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What is the safety of “pepper spray” use by law enforcement or mental health service staff?

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LEVEL OF EVIDENCE CONSIDERED IN TECH BRIEFS

Tech Briefs are rapidly produced assessments of the *best available evidence* for a topic of highly limited scope. They are less rigorous than systematic reviews. Best evidence is indicated by research designs which are least susceptible to bias according to the Australian National Health and Medical Research Council's (NHMRC) criteria (see **Appendix 1**). Where methodologically acceptable and applicable, appraised evidence is limited to systematic reviews, meta-analyses, evidence-based clinical practice guidelines, health technology assessments and randomised controlled trials (RCTs). Where not available, poorer quality evidence may be considered.

CONFLICT OF INTEREST

None.

BACKGROUND

This Tech Brief was requested by Mr Anthony Duncan, Deputy Director of Mental Health, Mental Health Directorate, Ministry of Health, New Zealand Government.

Oleoresin capsicum (OC) spray, referred to here as “pepper spray”, is a chemical incapacitant causing intense irritation of the mucous membranes and skin. The organic agent oleoresin capsicum contains the active ingredient capsaicin, obtained from cayenne pepper plants. It is usually mixed with a carrier agent for dispersion, such as oil, alcohol or kerosene for application using an aerosol spray (Chambers, 2000).

Pepper spray has been employed as a less-than-lethal inflammatory agent in civilian, government and military sectors, and particularly for law enforcement, criminal incapacitation and, in the United States of America (USA), personal self-defense. First used in the USA in 1973 by Federal Bureau of Intelligence (FBI) personnel who approved it for police use¹, it became widely adopted by law enforcement agencies from the late 1980’s (Kaminski et al. 1999). Pepper spray has also been used in correctional facilities in the USA (American Civil Liberties Unions of Southern California, 1995). Though banned in Sweden because of its potential to cause eye damage, it has been increasingly used by European security forces in Belgium, Luxembourg, Netherlands, and Switzerland (Chambers, 2000). The Home Office reportedly recommended that pepper spray be not introduced by British police services due to health concerns. In contrast, pepper spray is available for use by police across Australia, albeit in some States on a trial basis (Criminal Justice Commission and Queensland Police Service, 1999). The New Zealand police introduced pepper spray to front line members in 1997 as a less-than-lethal option when dealing with violent incidents where injury is likely to ensue (Doone, 1997).

Inhalation of, and skin and eye contact with, pepper spray causes an almost instantaneous onset of responses. Effects on the eyes include severe burning pain, involuntary closure, lacrimation (tearing), conjunctival inflammation, redness, swelling and blepharospasm (eyelid twitching). Skin contamination causes tingling, burning pain, edema, erythema and occasional blistering. Respiratory symptoms include nasal irritation, bronchoconstriction, a burning sensation in the throat, severe coughing and sneezing, and shortness of breath (Olajos and Salem, 2001). More systemic effects include disorientation, panic and loss of body motor control (Smith, 2002). Most symptoms resolve within 30 to 45 minutes. The inflammatory properties of pepper spray have been suggested as being particularly effective in managing violent, intoxicated, drugged and mentally ill people who may be less susceptible to pain. However, some data (Edwards et al. 1997; Granfield et al. 1994; ACLA of Southern California, 1995) suggest that precisely such individuals “may be resistant or immune to OC’s effects or that OC may actually exacerbate the difficulty associated with controlling such persons” (pg 6) (Edwards et al. 1997). Acute effects of capsaicin have been suggested including bronchospasm, respiratory arrest, pulmonary edema, hypertensive crisis and hypothermia as well as serious respiratory and cardiovascular effects and permanent damage to the sensory nervous system (Stopford, 1996; Olajos and Salem, 2001).

The safety of pepper spray is the subject of this Tech Brief. It aims to consider evidence for adverse events of pepper spray used in ways comparable to their application by police officers or mental health service personnel to acutely subdue a disturbed person. It also aims to identify situations or populations related with increased risk².

¹ Approval has been controversial after FBI special agent Thomas WW Ward was later prosecuted for “taking a kickback” of US\$57,000 from a pepper spray manufacturer (Chambers, 2000).

² This information is being gathered along with another NZHTA Tech Brief on an alternative approach in similar circumstances: Day, P. What evidence exists about the safety of physical restraint when used by law enforcement and medical staff to control individuals with acute behavioural disturbance? *NZHTA Tech Brief Series 2002*; 1(3).

SELECTION CRITERIA

Study inclusion criteria

Publication type

Studies published to May 2002 in the English language, including primary (original) research (published as full original reports) and secondary research (systematic reviews and meta-analyses) appearing in the published literature.

Intervention

Aerosol exposure of Oleoresin capsicum (OC) or “pepper spray” at levels consistent with administration for restraint purposes.

Population

Adult individuals (aged 16 years and over) exhibiting acute behavioural disturbance – i.e., exhibiting: extreme agitation, aggressive, destructive, disruptive, assaultive, violent or hostile behaviour, and/or behaviour which places the individual or those around them at risk of physical harm.

In experimental settings, studies of healthy volunteers were also considered.

Setting

Use by law enforcement officers (police services) or mental health services to acutely subdue a disturbed person.

Sample size

Studies with samples of at least 20 participants.

Outcomes

Medium and long-term adverse health effects including:

- psychological indices – e.g., post-traumatic stress syndrome
- pulmonary function
- respiratory function
- ocular function
- dermal injury
- death.

Follow-up

Outcomes that persist **at least one hour** after exposure to pepper spray – i.e., excluding temporary physical responses which may be associated with its effectiveness as an incapacitant.

Study exclusion criteria

The following criteria will be used to exclude studies from appraisal.

Studies reporting on include:

- animal experimentation
- aqueous nasal sprays or topical applications
- use of other chemical sprays such as mace

- use of pure capsaicin, which is about 10 times more potent than OC used in pepper sprays (Lee et al. 1996)
- propellants or carriers used in the sprays in isolation from OC
- use of pepper spray by the general public for personal self-defence
- use of pepper spray as a treatment (e.g., for nasal complaints, rheumatoid arthritis, osteoarthritis, peripheral neuropathies)
- use of pepper spray for “crowd” or “riot” control of groups of persons.

Studies which:

- had samples of fewer than 20 participants
- included samples where any study participant was under 16 years of age
- investigated pain or cough mechanisms through OC responsiveness
- were single case presentation/series/reports
- were expert opinions, editorials, or non-systematic, narrative reviews
- did not clearly describe their methods and results, or had significant discrepancies
- were “correspondence”, book chapters, conference proceedings, abstracts only
- were not published in English.

MAIN SEARCH TERMS

Details of the search strategy are presented in **Appendix 2**.

- index terms from Medline: capsaicin, capsicum
- index terms from Embase: capsaicin, capsaicin derivative.

The above index terms were used as keywords in databases where they were not available and in those databases without controlled vocabulary:

- additional keywords (not standard index terms) were used in all databases: pepper spray, oleoresin capsicum, spray, assault, emergenc\$, polic\$, restrain\$.

SEARCH SOURCES

The NZHTA core search that is usually employed for Tech Briefs was not employed for this topic given the nature of the initial request. A more extensive search strategy was necessary in order to identify the pertinent “grey literature” in this area.

An initial search for key articles from the health literature was carried out in September 2001. This was updated and extended into a comprehensive, wide-ranging search in May 2002. Filters for high quality study designs were not employed. Articles published in English language only were considered.

Major sources of information were:

Bibliographic databases

- Medline
- Premedline
- Embase
- Current Contents
- Cinahl
- Amed
- Psychinfo
- Science Citation Index
- International Pharmaceutical Abstracts

- Cochrane Controlled Trials Register
- Index New Zealand

Review databases

- Cochrane Database of Systematic Reviews
- Database of Abstracts of Reviews of Effectiveness
- NHS Economic Evaluation database
- Health Technology Assessment database
- ACP Journal Club

Other sources

- New Zealand bibliographic database and selected large international library catalogues
- Websites of all member agencies affiliated to the International Network of Agencies for Health Technology Assessment (INAHTA), and other selected health technology agency websites
- Evidence-based compilations and gateways
- Guidelines sites
- Selected health and justice government agencies in the United States, UK, New Zealand, Australia, and Canada
- Reference lists of papers retrieved in the course of the review
- Contact people in the New Zealand Police College Library, New Zealand International Documents Collection, New Zealand Ministry of Justice Library, US Agency for Health Research Quality Information Service, and New Zealand Police
- Contacts with INAHTA colleagues

Extensive efforts were undertaken to trace unpublished “grey” literature (including government and police agency reports) as identified in citations of retrieved publications. One author was contacted by email to provide his unpublished report and a Masters thesis was purchased from the University of New South Wales, Australia.

A complete list of sources searched is given in **Appendix 2**.

APPRAISAL METHODOLOGY

Summaries of appraisal results will be shown in tabular form (known as *Evidence Tables*) which detail study design, study setting, sample, methods, results, limitations and conclusions.

The evidence presented in the selected studies were assessed and classified according to the NHMRC’s revised hierarchy of evidence (**Appendix 1**).

RESULTS

From the above search strategy we identified, 93 potentially relevant articles/abstracts of which 37 were eligible for retrieval. Of these, 30 were excluded for the following reasons: expert opinion or narrative reviews (n=11), case reports with sample size of fewer than 20 (n=4), not relevant to the topic (n=3), outcomes not measured beyond one hour post pepper spray exposure (n=3), letter only (n=3), related to topical application of pepper spray (n=2), abstract only (n=2), did not clearly describe their methods and results (n=1), paper not retrieved within the review timeframe (n=1). These excluded papers, annotated with the reason for exclusion and a brief description of content, are listed in **Appendix 3**.

Seven retrieved articles were appraised (listed in **Appendix 4**). Included papers are presented in the evidence table below. Using NHMRC’s hierarchy of evidence, all papers were graded Level IV. Papers are presented in alphabetical order within each level of evidence.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
American Civil Liberties Unions of Southern California (1995) California, USA	Level IV	<p>Study setting American Civil Liberties Unions of Southern California (ACLU) identified in-custody deaths after use of pepper spray.</p> <p>Participants n=26 incidents where persons in custody died after confrontation with police involving pepper spray. Only reported on 24 where complete data was available.</p> <p>Sample characteristics 100% male Mean age=35 years, range: 21-47. 54% White, 19% Black, 27% Latino 96% involved a struggle 85% drugs/alcohol involved, 8% unknown, 8% no involvement 100% “irrational” combative behaviour.</p> <p>61% showed evidence of serious underlying heart or respiratory disease including 8% (n=2) who were asthmatics; 31% unknown; 8% no underlying condition.</p> <p>OC effectiveness Not at all effective (100%).</p> <p>Restraint/control methods after OC Hobble restraint or “hog-tie” (50%) Handcuffs (23%) Cuff/leg restraint (4%) Tasers/“stun guns” (8%) Baton (23%).</p>	<p>Study design Retrospective case series between Jan 1993 – May 1995.</p> <p>Inclusion criteria In-custody death incidents where pepper spray has been used in California.</p> <p>Exclusion criteria Cases where sufficient information (autopsy and police reports) was not available to come to a reasonable conclusion about cause of death.</p> <p>Outcome measures Cause of death after review from following sources:</p> <ul style="list-style-type: none"> ▪ coroner or medical examiner records ▪ California Environmental Protection Agency’s Office of Environmental Health Hazard Assessment documents ▪ published news accounts ▪ interviews with witnesses and family of the deceased ▪ interviews with investigating law enforcement officers ▪ review of incident reports filed with the Californian Department of Justice ▪ reports by the Special Investigations Division of the Los Angeles County District Attorney’s Office. 	<ul style="list-style-type: none"> ▪ pepper spray was not officially cited as the cause of death for any case ▪ time from spray to death was one hour or less in most cases (79%) ▪ sample included two cases where direct cause of death was suicide shortly after pepper spray use, and one was officer-involved shooting ▪ there were lethal doses of drugs in 25% of the sample ▪ report concluded that in 12 cases (50%), restraint practices materially contributed to the cause of death, and in 25% of all cases positional asphyxia or a struggle was mentioned in Cause of Death ▪ report concluded that pepper spray may be a serious complicating factor when used on people with cardiovascular or cardio-respiratory disease, especially asthma, and when used in combination with restraint techniques such as the “hog-tie”. 	<p>Limitations</p> <ul style="list-style-type: none"> ▪ small sample ▪ lack of information on pepper spray concentration and distance sprayed, though frequency and context described in detail ▪ outcome measures are not validated: autopsy reports are notoriously non-specific with little pathological evidence making conclusions open to interpretation. Extraction of data is assumed to be qualitative and not blind ▪ interviews with friends, relatives, attorneys of the deceased, and police, as well as media reports, may provide biased testimony, especially as litigation has sometimes been initiated ▪ no comparison groups of people taken into custody in similar conditions, where pepper spray was not used, or where death did not occur, to investigate causation systematically ▪ retrospective, no control group. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Brown et al. (2000) USA	Level IV	<p>Study setting Hospital emergency area for adults in custody in jail.</p> <p>Response/chart availability rate = 82% (100/122).</p> <p>Participants n=100 patients in custody exposed to pepper spray (10% OC) applied by police officers.</p> <p>Sample characteristics 87% male Males' mean age=31.8 years Female's mean age=36.8 years</p>	<p>Study design Retrospective case series (emergency physician medical record review of eligible presentations for 3 years between 1994 – 1996).</p> <p>Inclusion criteria Had medical records available containing the words “pepper spray” in the final diagnosis. Multiple presentations allowed (n=1).</p> <p>Exclusion criteria No medical records/chart available for review.</p> <p>Outcome measures Standardised data record sheet used by single data collector to extract recorded data including demographics, diagnosis, symptoms, and treatment.</p> <p>Follow-up interval Whilst attending the emergency area.</p>	<p>Symptoms on arrival</p> <ul style="list-style-type: none"> ▪ scleral injection (38%) ▪ corneal abrasions (7%) ▪ slightly alkalotic conjunctival pH of 8 (2%), which returned to normal after irrigation ▪ 52% had concomitant illicit drug or alcohol use ▪ 44% had acute traumatic injuries in addition to pepper spray. 	<p>Limitations</p> <ul style="list-style-type: none"> ▪ no data on potential confounders such as physical restraint practices, use of pepper spray (such as distance sprayed), and decontamination methods ▪ 10% OC used instead of usual 5% ▪ selection bias. Only considered those who had received medical attention ▪ no data on respiratory or dermal health effects as outcomes ▪ follow-up period not clear, but likely to have been more than one hour ▪ no repeated, longer-term follow-up ▪ not clear what factors may have contributed to corneal abrasions (content of pepper spray such as OC, carrier, and/or propellant, distance sprayed, eye rubbing, etc) ▪ retrospective, no control group. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events. However, an association with pepper spray use appears plausible. The role of other contributing factors is not clear.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Criminal Justice Commission and Queensland Police Service (1999) Queensland, Australia	Level IV	<p>Study setting Trial of pepper spray at two regional sites of the Queensland Police Service: South-east (SE) region, and Metropolitan North (MN) Region.</p> <p>Participants n= 40 suspects were sprayed with “burst” type pepper spray by police officers (mostly Constable and Senior Constable rankings) in 28 incidents during the study trial.</p> <p>Sample characteristics (of 40 subjects)</p> <ul style="list-style-type: none"> ▪ 37 adult males, 2 juvenile males, one adult female ▪ “most aged in their 20’s” ▪ 22 reported by police to be affected by alcohol and/or drugs ▪ 9 were reported to be “under psychiatric care”. <p>Note Use on dogs also recorded but excluded from data reported on here.</p>	<p>Study design Retrospective case series: review of incident reports by police officers during trial of pepper spray between March 1998 – March 1999.</p> <p>Inclusion criteria Officers in the SE and MN regions who used the pepper spray during the trial period.</p> <p>Exclusion criteria None described.</p> <p>Outcome measures Any data on injuries or deaths caused by application of pepper spray extracted from “use of force incident reports”. Other outcomes and measures related to effectiveness are not discussed here.</p> <p>Follow-up period is unspecified.</p> <p>Also an email survey sent to 824 officers with 72 respondents (9% response rate) of whom 22 had used pepper spray.</p>	No deaths, reported injuries or other medical problems as a direct result of pepper spray use.	<p>Limitations</p> <ul style="list-style-type: none"> ▪ small sample ▪ no data on potential confounders such as physical restraint practices, distance sprayed, decontamination ▪ no data on pre-existing medical conditions of sprayed subjects and drug and psychiatric status not validated ▪ outcomes based on self-report data by officers at unknown follow-up. No information about the completeness of data from incident reports. Not clear whether all incidents of pepper spray use were reported. Potential for bias ▪ no data collected from suspects, medical data, or any follow-up. ▪ data extraction not described. Incident report’s emphasis was on effectiveness and injury to officers. Not clear whether incident forms specifically elicited injury information ▪ not clear whether (poorly responded) email survey contributed to safety data ▪ retrospective, no control group. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ small sample size and a vague outcome measure by officer self-report likely to reduce the likelihood of identifying adverse events ▪ the study design is poorly able to establish a clear causal link between pepper spray use and adverse events.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Granfield et al. (1994) USA	Level IV	<p>Study setting International Association of Chiefs of Police (IACP) collected data from four sources: news media services; the California POST; the American Civil Liberties Unions (ACLU) of Southern California; networking among IACP members.</p> <p>Participants n=30 incidents where persons in custody died immediately or shortly after exposure to pepper spray from confrontation with police. Of the sample, only reported on 22 where complete data was available to determine cause of death.</p> <p>Sample characteristics (for 30 incidents) 100% male age=24-53 years 40% White, 43% Black, 7% Hispanic 100% “bizarre”, combative behaviour 100% involved a struggle 77% drugs/alcohol involved 40% “significant disease present”.</p> <p>Pepper spray effectiveness Not at all effective (60% of cases) Partially effective (23%) Effective (13%) Unknown (3%, n=1).</p> <p>Restraint methods subsequent to OC Hog-tie (17%) Handcuffs (20%) Cuff/leg restraint (50%) Strapped to stretcher (13%).</p> <p>From 13 states in the USA.</p>	<p>Study design Retrospective case series between August 1990 – December 1993.</p> <p>Inclusion criteria In-custody death incidents where pepper spray has been used during arrest in the USA.</p> <p>Exclusion criteria Cases where sufficient information (autopsy and police reports) was not available for a panel of pathology experts to come to a reasonable conclusion about cause of death.</p> <p>Outcome measures Cause of death after review from three sources:</p> <ul style="list-style-type: none"> ▪ review of incident reports from relevant law enforcement agency ▪ review of coroner or medical examiner records (including autopsy reports, toxicologic information, and conclusions regarding cause of death) ▪ comparison of all cases where complete details exist to determine any patterns in the nature of confrontations. 	<p>Cause of death</p> <ul style="list-style-type: none"> ▪ positional asphyxia (81%) ▪ cocaine related death (14%) ▪ cocaine/disease related death (5%). <p>Report concludes that positional asphyxia was probably related to transferring subjects in a “prone” position, restrained whilst on their stomachs, aggravated by subject’s drug use, disease and obesity.</p> <p>Review for this study concluded that pepper spray was not the cause of death in any of the 22 cases for whom full data was available. The current study’s review differed in its conclusion to one autopsy report where pepper spray was listed as a factor in death.</p>	<p>Limitations</p> <ul style="list-style-type: none"> ▪ small sample ▪ no data on potential confounders including use of pepper spray (such as concentration, distance sprayed, and frequency) ▪ drug status and existing medical conditions reported by officers not validated ▪ no comparison of demographics of 22 included cases with 8 cases with missing data. Possible inclusion bias ▪ likely to include some cases from overlapping collection period in 1993 with ACLU (1995) study above ▪ no detail on extraction or interpretation of data - assumed to be qualitative. Autopsy reports are notoriously non-specific with little pathological evidence making conclusions open to interpretation and bias ▪ no interviews with any witnesses ▪ no comparison groups of people taken into custody in similar conditions, where pepper spray was not used, or where death did not occur, to investigate causation systematically. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ authors suggest indicators for risk of sudden custody death based on common case characteristics. No comment is made about pepper spray’s possible contribution ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Stopford (1996) North Carolina, USA	Level IV	<p>Study setting Training for Department of Corrections Officers.</p> <p>Participants n=approximately 6000 officers exposed to pepper spray during training.</p> <p>Sample characteristics Not described.</p>	<p>Study design Retrospective case series: review of presentations between 2/1993 – 8/1995.</p> <p>Inclusion criteria Officers receiving medical treatment or lost work time during study period.</p> <p>Exclusion criteria None described.</p> <p>Outcome measures Description of symptoms/conditions post exposure, whether medical treatment was required, whether symptoms persisted beyond one week.</p> <p>Follow-up interval Whilst attending the emergency area.</p>	<p>61 / 6,000 developed conditions requiring medical treatment (1%).</p> <p>Symptoms (% of 61)</p> <ul style="list-style-type: none"> ▪ eye irritation (n=28, 46%) - one with eye burn losing 5 days work ▪ chest symptoms (n=20, 33%) – one allergic respiratory reaction, four with asthma ▪ nose/eye/throat symptoms (n=7, 11%) ▪ skin effects (n=5, 8%) - two with hives ▪ hypertension (n=11, 18%) - one with BP 180/110, one with BP 200/110 ▪ headache (n=16, 26%) - severe in nine cases ▪ cardiovascular effects (n=2, 3%) – one with EKG changes, one with chest pain requiring nitroglycerin ▪ loss of consciousness (n=2, 3%) ▪ hyperventilation (n=3, 5%). <p>Of 61 trainees requiring medical attention, 8 trainees (13%, or 0.1% of all officers) had symptoms that persisted for more than one week:</p> <ul style="list-style-type: none"> ▪ three with eye problems ▪ three with chest problems ▪ two with headaches (one with disorientation). 	<p>Limitations</p> <ul style="list-style-type: none"> ▪ no data on potential confounders including use of pepper spray (such as concentration, distance sprayed, and frequency) and decontamination practices used prior to examination ▪ no precise sample size, sample characteristics, and no data on pre-existing medical conditions of presenting trainees ▪ no detail of methods for data retrieval (assumed to be case review) or measurement of outcomes ▪ not clear how long after exposure outcomes were measured ▪ retrospective design ▪ no data on any adverse events for the people sprayed by pepper spray who did not receive medical attention. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ poorly described methods in this unpublished “statement” ▪ health effects requiring medical treatment exist for a small but significant proportion of cases, whilst health effects persisting beyond a week appear to be rare ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events. However, an association with pepper spray use appears plausible. The role of other contributing factors is not clear.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Watson et al. (1996) Kansas City, Missouri, USA.	Level IV	<p>Study setting Emergency Department (ED).</p> <p>Participants n=81 ED patients exposed to pepper spray (5% Cap-Stun™ spray) applied by police officers. 13 exclusions (N=94).</p> <p>Sample characteristics 91% male Mean age=27.6 years 73% African-Americans.</p> <p>Characteristics of overall ED population 48% male Mean age=34 years 60% African-Americans.</p>	<p>Study design Retrospective case series (medical record review of consecutive eligible presentations between June 1991-June 1994).</p> <p>Inclusion criteria Presentations following exposure to pepper spray by Kansas City Police Department (KCPD) officers.</p> <p>Exclusion criteria Non-law enforcement related exposures to sprays which may not have been pepper spray, including chloroacetophenone.</p> <p>Outcome measures Data record sheet used to extract recorded data including patient presentation and symptoms, evaluation and treatment during ED stay, as well as concurrent trauma and other medical conditions.</p> <p>Follow-up interval Whilst in the ED, on average this was 1.6 ± 0.9 hours.</p>	<p>Reported that, prior to presentation at ED, 18 patients received fluid irrigation, and 13 were physically restrained.</p> <p>Symptoms (<i>multiple responses</i>) on arrival. ocular burning (55%); conjunctival injection (44%); erythema (39%); lacrimation (16%); dermal burning and erythema (32%). Heart rate > 100 beats per minute (40%); and respiratory rate > 20 breaths per minute (20%).</p> <p>More seriously Altered vision (9%), corneal abrasions - 7 (9%) patients. Respiratory symptoms (7%) including shortness of breath (n=3); wheezing (n=2); cough (n=1); throat irritation (n=1).</p> <p>Two of 12 (16%) patients with a history of asthma reported wheezing; compared with 4/69 (5%) of non-asthmatics who had other respiratory symptoms.</p> <p>No patients required hospitalisation due to pepper spray toxicity.</p> <p>During same three year period, KCPD report that 908 were exposed to pepper spray, suggesting 10% require medical examination.</p>	<p>Limitations</p> <ul style="list-style-type: none"> ▪ no data on potential confounders (such as concentration, distance sprayed, and frequency) ▪ data on decontamination practices and physical restraint prior to ED was not cross-tabulated to symptom data ▪ incomplete data (e.g., no information on presentation for nine patients) ▪ no validated outcome measures used ▪ not clear how long after exposure outcomes were measured; however, likely to have been more than one hour ▪ no statistical comparisons between subgroups (e.g., asthmatics) ▪ patients may have been brought to other EDs, suggesting that estimate of attendance, and of the proportion of the exposed requiring medical attention, are likely to be underestimated ▪ retrospective, no control group ▪ no follow-up post ED measured. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ a small number of patients had ocular or pulmonary toxicity. No data on longer-term effects post ED ▪ proportion of suspects requiring attention likely to be an underestimate ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events. However, an association with pepper spray use appears plausible. The role of other contributing factors is not clear.

Table 1. Evidence tables: Appraised articles relating to safety of “pepper spray” use by law enforcement or mental health service staff (continued)

Authors Country	Study Design	Sample and Interventions	Methods	Results	Limitations and Conclusions
Zollman et al. (2000) Seattle, USA	Level IV	<p>Study setting Police cadets voluntarily exposed during training.</p> <p>Participants n=47 police cadets.</p> <p>Two types of water-based pepper spray Def+tex™ (0.5 mill SHUs) for 20 cadets, Southern Cross Defense Spray™ (1 mill. SCUs) for 27 cadets.</p> <p>Cadets sprayed from one metre whilst attempting to fight a mock “attacker”. After one minute, cadets tried to find and unlock their police car. Cadets instructed to hold their breath (to prevent risk of bronchospasm) before exposure and to hold their eyes open, without rubbing their eyes before or after exposure. After the simulation, cadets were decontaminated with baby shampoo and copious water irrigation. Some had a fan blowing on their face to ease pain.</p> <p>About one minute before the 10 minute post exposure assessment, cadets' eyes were randomly given one pain relief intervention: artificial tear (AT) drop (n=14), topical anaesthetic in one eye, and AT in the other (n=29) and non-steroidal anti-inflammatory drug in one eye, and AT in the other (n=11).</p> <p>Sample characteristics 74% male Age range 21-47 years.</p>	<p>Study design Before and after study without a control group.</p> <p>Inclusion criteria Agreeing to participate in pepper spray training exercise. No information on any refusals.</p> <p>Outcome measures</p> <ul style="list-style-type: none"> ▪ visual acuity and corneal sensitivity using a Cochet-Bonnet aesthesiometer (scale 1-6 cm) ▪ examination of the eyes using a portable slit lamp using fluorescein ▪ subjective questionnaire of symptoms of pain, blurring of vision, tearing recorded scored 0-10 for both eyes combined. <p>Follow-up interval Before exposure, at 10 minute and one hour after exposure. Only report on one hour post exposure here.</p> <p>Assessments were repeated at one week post exposure for 11 cadets returning for examination which is too few to report on here reliably.</p> <p>Statistics Student's <i>t</i> test (significant level of $p=0.05$).</p>	<p>Results were the same for both sprays and so results were combined.</p> <p>Visual acuity did not alter between before and after assessments throughout study.</p> <p>Corneal sensation was greatly reduced from pre-exposure level (mean=5.7) at one hour post exposure (mean=2.9).</p> <p>Symptoms (<i>multiple responses</i>) on arrival.</p> <ul style="list-style-type: none"> ▪ blepharospasm not present at one hour post ▪ punctate epithelial erosions in 21% at one hour post (some erosions as large as 1mm, but no frank corneal abrasions) ▪ subjective assessments for pain, blurring and tearing were higher at one hour post exposure (mean=1.8, 1.7, 1.9 respectively) than pre-exposure. <p>No cadet required medical intervention.</p>	<p>Limitations</p> <ul style="list-style-type: none"> ▪ small sample ▪ exposure at one metre in open, paved area, no rubbing of eyes, and comprehensive decontamination may lead to safer outcomes than usual in the field ▪ too few cadets at one week follow-up to report on reliably and without bias ▪ multiple <i>t</i> tests conducted without appropriate adjustment to the <i>p</i> value (some differences may be chance) ▪ study limited to visual outcomes only ▪ no control group. <p>Conclusions</p> <ul style="list-style-type: none"> ▪ corneal sensitivity only partially recovered after one hour ▪ corneal erosions in over a fifth of sample after one hour, though no medical treatment required ▪ study in controlled dust-free conditions, with no eye rubbing, thorough decontamination and pain relief which may have reduced health effects expected compared with those likely to occur in the field ▪ long-term effects not measured ▪ the study design is poorly able to establish a clear causal link between pepper spray use/other factors and adverse events.

Key:

SHU: Scoville Heat Unit

OC: Oleoresin capsicum a.k.a. pepper spray

OVERVIEW

Overall quality of evidence

Of the seven studies appraised, five considered adverse effects on suspects sprayed with pepper spray by police officers in the field, and two considered adverse effects on police officers themselves, sprayed during training. There were six retrospective case series: two based on autopsy reports of in-custody deaths after pepper spray use, one review of incident reports completed by police after spray use on suspects, two set in emergency medical rooms treating suspects who had been sprayed, and one medical treatment of police officers sprayed in training. The seventh study was a before-and-after quasi-experimental study involving police officers exposed to pepper spray during training.

All seven studies were of the poorest quality in the hierarchy of evidence considered. A major flaw with all these descriptive studies is the lack of a control or comparison group of people who have not been exposed to pepper spray. For research identifying relatively rare outcomes, it is appropriate to conduct large prospective cohort studies or case control studies, where cases where pepper spray has been used are compared with those where pepper spray has not been used. Such methods would strengthen the ability to infer a causal link between pepper spray exposure and health outcomes where they were significantly more common in the pepper spray exposed group compared to the non-pepper spray exposed group. Randomised controlled trials are likely to be impractical for determining relatively rare adverse events, especially those which are longer-term.

There were only three studies published formally in peer-reviewed medical and scientific journals, including the two studies considering the emergency room treatment of in-custody suspects sprayed with pepper spray (Brown et al. 2000; Watson et al. 1996), and the experimental study of police officers exposed during training (Zollman et al. 2000). The other four papers dealt with here were sourced from unpublished reports.

The quasi-experimental study was the only one where follow-up safety outcomes were rigorously assessed at specific time points. Only data at one-hour post exposure was eligible for review. No study systematically assessed longer-term adverse events (apart from death) beyond a few hours.

Degree of evidence for safety of pepper spray

- Zollman et al's. (2000) before-and-after study suggested some short-term, minor effects including corneal sensitivity only partially recovered after one hour, and corneal erosions in over a fifth of sample in this period. Whilst this experimental study found no adverse events requiring medical treatment, or corneal abrasions, the exposures occurred in controlled dust-free conditions, with no eye rubbing, thorough decontamination and pain relief. The study also considered single-dose exposures at the recommended range (around 1.5 metres) whereas in real-life field settings, closer, longer, and repeated exposures can commonly occur (Chan et al. 2002), as discussed further under "possible confounders" below.
- There were two, reasonably large, well-conducted studies of exposed suspects attending emergency rooms over separate three-year periods (Brown et al. 2000; Watson et al. 1996). Subjects were selected based on their requiring medical attention and though a minority of those exposed, revealed significant adverse events including corneal abrasions and pulmonary toxicity in 7 to 9%. These outcomes appear reasonably likely to have resulted from pepper spray use (or misuse), although not necessarily as the sole causal factor.
- The largest study included an approximate sample of 6,000 officers exposed to pepper spray during training (Stopford, 1996). Whilst the methods are poorly described in this unpublished "statement", results are consistent with the emergency room studies that health effects requiring medical treatment appear to exist for a small but significant proportion of cases. Health effects persisting beyond a week occurred though rarely, and included eye problems, chest problems and headaches.

- Medical examiners have difficulty in identifying pathological evidence, including the residual effects of pepper spray (American Civil Liberties Union of Southern California, 1995). The non-specific nature of autopsy reports allows them to be more susceptible to biased interpretation. This is consistent with the completely contradictory conclusions found for two deaths-in-custody reports appraised here which include overlapping sampling periods and therefore are likely to include at least some of the same cases. These reports were produced from very different perspectives: one from a civil liberties group (American Civil Liberties Union of Southern California, 1995) which implicated pepper spray use in most deaths, and one from a law enforcement agency (Granfield et al. 1994) which found no contribution by pepper spray in any deaths. Autopsy reports have rarely made direct links with pepper spray use and death. An oft-quoted exception was a case study report published in the *American Journal of Forensic Medicine & Pathology* (Steffee et al. 1995)³. This report indicated that pepper spray was responsible for the death of a 24 year old man with underlying pulmonary disease and a history of asthma who was sprayed 10 to 15 times. The authors argued that whilst pepper spray is relatively safe, there is insufficient physiological data at present to conclude that it is incapable of causing death. However, demonstrating any causal link, or the lack of it, between pepper spray exposure and death is limited without epidemiological designs with comparable data on deaths where pepper spray has not been used.
- A small study reviewing incident forms reported by police after use of pepper spray identified no injuries or death (Criminal Justice Commission and Queensland Police Service, 1999), but the self report data was likely to be unreliable, and no follow-up of sprayed suspects was conducted to give confidence in the accuracy of the health outcomes (or lack thereof) reported.

Applicability to New Zealand

Six of the studies were conducted in the USA, and one in Australia. In the USA, pepper spray has been marketed heavily by the manufacturers and is available for purchase on the internet. A report to the European Parliament warned that the USA has a highly armed force and in the context of more aggressive alternatives, pepper spray may be more appropriate than in Europe (Chambers, 2000). The comparability of use of pepper spray in the United States with use in New Zealand is likely to be similarly limited. Aspects of use (including misuse) which relate to contextual and training issues are particularly likely to vary.

Possible confounders

Most of the appraised studies lacked important information on the type of spray used, its carrier, propellant and OC strength, and whether the spray was used as recommended with regards to distance and frequency. These variables are possible confounders to the relationship between pepper spray exposure and safety outcomes.

OC strength

Research indicates that there is a large variability in the constituents of pepper sprays which differ in terms of *carrier solvents*, *propellants* as well as *capsacinoid strength*. This may effect their effectiveness and safety profile differently (Haas et al. 1997). It is the strength of the OC in the spray rather than its percent per volume that is important; strength is measured in Scoville Heat Units (SHU's) which are based on taste tests (United States National Institute of Justice Technology Assessment Program, 1994).

³ This study was excluded from appraisal here due to its small number of cases (n=3).

Misuse/abuse of pepper spray

Use of pepper spray by the Baltimore County Police Department suggests that over 60% of 690 incidents, the spray was activated at a distance of less than 75 cm (Kaminsky et al. 1999). The full contents of the container was applied in four incidents (Edwards et al. 1997). Discharges close to the face and repeated exposures may increase the chance of adverse events, such as corneal abrasions (Kaminsky et al. 1999). Repeated doses are possible for police officers (with spray drift or if used on them by a suspect), correctional facility workers and inmates of prisons where pepper spray is routinely used (Zollman et al. 2000).

An investigation of allegations against the use of pepper spray by members of the New York Police Department described various abuses of the spray, including use on a large crowd, use for “cursing”, and unexplained use where the civilian was already subdued (Greinsky et al. 2000). According to reports to Amnesty International, there are other case reports where some police officers in Seattle and San Francisco have used pepper spray inappropriately in a punitive way on non-violent protestors in demonstrations.

It has been argued that codes of conduct and training need to be adequate to ensure the prevention of the misuse/abuse of pepper spray (Chambers, 2000). It is possible that misuse of pepper spray may have contributed to adverse events found in some of the studies appraised in this report, including deaths in custody.

Ineffective use of pepper spray

Whilst this report does not consider the effectiveness of pepper spray, ineffective use may lead to repeated doses which could increase the chance of adverse events for some groups of individuals less affected by pepper spray, such as the mentally ill, intoxicated or drugged (Edwards et al. 1997).⁴

Context of pepper spray use

In the field, people sprayed with pepper spray are often in a state of extreme agitation and “excited delirium” as a result of recreational drug use and/or psychiatric illness. They are also often involved in violent physical struggles prior to use of pepper spray and therefore commonly undergo levels of psychological stress and exertion that can lead to exhaustion (Chan et al. 2002). It is possible that intense physical discomfort and anxiety associated with restraint measures generally may elicit cardiovascular changes that may have significant implications for individuals with a pre-existing disease (Olajos and Salem, 2001). Such factors and how they may interact with pepper spray have not been systematically investigated in studies designed to ascertain causal associations between pepper spray exposure and adverse events.

Other restraint practices

In some field studies, pepper spray use has been used in conjunction with other practices to control behaviour including physical restraint using controversial positional holds such as the “hog tie”. Physical restraint is discussed in a separate NZHTA Tech Brief by Researcher, Peter Day.

⁴ Evaluating the incident reports on 690 discharges of pepper spray by the Baltimore County Police Department in 1993, Kaminski et al. (1999) found that pepper spray was largely ineffective in 29% of incidents. Multivariate regression modeling revealed that pepper spray was less effective for suspects that appeared to be under the influence of drugs, of greater weight, and when sprayed at long compared with moderate distances. Those under the influence of alcohol were somewhat more susceptible to the spray, and results for mentally disturbed persons were mixed. Valid measures of drug and mental status were not applied. Uncertainty on effectiveness for the mentally ill has led the New York Civilian Complaint Review Board to recommend that the New York Police “restrict use of pepper spray against emotionally disturbed persons where possible” (Greinsky et al. 2000, pg 16) until further scientific research evidence has been conducted.

Areas of uncertainty

Major gaps

There were no appraised studies meeting review selection criteria:

- comparing pepper spray with other types of aerosol sprays (McMahon and Enders, 1999)
- on long-term health risks (beyond a day)
- on risks for sub-populations which may be particularly prone to adverse effects (such as asthmatics, mentally ill, etc)
- investigating use of pepper spray by mental health service staff.

Ascertaining risk

The feasibility of police ascertaining, prior to pepper spraying, whether suspects have pre-existing conditions (e.g., cardiovascular or cardiorespiratory disease) that *may* make them more prone to lasting health risks has not been established.

It has been argued that such conditions may not be readily recognised by police in emergency situations (American Civil Liberties Union of Southern California, 1995).

Long-term effects

Little is known about the long-term/chronic effects of pepper spray. Mutagenic and carcinogenic activity of OC has not been clearly established, although some animal studies are suggestive of this possibility (Busker and van Helden, 1998; Olajos and Salem, 2001). Whilst some authors argue that single or incidental doses of relatively low doses of pepper spray, as used by police, would not produce a significant cancer risk (Busker and van Helden, 1998), there is no data on this issue. Long-term risks for those sprayed multiple times (e.g., training instructors, incarcerated in-mates, etc) are also unknown.

Conclusions

It is difficult to make conclusions on the safety of pepper spray use by police officers and mental health service staff given the methodological limitations of the evidence base, and the many gaps in current knowledge. However, the connection of pepper spray with deaths in custody in the United States, even when the medical condition of the victim and lack of proper after-care are accepted as contributing factors, is of concern (McMahon and Enders, 1999). Health effects described in the two large, well conducted studies of sprayed suspects attending emergency rooms appear reasonably likely to have resulted from pepper spray use (although not necessarily as a single contributing factor, and not necessarily when used in accordance with established guidelines). Whilst these health effects cannot be directly attributed to pepper spray use given the epidemiological limitations of the study designs used to date, there does appear to be sufficient data to warrant caution. A careful approach, advocated by a consultative report to the European Parliament, would be to oppose the deployment or usage of pepper spray “until independent research has more fully evaluated the risks it poses to health” (pg x) (Chambers, 2000).

This report discusses the safety of the use of pepper spray. However, this risk needs to be balanced against the alternatives and their associated risks as well as the problems that may arise if control is not established. For example, pepper spray has been reportedly associated with a reduction in violent encounters and injury to police officers and suspects (e.g., Gauvin, 1995). Although beyond the scope of the current report, decision-makers concerned with the continued use of pepper spray in New Zealand need to balance such aspects of the agent’s effectiveness against relatively rare, though potentially serious adverse events that may arise from the use of pepper spray.

In the absence of clear evidence, taking into account the inherent risks of managing people who are behaviourally disturbed and the risks of applying alternative techniques of control or restraint, may lead to a decision that, when used appropriately, pepper spray’s safety profile appears to be currently acceptable. If this approach is followed, guidelines for use should be adhered to and compliance with

them closely and regularly monitored (e.g., United States National Institute of Justice Technology Assessment Program, 1994).

The use of pepper spray may be less supportable in the training of police officers, which has been advocated to help them understand the spray's effectiveness, have compassion for victims, and be wary of accidental self-exposure (United States National Institute of Justice Technology Assessment Program, 1994). Due to the potential health risks to officers, it has been argued that such practices be discontinued or at least modified (Smith and Stopford, 1999).

More robust research in this area is keenly needed and the conclusions of this Tech Brief should be revisited in the face of additional, reliable evidence.

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APPENDIX 1: LEVELS OF EVIDENCE

- Level I Evidence obtained from a systematic review (or meta-analysis) of relevant randomised controlled trials.
- Level II Evidence obtained from at least one randomised controlled trial.
- Level III. 1 Evidence obtained from pseudorandomised controlled trials (alternate allocation or some other method).
- 2 Evidence obtained from comparative studies (including systematic reviews of such studies) with concurrent controls and allocation not randomised, cohort studies, case control studies or interrupted time series with a control group).
- 3 Evidence obtained from comparative studies with historical control, two or more single-arm studies or interrupted time series without a parallel control group.
- Level IV Evidence obtained from case series, either post-test or pretest/post-test.

APPENDIX 2: SEARCH STRATEGY

Medline

- 1 pepper spray.mp. (22)
- 2 oleoresin capsicum.mp. (15)
- 3 capsicum/ae (45)
- 4 CAPSAICIN/ad, ae, po, st, tu, to [Administration & Dosage, Adverse Effects, Poisoning, Standards, Therapeutic Use, Toxicity] (869)
- 5 limit 4 to human (412)
- 6 or/1-3 (66)
- 7 from 6 keep (selected references)
- 8 5 (412)
- 9 from 8 keep (selected references)

Embase

- 1 pepper spray.mp. (16)
- 2 oleoresin capsicum.mp. (13)
- 3 1 or 2 (22)
- 4 CAPSAICIN/ae, to [Adverse Drug Reaction, Drug Toxicity] (660)
- 5 Capsaicin Derivative/ae, to [Adverse Drug Reaction, Drug Toxicity] (7)
- 6 1 or 2 or 5 (29)
- 7 from 6 keep (selected references)
- 8 (rat or rats or mouse or mice).mp. (784523)
- 9 experimental animal/ or animal model/ or animal experiment/ (624260)
- 10 nonhuman/ (1648410)
- 11 or/8-10 (1698973)
- 12 4 not 11
- 13 from 12 keep (selected references)

Current Contents

- 1 pepper spray.mp. (22)
- 2 oleoresin capsicum.mp. (14)
- 3 (capsaicin or capsicum).mp. (5434)
- 4 (animal or rat or rats or mouse or mice).mp. (624776)
- 5 3 not 4 (2819)
- 6 1 or 2 (26)
- 7 from 6 keep 1,7 (2)
- 8 cs spray.mp. (9)
- 9 from 8 keep 1-5,7-9 (8)
- 10 (spray or assault or emergenc\$ or police or restrain\$).mp. (79563)
- 11 5 and 10 (68)
- 12 11 not 6 (54)
- 13 from 12 keep 35 (1)
- 14 9 or 13 (9)
- 15 from 14 keep 1-9 (9)
- 16 7 or 15 (11)

Cinahl

- 1 pepper spray.mp. (9)
- 2 oleoresin capsicum.mp. (1)
- 3 1 or 2 (9)
- 4 Self Defense Agents, Chemical/ (15)
- 5 (capsaicin or capsicum).mp. (78)

- 6 or/3-5 (95)
- 7 from 6 keep (selected references)

Psychinfo

- 1 pepper spray.mp. (3)
- 2 oleoresin capsicum.mp. (1)
- 3 (capsaicin or capsicum).mp. (329)
- 4 cs spray.mp. (0)
- 5 mace.mp. (44)
- 6 tear gas.mp. (2)
- 7 or/1-6 (376)
- 8 (animal or rat or rats or mice or mouse).mp. (120796)
- 9 7 not 8 (199)
- 10 from 9 keep (selected references)

International Pharmaceutical Abstracts

- 1 pepper spray.mp. (1)
- 2 oleoresin capsicum.mp. (1)
- 3 (capsaicin or capsicum).mp. (178)
- 4 cs spray.mp. (0)
- 5 mace.mp. (10)
- 6 tear gas.mp. (2)
- 7 or/1-6 (190)
- 8 (animal or rat or rats or mice or mouse).mp. (18337)
- 9 7 not 8 (166)
- 10 from 9 keep 164 (1)
- 11 from 10 keep (selected references)

Other databases

Combinations of the keywords in the strategies above were used in free text searching of other databases and sources for which index terms were not available.

Complete list of sources searched

Bibliographic databases

Medline
 Premedline
 Embase
 Cinahl
 International Pharmaceutical Abstracts
 Amed
 Current Contents
 Psychinfo
 Cochrane Controlled Trials Register
 Index New Zealand

Review databases

Cochrane Database of Systematic Reviews
 ACP Journal Club
 NHS Centre for Reviews and Dissemination databases (DARE, NHS Economic Evaluation, Health Technology Assessment)

Health Technology Assessment agencies

Websites of all member agencies affiliated to the International Network of Agencies for Health Technology Assessment via links on the INAHTA website (see www.inahta.org for list of agencies)
 Centre for Clinical Effectiveness (Monash University)
 Medical Technology Assessment Group (M-TAG)
 Institute for Clinical Systems Improvement
 Minnesota Health Technology Advisory Committee
 Medical Technology and Practice Patterns Institute

Library catalogues

New Zealand bibliographic database – Te Puna
 NZ Ministry of Health
 NZ Parliamentary Library – International Documents Collection
 NZ Police College Library
 US National Library of Medicine
 US Agency for Health Research Quality
 British Library
 COPAC - combined catalogues of major academic libraries in UK & Ireland
 World Health Organisation
 University of Sydney

Other Websites

UK

ARIF – Aggressive Research Intelligence Facility
 OMNI – Organised Networked Medical Information
 Bandolier
 Department of Health Publications
 TRIP database – Turning Research Into Practice

Australia

Commonwealth Department of Health & Family Services
 National Health & Medical Research Council

United States

Centers for Disease Control
 National Institute of Justice
 National Criminal Justice Reference Service
 Food and Drug Administration
 Guidelines.gov
 Primary care guidelines

Canada

Canadian Medical Association Infobase

Other

Euroscan
 International Society for Technology Assessment in Health Care
 Google search engine
 Searchnz

Agencies contacted

NZ Police College Library
 NZ International Documents Collection
 NZ Ministry of Justice
 US Agency for Health Research Library
 INAHTA email list request for information

APPENDIX 3: EXCLUDED RETRIEVED PAPERS

Buchanan, H. (2001). The health effects of oleoresin capsaicin: a thesis submitted for the degree of Master of Science. Sydney: University of New South Wales School of Safety Science.

This Australian MSc thesis predominately at the topical application of capsaicin on the skin in an investigation of the health and safety implications of exposure to pepper spray during officer training in the NSW police service. Only 18 officers of 953 exposed during training were sprayed with pepper spray. The rest had the pepper spray dabbed or wiped on their forehead in varying amounts and then were sprayed with an atomiser with water to disperse the pepper spray.

Busker, R. W., & van Helden, H. P. (1998). Toxicologic evaluation of pepper spray as a possible weapon for the Dutch police force: risk assessment and efficacy. *American Journal of Forensic Medicine & Pathology*, 19, 309-316.

Narrative review/expert opinion. This review was funded by the Dutch Ministry of Internal Affairs and considers the effectiveness and safety of the use of pepper spray for the Dutch Police Force. It is broadly favourable towards the use of pepper spray by police members except for crowd control.

Chambers, G. (2000). Crowd control technologies: an appraisal of technologies for political control. Final study. Working document for the STOA Panel. Luxembourg: European Parliament Directorate General for Research.

Narrative review/expert opinion. Detailed consultative report to the European Parliament on various "technologies for political control" including pepper spray. Recommends opposing the deployment or usage of pepper spray by EU Member States "until independent research has more fully evaluated the risks it poses to health" (p. vi).

Chan, T. C., Vilke, G. M., Clausen, J., Clark, R., Schmidt, P., Snowden, T., & Neuman, T. (2001a). *Pepper spray's effects on a suspect's ability to breathe*. Washington, DC: National Institute of Justice.

A short follow-up period of nine minutes was employed in this experimental study of pepper spray combined with physical restraint.

Chan, T. C., Vilke, G. M., Neuman, T., Clausen, J., Schmidt, P., Snowden, T., & Clark, R. F. (2001b). Does oleoresin capsicum "pepper spray" exposure impact cardiovascular function in human subjects? *Academic Emergency Medicine*, 8, 442.

Abstract only. Appears to report on Chan et al. (2001) above.

Chan, T. C., Vilke, G. M., Clausen, J., Clark, R. F., Schmidt, P., Snowden, T., & Neuman, T. (2002). The effect of Oleoresin capsicum 'Pepper' spray inhalation on respiratory function. *Journal of Forensic Sciences*, 47, 299-304.

A short follow-up period of nine minutes was employed in this experimental study of pepper spray combined with physical restraint. Reports in greater detail on the same study as for Chan et al. (2001) above.

Doone, P. E. C. (1997). Oleoresin capsicum spray. *New Zealand Medical Journal*, 110, 471.

A letter describing introduction of pepper spray (streamer unit) as a less-than-lethal option for front-line New Zealand police officers. Recommendations for after-care are provided. Case-reports for patients after pepper spray exposure were invited.

Edwards, S., Granfield, J., & Onnen, J. (1997). *Evaluation of pepper spray*. Washington, DC.: National Institute of Justice.

Not directly relevant to this topic, focusing on effectiveness and not safety issues. A brief summary report of an evaluation of the effectiveness of pepper spray in an Institute of Justice funded study of pepper spray use by the Baltimore County Police Department in 1993-4. The report provides some information from surveys and interviews of 174 incidents where the spray was used on humans by police officers in the field. Some data comparing statistics before and after pepper spray introduction seems questionable as the comparability of the two periods is under doubt. Safety issues were not addressed systematically.

Farina, S., Valeriani, M., Rosso, T., Aglioti, S., Tamburin, S., Fiaschi, A., & Tinazzi, M. (2001). Transient inhibition of the human motor cortex by capsaicin-induced pain. A study with transcranial magnetic stimulation. *Neuroscience Letters*, 314, 97-101.

This study looked at the topical application of capsaicin on the skin in an investigation of transient inhibition of the human motor cortex by capsaicin-induced pain.

Greinsky, C. M., Holland, S., & Martin, J. (2000). *Report of the Pepper Spray Committee*. New York, NY: New York City Civilian Complaint Review Board.

This report was excluded due to a lack of a clear description of methods and results. The report was by the Pepper Spray Committee of the New York Civilian Complaint Review Board (CCRB). The report describes New York Police Department (NYPD) policy on pepper spray, briefly reviews the literature, and analyses complaints against the use of pepper spray by the NYPD. Much of the data on police complaints is missing and data on adverse events are described in only vague terms with a report of chemical eye burn ascribed to one of nine persons receiving medical attention in the sample of cases where the allegation of inappropriate use of pepper spray was substantiated.

The report is useful in describing various abuses of pepper spray, including use on a large crowd, use for "cursing", and unexplained use where the civilian was already subdued. There was an over-representation of African-American complainants observed which is unexplained. The report concludes that pepper spray continues to be used by the NYPD; however, recommends that "until further scientific research evidence has been conducted" the NYPD "restrict use of pepper spray against emotionally disturbed persons where possible" (pg 16).

Kaminski, R. J., Edwards, S. M., & Johnson, J. W. (1999). Assessing the incapacitative effects of pepper spray during resistive encounters with the police. *Policing*, 22, 7-29.

Not directly relevant to this topic, focusing on effectiveness and not safety issues. This article reports on an evaluation by the International Association of Chiefs of Police (IACP) of the introduction of pepper spray by the Baltimore County Police Department in 1993 (a smaller sample is reported on by Edwards et al. 1997, above). The detailed report provides information from pepper spray incident forms concerning 690 incidents where the spray was used by police officers in the field, after excluding incidents (n=188) involving crowd situations, animals, misses, canister misfires, and multiple uses by the same officer (to avoid non-independence of responders).

About 71% of suspects were totally incapacitated or submissive, whereas the remainder were resistive (13.2%), fleeing (5.1%), combative (6.3%) or unaffected by the pepper spray (4.3%). Thorough statistical analyses reported using linear multivariate regression modeling. Pepper spray was found to

be less effective for suspects that appeared to be under the influence of drugs, though those under the influence of alcohol were somewhat more susceptible to the spray and results for mentally disturbed persons were mixed. It should be noted that these characteristics were as what appeared to officers and were not empirically measured. Increases in suspect weight, and spraying at longer compared with moderate distances, were associated with pepper spray ineffectiveness. Notably, 60% of discharges occurred at distances of less than 2.5 feet (75 cm), well within the recommended range of 4-6 feet (120-180 cm). The models did not explain much of the variance in effectiveness suggesting that other factors not measured should be considered.

Lee, R. J., Yolton, R. L., Yolton, D. P., Schnider, C., & Janin, M. L. (1996). Personal defense sprays: effects and management of exposure. *Journal of the American Optometric Association*, 67, 548-560.

Reports very briefly on two studies of "personal defense sprays" where police officers were sprayed in the field to explore effects on the eyes. Both are excluded due to small sample sizes, the first with 13 officers, and the second with nine. Testing for both studies also focus on measuring changes within 10-15 minutes of spraying although reports of delayed problems (or lack thereof) are presented. Also, reports on effect of personal defense sprays on soft contact lenses, concluding that soft lenses contaminated should be discarded. Provides comprehensive advice for decontamination procedures.

MacDonald, H. A. (1998). Possible idiosyncratic reaction to OC spray. *New Zealand Medical Journal*, 111, 327.

A letter describing adverse reaction to pepper spray by a New Zealand police officer who was voluntarily sprayed during training. Ongoing headaches have been reported, as well as sleep disturbance and chronic neck pain.

McMahon, B., & Enders, M. (1999). *Police force: humane restraint and use of force by police. PDC (Policing) Research Report No. 1.* Goulburn, NSW: Charles Sturt University.

Narrative review and expert opinion. This report provides a discussion of restraint methods and use of force by police in Australia. Pepper spray is discussed among other practices, questioning whether it is better than tear gas (CS/CN spray) which has received greater research attention and was selected by the Home Office for use by police in the UK. Recommends that research be carried out on the dangers of aerosol sprays and the relative merits of different forms.

Nordberg, M. (1996). Assault & pepper... pepper spray. *Emergency Medical Services*, 25, 41-46.

Narrative review/expert opinion. A fairly balanced discussion of the use of pepper spray by emergency medical services (EMS) staff. Includes quotes from interviews with various staff expressing a range of opinions concerning whether EMS staff should carry pepper spray.

Norton, S. A. (1998). Useful plants of dermatology. V. Capsicum and capsaicin. *Journal of the American Academy of Dermatology*, 39, 626-628.

Not directly relevant to this topic. Brief overview of various medicinal uses of capsaicin.

Olajos, E. J., & Salem, H. (2001). Riot control agents: Pharmacology, toxicology, biochemistry and chemistry. *Journal of Applied Toxicology*, 21, 355-391.

Narrative review/expert opinion. Extremely detailed review and discussion of the pharmacology, toxicology, biochemistry and chemistry of various riot control agents including pepper spray with over 400 references, with discussion of research relating to animal and human response and adverse events.

Onnen, J. (1996). *Oleoresin capsicum (OC) usage reports: summary information*. Sacramento, CA.: State of California Department of Justice.

This paper was requested from a website but was not retrieved in the timeframe (several weeks). It was an unpublished summary report on "usage" produced by the State of California Department of Justice. It is likely to report on data described in two other publications which include Onnen as a co-author: a paper on effectiveness by Edwards, Granfield and Onnen (1997) and an included paper by Granfield, Onnen and Petty (1994).

Pollanen, M. S., Chiasson, D. A., Cairns, J. T., & Young, J. G. (1998). Unexpected death related to restraint for excited delirium - a retrospective study of deaths in police custody and in the community. *CMAJ: Canadian Medical Association Journal*, 158, 1603-1607.

Case studies including autopsy results for four deaths where pepper spray was used in conjunction with physical restraint for excited delirium.

Ray, N., McMahon, B., Enders, M., & Mullan, B. (1999). The use of oleoresin capsicum defensive spray. *Policing Issues and Practice Journal*, 7, 1-7.

Narrative review/expert opinion. This article reports on the use of pepper spray from July 1998 by the NSW Police Service. It reports on statistics of the context in which pepper spray was used by police, and discusses guidelines for when pepper spray can be used, use of force policies, legal issues relating to use of pepper spray for self defense, and decontamination advice. This last issue includes advice on seeking appropriate medical assistance and carrying a decontamination kit in operational police vehicles.

Smith, C. G., & Stopford, W. (1999). Health hazards of pepper spray. *North Carolina Medical Journal*, 60, 268-274.

Narrative review/expert opinion. Thorough discussion of the health risks of pepper spray. For health risk and legal reasons the authors advise against occupational exposure during training, and where it is considered, suggest screening out of employees at particular risk, as well as other safety measures.

Smith, J., & Greaves, I. (2002). The use of chemical incapacitant sprays: A review. *Journal of Trauma-Injury Infection and Critical Care*, 52, 595-600.

Narrative review/expert opinion. Brief review of chemical incapacitants, with an emphasis on CS spray although pepper spray is also discussed. Generally favourable to use by police officers.

Smith, M. R., & Alpert, G. P. (2000). Pepper spray - A safe and reasonable response to suspect verbal resistance. *Policing*, 23, 233-245.

Narrative review/expert opinion. Discusses use-of-force tactics, especially pepper spray, and discusses force continua checklists and their application.

Steffee, C. H., Lantz, P. E., Flannagan, L. M., Thompson, R. L., & Jason, D. R. (1995). Oleoresin capsicum (pepper) spray and in-custody deaths. *American Journal of Forensic Medicine & Pathology*, 16, 185-192.

Case study reporting detailed autopsy and toxicology analysis for two in-custody deaths where pepper spray was used, and contributed to death in one of these cases. Gives advice about how to conduct autopsies in this circumstance and what to look for.

Tsun, J. (2000). Pepper spray just won't go away. *North Carolina Medical Journal*, 61, 245-246.

A letter opposing use of pepper spray, especially for crowd control.

United States National Institute of Justice Technology Assessment Program (1994). *Oleoresin capsicum: pepper spray as a force alternative*. Washington, DC.: National Institute of Justice.

Narrative review/expert opinion. Brief review of benefits and limitations of pepper spray use by police officers. Generally favourable. The report suggests that where pepper spray is used during law enforcement officer training, issues covered should include: appropriateness of pepper spray use, necessity of verbal warnings prior to use, product derivation, physiological reactions, technical application, decontamination and aftercare procedures, incident documentation, and legal and tactical issues.

Vesaluoma, M., Muller, L., Gallar, J., Lambiase, A., Moilanen, J., Hack, T., Belmonte, C., & Tervo, T. (2000). Effects of oleoresin capsicum pepper spray on human corneal morphology and sensitivity. *Investigative Ophthalmology & Visual Science*, 41, 2138-2147.

This experimental study of 10 volunteer police officers was excluded due to its small sample size. It investigated effects of the spray on corneal morphology and sensitivity at follow-up intervals of up to one month. Immediate changes to mechanical and chemical sensitivity persisting to one week were observed after a single exposure which was concluded as being "possibly associated with damage of corneal nerve terminals of mainly unmyelinated polymodal nociceptor fibers" (pg 2138).

Weaver, W., & Jett, M. B. (1989). *Oleoresin capsicum training and use*.

Available from: <http://www.zarc.com/english/cap-stun/reports/fbireport.html>. Quantico, VA.: US Department of Justice Federal Bureau of Investigation Firearms Training Unit.

The lack of systematic investigation of safety beyond one hour precluded this study from formal appraisal. The brief study was produced for the Firearms Training Unit of the FBI Academy which was retrieved from the web page of a pepper spray manufacturer, Zarc International. Reports with very little detail on experimental tests conducted between 1987 to 1989 on 828 individuals sprayed with pepper spray (1% and 5% solutions) for varying spray bursts and duration of exposure. A narrative description of short-term side effects was provided, without statistics, with a summary statement of no "long-term effects".

It should be noted that decontamination with water and soap was provided after 10 to 45 seconds of exposure. It is unlikely that a suspect would be decontaminated so quickly in the field (indeed police guidelines from the United States commonly only require decontamination measures once the suspect is brought in to the police station). A second study reported considers a questionnaire of 42 law enforcement agencies where no medical problems were said to have been reported through the use of pepper spray. However, essentially this was a collection of anecdotal experiences with pepper spray and the lack of detail on the study methodology, response rate, sample, questionnaire, analysis, etc, precluded it from formal appraisal.

Wright, S. (1998). *An appraisal of technologies of political control: working document (consultation version)*. Luxembourg: European Parliament Directorate General for Research.

Narrative review/expert opinion. Detailed consultative report to the European Parliament on various "technologies for political control", including pepper spray. Appears to have been supplanted by the later report by Chambers (2000). Recommends opposing the deployment or usage of pepper spray by EU Member States.

Zollman, T. M., Bragg, R., & Harrison, D. A. (1999). Clinical effects of oleoresin capsicum (pepper spray) on the human cornea and conjunctiva. *Investigative Ophthalmology & Visual Science*, 40, 1797-1805.

Abstract only. The same paper as Zollman et al. (2000), which is included in the Evidence Tables.

APPENDIX 4: APPRAISED RETRIEVED PAPERS

American Civil Liberties Union of Southern California (1995). *Pepper spray update: more fatalities, more questions*. Los Angeles, CA: ACLU.

Brown, L., Takeuchi, D., & Challoner, K. (2000). Corneal abrasions associated with pepper spray exposure. *American Journal of Emergency Medicine*, 18, 271-272.

Criminal Justice Commission, & Queensland Police Service (1999). *Trial of capsicum spray in Queensland: evaluation report*. Queensland Criminal Justice Commission.

Granfield, J., Onnen, J., Petty, C., & Granfield, J. (1994). Pepper spray and in-custody deaths. *RCMP Gazette*, 56, 12-17.

Stopford, W. (1996). *Statement concerning pathophysiology of capsaicin and risks associated with oleoresin capsicum exposure*. Durham, N.C.: Division of Occupational and Environmental Medicine, Duke University Medical Center.

Watson, W. A., Stremel, K. R., & Westdorp, E. J. (1996). Oleoresin capsicum (cap-stun) toxicity from aerosol exposure. *Annals of Pharmacotherapy*, 30, 733-735.

Zollman, T. M., Bragg, R. M., & Harrison, D. A. (2000). Clinical effects of oleoresin capsicum (pepper spray) on the human cornea and conjunctiva. *Ophthalmology*, 107, 2186-2189.