure cases reported to a poison control center

Demographics	Minor/self-limiting symptoms (n = 3,422)	More severe/ medical evaluation needed (n = 249)
Gender		
M	1,746 (51%)	136 (55%)
F	1,609 (40 pregnant)	113 (4 pregnant)
Unknown	67	
Age		
Mean (SD)	24 (15.1)	23 (14.1)
Range	(6–94 years)	(7–45 years)

TABLE 2. Comparison of pepper spray exposures between cases with minor/self-limiting symptoms versus more severe symptoms warranting medical evaluation

	Minor/self-limiting symptoms (n = 3,422)	More severe/medical evaluation needed (n = 249)	Total (n = 3,671)
Type of exposure (intent), n (%)			
Unintentional, direct	680 (19.9)	31 (12.5)	711 (19.4)
Intentional, direct	232 (6.8)	32 (12.9)	264 (7.2)
Unknown, direct	1,672 (48.9)	144 (57.8)	1,816 (49.5)
Indirect	838 (24.5)	42 (16.9)	880 (24.0)
Intended use of product, n (%)			
Self-defense	491 (14.3)	32 (12.9)	523 (14.2)
Animal repellent	203 (5.9)	10 (4)	213 (5.8)
Law enforcement	121 (3.5)	21 (8.4)	142 (3.9)
Law enforcement training	14 (0.41)	8 (3.2)	22 (0.6)
Unknown	2,592 (75.8)	178 (71.5)	2,771 (75.5)
Route of exposure, n (%) ^a			
Dermal	2,080 (60.8)	103 (41.4)	2,183 (59.5)
Ocular	1,752 (51.2)	161 (64.7)	1,913 (52.1)
Inhalation	678 (19.8)	76 (30.5)	754 (20.5)
Ingestion	152 (4.4)	2 (0.8)	154 (42.0)

Type of exposure (intent) – unintentional direct, for example, accidental exposure but sprayed directly on person; intentional direct, for example, purposeful exposure sprayed directly on person; indirect, for example, environmental exposure, such as walking into area where pepper spray was released; direct unknown, for example, direct contact with spray but intent is unknown. Intended use of product/product type – self-defense (used by public), animal repellent (bear or dog most commonly), law enforcement (individual target or for crowd control), law enforcement training (intentional use on officers), unknown (original purpose of spray not known).

^aMultiple routes of exposure are possible.

use for pepper spray was self-defense (14.2%) followed by use as an animal repellent (5.8%) and law enforcement (4.5%). The most common route of exposure was dermal (59.5%) followed by ocular (52.1%), and inhalation (20.5%). Note that several cases had multiple routes of exposure.

Table 3 categorizes, by organ system (i.e., ocular, dermal, respiratory), the health effects for the 249 more severe cases reported following pepper spray exposure. The most common effects were ocular or eye injury, such as possible corneal abrasion (53.8%); respiratory, such as bronchospasm (31.7%); and dermal burns/blisters (17.7%). Table 4 lists the risk factors with the largest associations for more severe symptoms among all 3,671 cases. Factors with largest independent associations with more severe outcomes were use for law enforcement training (OR, 7.39; 95% CI, 2.98–18.28), direct intentional exposure for purposeful

use to incapacitate (OR, 3.02; 95% CI, 1.80–5.06), and use for law enforcement on individual target suspects or crowd control (OR, 2.45; 95% CI, 1.42–4.23). This was followed by inhalation exposures (OR, 1.77; 95% CI, 1.34–2.35) and ocular exposures (OR, 1.65; 95% CI, 1.26–2.16).

DISCUSSION

Our experience with pepper spray exposures managed by a poison control system suggests that there is a low risk for more severe adverse health effects in persons exposed to these products. The prevalence of severe symptoms of 6.8% seen in our study is consistent with the range (2.7–15%) observed in other epidemiological studies.^{6,10,14,15} The severity of health effects from pepper spray exposures may be contingent on several product-, dispersal-, and patient-related factors.³ Pepper spray products have varying capsaicin and capsaicinoid concentrations, as well as different solvents that

TABLE 3. Severe adverse health effects by organ system from pepper spray exposure (N = 249)

Body/organ system effect	Associated signs and symptoms	n	% ^a
Ocular	Persistent pain, blurred vision, foreign body sensation, discharge or exudate, periorbital swelling ^b	134	53.8
Respiratory	Shortness of breath, chest tightness, wheezing ^c	79	31.7
Dermal	Rash, blisters	44	17.7

^aTotal is >100%. Multiple symptoms were present in many patients but only 6 patients had significant adverse effects in more than one organ system.

^b12 cases had a documented corneal abrasion.

^c10 cases had documented wheezing and bronchospasm.

TABLE 4. Association of factors with risk of more severe symptoms among 3,671 cases of pepper spray exposures

Factor	95% CI		
	OR	(lower, higher)	P
Training of law enforcement personnel (yes/no)	7.39	2.98, 18.28	<0.001
Intentional direct ^a (yes/no)	3.02	1.80, 5.06	<0.001
Used for law enforcement (yes/no)	2.45	1.42, 4.23	= 0.001
Inhalation exposure (yes/no)	1.77	1.34, 2.35	<0.001
Ocular exposure (yes/no)	1.65	1.26, 2.16	<0.001

^aPurposeful exposure sprayed directly on person.

serve as carrying or suspending agents.^{3,4,7} The dispersal system for these products ranges from a liquid spray to aerosolization, thus dictating particle size and penetration into mucosal membranes and airways.

The variable with the greatest predictability for more severe symptoms was direct intentional exposures on law enforcement personnel for training. Case reports of more serious injuries to the eye from pepper spray have involved training of civilian and military law enforcement.⁸ Seven out of eight cases with severe symptoms due to exposure from training of law enforcement personnel in our series involved the eyes. The symptoms persisted from a minimum of 3 hours to 5 days. The other case involved respiratory symptoms — a persistent cough for over a day. Noteworthy was a case in which ocular decontamination was performed, the symptoms seemed to lessen, but became worse at 24 hours, and a corneal abrasion was diagnosed in the emergency department. Our case had a similar course as one cited in the literature.⁸ This suggests that routine use of pepper spray for training of law enforcement or military personnel be reconsidered. Use of protective goggles by trainees may be an option when direct spraying into the face to prevent exposure to the eyes.

The circumstances of the exposure can impact the intensity and dose delivered to include the distance between the patient and release point of the spray, duration of contact, and degree of confinement and ventilation. Co-ingestants by the patient, in particular sympathomimetics, chronic disease states, contact lens, and the ability to promptly and thoroughly irrigate exposed areas may impact the severity.^{7–16} For a given case it may be difficult to ascertain all risk factors, so we used broad categories to characterize exposure circumstances and determine if any were prognosticators for more severe outcomes. The presence of law enforcement in our study was a predictor of higher risk for adverse outcomes. This is most likely due to their presence in situations of higher risk that might require longer OC applications or other forceful tactics for control. These tactics have a higher potential for injury but may be necessary based on the subject's behavior.

Ocular exposure and symptoms are primary targets for riot control agents to incapacitate or deter individuals. Acute exposure to pepper spray results in immediate eye pain, tearing, blurred vision, and blepharospasm. More long-lasting and consequential ocular and conjunctival injuries include corneal ulcers, erosion, and abrasions, conjunctival proliferation, and persistent dry eyes.^{7–10}

The respiratory system is also at risk of significant toxicity following OC exposure. The principal symptoms observed with mucous membrane and respiratory tract exposure are cough and transient throat irritation.^{1,3} Bronchospasm and laryngospasm

have been reported, including one reported death.^{11,12} The effects on airway resistance are variable and often noted as transient.⁵ It has not been shown that asthmatics are at higher risk for OC-induced bronchospasm.⁵

The prehospital management of a person exposed to pepper spray should include prompt on-scene removal from exposure, decontamination, and monitoring for respiratory distress. If a cough or respiratory distress develops, the patient should be evaluated for hypoxia. Initial treatment may include 100% humidified supplemental oxygen and inhaled beta adrenergic agents, e.g., albuterol, if bronchospasms develop. Eye exposures should be irrigated using copious amounts of room-temperature water or normal saline for at least 15 minutes. Contact lenses should be removed prior to the irrigation procedure. If a high level of spray residue is present in the clothing it should be removed and placed in sealed plastic bags for either washing or disposal. This situation could pose a risk for secondary contamination and those involved in the response and care of exposure victims should use personal protective measures, such as rubber gloves, aprons, goggles, and masks. Exposed skin should be copiously irrigated. Topical application of magnesium–aluminum hydroxide containing antacids to pepper spray exposed skin following an irrigation procedure may alleviate pain.²⁰ However, a randomized controlled study did not find this treatment effective in providing pain relief following OC exposure in law enforcement trainees.²¹

There are no clear guidelines indicating which patients should be triaged to a health-care facility. One source from the Police Policies Studies Council recommends that the exposure victim be brought to a hospital if symptoms persisted for longer than 45 minutes.² They also noted that an officer sprayed during training should wait at least 4 hours to allow the conjunctivitis to subside before driving a car. The triage decision should be made on the collective assessment of the severity and organ system involved. There should be a higher priority for those with severe respiratory symptoms. One caveat is the phenomenon of a waxing and waning of symptoms, particularly ocular ones. Patients should be counseled about the potential delay and worsening of ocular symptoms for up to a day later as well as provided specific symptoms suggestive of corneal injury.

LIMITATIONS

There are several limitations to the data. The retrospective review of the data source used (poison control center case reports) was an inherent limit to completeness of the data. Poison center staff will focus on patient management and were not under protocol to collect

detailed circumstantial information. As a result, some information may be missing in our data set. In addition, patients are frequently lost to follow-up due to patients leaving against medical advice or having already been discharged upon follow-up call, as well as due to workload limitations. This explains the minimal information about long-term health consequences in the severe outcome group.

As this is an observational study and retrospective review, we are unable to claim a definitive causal relationship between the exposure and resultant symptoms or outcomes. There are likely other variables or confounders present. For example, we don't know the precise time and effectiveness of decontamination procedures or other interventions performed on exposure victims. Since exposures to pepper spray are principally from aerosolization of multiple products (with variable concentrations of capsicum, solvents, and propellants), the particle size, dose administered, and impact of the ingredients are difficult to estimate. Our results may also be subject to reporting bias because reports to the poison control center are voluntary and may not reflect the true population prevalence of pepper spray exposures and outcomes. We chose a time period of 1 hour or longer to delineate the threshold for persistence of symptoms by the reviewers, which was based on the triage criteria utilized by the poison center. This may have resulted in reviewer bias with the misclassification of some cases into the severe outcome group. In addition, case outcomes were determined by associated signs and symptoms and not by physician diagnosis. However, our overall prevalence results were consistent with previous studies and our time interval defining persistence exceeded that of other references.² Our review does not address chronic toxicity or residual disability in persons exposed to pepper spray to include effects on pregnancy.

CONCLUSION

Our experience with pepper spray exposures managed by a poison control system suggests that there is a low 1 in 15 potential risk for more severe adverse health effects involving ocular and respiratory injury. The risk was notably highest when used for training of law enforcement personnel when directly sprayed in the face resulting in severe ocular symptoms. This suggests that routine use of pepper spray for training of law enforcement or military personnel be reconsidered. Use of protective goggles by trainees may be an option when direct spraying into the face to prevent exposure to the eyes. Emergency response personnel should consider transport for medical evaluation in an emergency department for pepper spray-exposed persons that manifest persistent ocular or respiratory symptoms following decontamination procedures.

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