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Medical implications of Conducted Energy Devices in law enforcement.

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Declaration of interests

Dr Richard Stevenson is a reviewer for the Journal of Forensic and Legal Medicine.

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Medical implications of Conducted Energy Devices in law enforcement.

Abstract

This study examines the medical implications of Conducted Energy Devices (CEDs) in law enforcement, of which TASER® is the brand most recognised. In order to develop understanding of TASER® use, this study undertook both a literature review and original research using data provided by a number of UK police forces.

The comprehensive review of literature identified a range of injures, including both primary and secondary complications.

Research was conducted into TASER(R) use in the United Kingdom using a number of data sets, including a retrospective study of some 60,000 uses of force. This data shows TASER® was only discharged on 18% of occasions it was drawn from the holster. The injuries sustained by both subjects and Police Officers associated with TASER(R) use were compared and it was found that fewer injuries, as a proportion of use, were associated with TASER® than Police Dogs, baton or irritant spray or physical confrontation. The data examined 948 discharges of TASER® and recorded 159 attendances at the Emergency Department as a result. Only three hospital admissions were identified.

The paper concludes that the use of CEDs as a police use-of-force may be associated with injury; the overwhelming majority of such are classified as minor. Death or the more severe injuries described in the medical literature are rare and any deaths occurring within temporal proximity to the use of a CED should be investigated thoroughly and the presentation of the individual carefully recorded.

The collection of post-incident data provides evidence to the relative operational safety of the TASER® by the UK Police; it is accepted by the police that no use-of-force option is risk free, however data provided showed a greater incidence of injury to both the officers and subjects, as a proportion of use, when baton, irritant spray or physical confrontation was used.

Introduction

This paper will explore some of medical complications that have been experienced as a result of police use of Conducted Energy Devices (CEDs) of which the TASER® brand is most recognised.

TASER® was introduced in the United States to law enforcement agencies (using nitrogen as a dart propellant) in 1999. The UK was cautious in their adoption initially restricting use to authorised firearms officers (AFOs) during authorised firearms operations from 2003, expanding to AFOs in non-firearms incidents and to non-firearms officers from 2007 (National Police Chiefs Council [NPCC], 2019), with the numbers of officers carrying the device slowly increasing year to year.

Referred to by the police as a less-than-lethal use of force, CEDs have evoked some concern from the public, sometimes as a result of media reporting of the device, often quoted as "50,000 volts" delivered to an individual by a "stun gun". High profile uses of the equipment whereby the recipient of the energy delivered has died necessitate full reviews of the device and circumstances.

Hitherto, Most of the medical literature relating to CEDs and injuries relating to their use originates from the US. This paper will describe a wide variety of injuries from across the globe before turning to the UK, where a number of different police tactics for dealing with confrontation will be studied and compared, in an attempt to understand which tactics cause the most injuries. The paper will conclude that TASER® is not risk free, but no use of force by the state could be considered risk free; a significant number of police uses of force were examined, some 38,000 incidents, where it will be found that fewer injuries to both officers and subjects were associated with TASER® than with somewhat 'traditional' uses of force, including baton, irritant spray and physical confrontation.

Published literature on Conducted Energy Device related injury

Prior to formal field testing in the UK, the Defence Scientific Advisory Council Sub-Committee on the Medical Implications of Less-lethal Weapons (DOMILL), concluded after reviewing over eight hundred references that *"from the available evidence on the use of the device, the risk of life-threatening or serious injuries from the M26 Advanced Taser appears to be very low"* (DOMILL, 2002). Initially trialled amongst five UK Home Office police forces, the (then) newer model TASER® X26™ was made available to authorised firearms officers only during authorised firearms operations in 2003; from 2007 the use of the TASER® X26™ was expanded to include use by firearms officers at incidents where firearms were not authorised (NPCC, 2019). Also in 2007, following a further trial in ten forces, the use of TASER® X26™ was further extended to non-firearms officers, known as Specially Trained Officers (STOs), "where officers would be facing violence or threats of violence of such severity that they would need to use force to protect the public, themselves and/or the subject(s)" (United Kingdom Home Office, 2013).

There is a paucity of academic research with respect to the operational deployment, success and failure of the device to achieve the desired objective(s) of the TASER® X26™ within the UK. Attempts to obtain reliable and

accurate information via Freedom of Information, has proved problematic (Payne-James et al., 2014). However, the UK Home Office publishes annual statistics concerning Taser 'use' in England and Wales. In this context, the meaning of the word 'use' is broad and includes a number of actions from simply drawing the Taser out of the holster up to discharging electricity towards the subject; types of use reported may be found in table one.

Table one: *Types of TASER® use report by the UK Home office.*

Level of use	Type of use	Definition	
Higher use	Angle-drive stun	The officer fires the weapon with a live cartridge installed. One or both probes may attach to the subject. The officer then holds the Taser against the subject's body in a different area to the probe(s), in order to complete the electrical circuit and deliver an incapacitating effect.	
	Fired	The Taser is fired with a live cartridge installed. When the trigger is pulled, the probes are fired towards the subject with the intention of completing an electrical circuit and delivering an incapacitating effect.	Discharge
	Drive stun	The Taser is held against the subject's body and the trigger is pulled with no probes being fired. Contact with the subject completes the electrical circuit which causes pain but does not deliver an incapacitating effect.	
	Arcing	Sparking of the Taser without aiming it or firing it.	
	Red-dot	The weapon is not fired. Instead, the Taser is deliberately aimed and then partially activated so that a laser red dot is placed onto the subject.	Non Discharge
	Aimed	Deliberate aiming of the Taser at a targeted subject.	
Lower use	Drawn	Drawing of the Taser in circumstances where any person could reasonably perceive the action to be a use of force.	

(United Kingdom, Home Office, 2017c)

Limitations to the data collected prior to 2014 are acknowledged, citing variable reporting detail provided by Police Forces (United Kingdom Home Office, 2017). Examining the data, there has been a steady rise in the use of the TASER® X26™; between 2015 and 2016 alone, an increase of nine per cent was recorded. However, the total number of non-discharge uses rose by eleven per cent, whereas total discharges had fallen by one per cent (United Kingdom Home Office, 2017). While useful, little can be inferred; similarly, the scientific literature regarding conducted energy weapon use, efficacy (the ability to produce an effect, for example collapse of posture), effectiveness (the ability of the device to assist real-world scenarios, for example collapse of posture in a subject who is intoxicated with drugs and violent), ethical issues and complications of the device are predominantly from the United States. Dymond (2014) highlights the lack of UK jurisdiction research and comparative data to other police use of force options to "inform the Taser debate". Further gaps in academic

research have been identified, with concerns raised by clinicians that experimental conditions do not replicate real life presentations and as such do not provide evidence of safety (Strote & Hutson, 2009).

Method

First, this paper examines online resources, searching for articles relating to CED injury and deployment rates. The medical literature was searched using the PubMed database for the terms "conducted energy weapon [tw] or TASER®" which yielded 337 citations; the abstracts of these articles were screened for references to injuries relating to CED exposure. Once identified, the references used in these publications were checked for any further sources of information. The criminal justice literature was similarly searched using the Applied Social Sciences Index & Abstracts and the National Criminal Justice Reference Service Abstracts Database.

Upon review of the literature, utilisation of the information provided (like any source) must be within the context of the setting; methodological biases (often retrospective studies), voluntary reporting of CED use, methods to identify cases (Kroll, Luceri, Lakireddy, & Calkins, 2016) using internet engines to search for incidents involving CEDs and conflict of interests (employment by manufacturers of a CED) are all legitimate concerns when examining papers. Azadani, Tseng, Ermakov, Marcus & Lee (2011) published a paper concluding that "studies funded by TASER® and/or written by an author affiliated with the company are substantially more likely to conclude that TASERs are safe"; however rather than a meta-analysis this was a simple statistical test of the likelihood of a publication reporting [CEDs are] "unlikely harmful or not harmful." Recognition of changes in CED technology, medical developments, numbers of CEDs issued and changes in population characteristics (for example, the introduction of so-called 'legal-highs') have all had implications for the deployment, use, and effectiveness of CEDs. A further factor confounding literature review is that publication bias is clearly evident; only the most serious injuries, or previously unrecognised complications following CED exposure are reported by clinicians.

Second, producing original research, as a retrospective study, working with the National Police Chiefs' Council (NPCC) Less Lethal Weapons Secretariat, to obtain data on TASER® use from as many UK police forces as possible. The NPCC wrote to fifty UK based forces, requesting anonymised and comprehensive data concerning use of Taser, other types of force, injuries and incidents. A number of forces replied, and working with the NPCC, some 60,000 discreet uses of force have been identified and examined in this study. This data has led to the publication of an internal police report already and there was a desire by the NPCC that this led to a peer reviewed academic paper, leading us to the study you read today. The data was anonymised and provided without conditions, indeed the original data is available for the public to read (for which, see NPCC, 2019).

The police data allowed for an analysis of injuries to both officers and subjects, linked to various different police tactics. An important aspect of the data to note, is that sometimes the police use multiple tactics on the same individual, and an injury to an officer or subject would be recorded against each tactic; each use of force data is not mutually exclusive. Consequently, it is impossible to calculate each individual use of force class, however what can be calculated is the odds ratio, that will show in interactions where TASER® was used, there was an odds of X that injury would occur to officer and Y to subject. To calculate the relative risk of each type of force used, a *prospective* study would be required where specific data is collected and the inclusion/exclusion of any injuries caused by each aspect of the interaction documented. Whilst consideration was given to calculating the statistical significance of the data, this would again require a prospective study.

Literature review

Comparisons with other countries can be illustrative of injury rates, however due to the multitude of confounders, such exercises are of limited benefit; with the implementation of national police use-of-force reporting within the UK, more meaningful evaluations may be drawn – that said, the wide demographic variation, type/rate of crime and geography again would need to be factored into account – as described in US studies (Neuscheler and Freidlin, 2015). One study outside the USA (Becour, 2013) described injury patterns ranging from a fractured humerus to cutaneous bruising presenting for hospital treatment. Most injuries (63%) were related to falling, with the remainder from CED darts.

Reflective of the longer period of issue to law enforcement agencies, the USA has a greater number of observational reports of CED use. Eastman et al. (2008) studied Dallas Police Department examining 426 cases of CED use by officers, stating no subjects necessitated anything other than first aid measures; there was one death attributed to cocaine intoxication and acute behavioural disturbance. Mild/no injury rates in criminal suspects reported by (Bozeman et al., 2009) were 99.75 percent, with three fatalities deemed not as a result of CED use.

The introduction of the CED for use by UK police forces initially to firearms officers, as a 'less lethal use of force' option compared to projectile weapons, implied that by their nature, CED may still be lethal. Much controversy arises when death occurs within temporal proximity to police attendance, even more so when a CED has been deployed. Lee et al. (2009) report that the number of deaths in US custody rose after the introduction of CED to the study groups; any interpretation of their results must account for the methodological limitations, with data missing, and reliance upon figures to be returned by the respective law enforcement agencies themselves (also problematic for UK studies as encountered by Payne-James, Rivers, Green & Johnston, 2014). In 2014, the then Independent Police Complaints Commission (IPCC) published a review of investigations into eight UK deaths following the use of TASER® X26™ and found that the device itself was not responsible for the death of the individuals involved (Independent Police Complaints Commission

[IPCC], 2014). However, the coroner has attributed TASER® to three deaths in the United Kingdom: First, the inquest concerning the death of Jordon Begley established that TASER® did not cause cardiac arrest, however it concluded, "the use of the TASER® and the restraint more than materially contributed to a package of stressful factors leading to his fatal cardiac arrest…" (Bunyan, 2015). "Another factor, they concluded, was Mr Begley's intoxication at the time of the incident and confrontation with police", the jury also found that the officer, "inappropriately and unreasonably used the stun gun for longer than was necessary" (BBC News, 2015). Second, in 2013 Andrew Pimlott died from multiple burns after dousing himself with petrol; a TASER® was discharged whilst he was allegedly holding a lit match; the petrol ignited (IPCC, 2014). It has been demonstrated that CEDs have the ability to ignite petrol vapours within a compartmented area (Clarke & Andrews, 2014). Finally, in 2017 Marc Cole died after being subject to three separate TASER® discharges totalling 40 seconds; he had taken cocaine and jumped out of a first floor window, going on to stab a woman in her garden and upon police arrival, slashed his own throat. The cause of death was recorded as, "use of cocaine, episode of altered behaviour including self-harm, exertion, excitement, the use of an x26 Taser device and restraint". (Dearden, 2020).

In contrast, since 1st April 2006, the Independent Office for Police Conduct (IOPC) (formally the Independent Police Complaints Commission - IPCC) have investigated 1,604 deaths relating to police contact (Independent Office for Police Conduct [IOPC], 2017), as described in *table two*. It seems that the significant majority of death following police contact do not involve TASER®.

Table two – *Investigations into death following police contact by the IPOC*

Category	Incidents										
	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
Road traffic incidents	35	18	33	26	24	19	23	11	13	20	28
Fatal shootings	1	4	3	2	2	2	0	0	1	3	6
Deaths in or following police custody	27	22	15	17	21	15	15	11	18~	14	14
Apparent suicides following custody	47	45^	56	54	46	39	65	70	71~	60	55
Other deaths following police contact*	21	30	33	37	49	37	20	41	43	101~**	121

^ Operational advice note issued in 2007 on the referral of these deaths.

* Change in definition of 'other deaths following contact' in 2010/11 to include only cases subject to an independent investigation.

** Expansion of IPCC investigative resource and capacity to conduct more independent investigations into serious and sensitive matters – this has a direct impact on the number of other contact deaths that are reported.

~ This table presents the most up-to-date set of figures for these categories; any additions to previously published data are indicated.

(IOPC, 2017)

In August 2018, the IOPC were investigating seven UK deaths during which TASER® was recorded as a factor, this does not mean TASER® contributed to the death just that it had been recorded as a factor in the IOPC

investigation (NPCC, 2019). When examining any death following the use of CED, it is crucial to determine if the cause of death was due to an underlying condition such as heart disease (Strote & Range Hutson, 2006), drug and/or alcohol intoxication, or the often contested acute behavioural disturbance (previously referred to as 'excited delirium') (White et al., 2013). The absence of any standards for CED and arrest-related death is noteworthy (Todak, Cesar & Louton, 2015). The time interval between CED exposure and subsequent death is of paramount importance to determine what, if any, contribution to the outcome it may have had (Kornblum & Reddy, 1991). As with many use-of-force incidents, often multiple use of force tactics are utilised during the event; to avoid erroneous attribution of cause and effect to a particular use of force, the independent and summative contribution(s) of any technique(s) must be appreciated (Smith, Kaminski, Rojek, Alpert & Mathis, 2007). Other papers are often contradictory: Robert Dziekanksi died during the confrontation between a Royal Canadian Mounted Police in 2007 in which he was subjected to CED discharges; a commission on CED usage, examining the medical evidence, experiential and policy issues published a report with many recommendations after a lengthy consultation process, involving many individuals with experience of CED (Braidwood, 2009). Commissioner Braidwood concluded that "I am satisfied that conducted energy weapons do have the capacity (even in healthy adult subjects) to cause heart arrhythmia…" (Braidwood, 2009); this has subsequently been challenged to even go so far to say "it is apparent that Commissioner Braidwood either did not understand the body of scientific, medical, and technical literature, or he disregarded it" (Williams, 2011).

Operational safety considerations for police officers using CEDs include risk of injury to the officers themselves, the subject or others within the locality; Bui, Sourkes, & Wennberg (2009) report an officer who received a CED probe discharge to the head when chasing a suspect and then had a seizure. Studies from the US have reported a reduction in officer injuries when using a CED (Lin & Jones, 2010; Taylor & Woods, 2010; PERF, 2009), and overall injuries to officers when equipped with a CED *without* incapacitant spray issued (Smith et al., 2007); Paoline, Terrill & Ingram report a reduced incidence of officer injuries only when CEDs were used alone compared to hands-only tactics (2012); contrary to these studies, MacDonald, Kaminski & Smith (2009) found no relationship between use of CED and officer injury. The external validity of these studies to other agencies who use CEDs is limited with all of them conducted within the US; common to all of the studies, the use of retrospective data capture and analysis is fraught with the issues of missing data, data categorisation (type of wound and severity) between law enforcement agencies and differing departmental practices post exposure to a CED.

The sudden contraction of muscles or loss of posture as a result of being exposed to a CED may result in injury to the subject and falls with subsequent head trauma may be anticipated (Kroll, Adamec, Wetli & Williams, 2016), as exemplified when a CED was used on a male in Llandudno who sustained a severe head injury, with significant recovery (IPCC, 2017). Sharma, Theivacumar & Souka (2009) report the (non-fatal) abdominal self-stabbing of a male holding a knife when a CED was used. Fractures of the spine resulting from back muscle

contraction during a CED demonstration upon law enforcement officers (whilst being supported so as not to fall) have been documented (Winslow, Bozeman, Fortner & Alson, 2007; Sloane, Chan & Vilke, 2008).

The subject of an incident can present responding officers with challenges; warning markers (violence, drugs and the like), age, any mental illness and prior behaviour patterns are an invaluable aid to officers in making their risk assessment, however such information is often unavailable and relies on knowing the identity of the subject prior to the police interaction. The use of alcohol, drugs and mental health conditions alone or in combination, can affect a person's ability to understand, process and respond appropriately to an instruction or the visual presentation of a CED such as drawing, aiming or 'red-dotting'. The use of CED on subjects with mental illness has been met with uneasiness, especially those detained under mental health legislation (MacAttram, 2016); A study conducted in the US found that those with mental illness, stimulant use, or a combination of the two factors, statistically received more shocks compared to those without such characteristics (Bailey, Smock, Melendez & El-Mallakh, 2016); yet in a UK case report a CED successfully resolved an incident when standard interventions had failed (Little & Burt, 2013). Munetz, Fitzgerald & Woody (2006) examined the use of CED by a crisis intervention team, comprising of police officers with additional training in mental illness; there were thirty-five incidents whereby a CED was used within the first eighteen months (ten featured the possession of a weapon, most commonly a knife), with no serious harm to the individual subject to the electrical discharge. Similarly, a retrospective study over three years reported an 85 percent success rate with no serious injury or death when an CED was used for incidents involving emotionally disturbed persons (White & Ready, 2007). O'Brien, McKenna, Thom, Diesfeld & Simpson (2011) report that CED discharge is statistically more likely in mental health emergencies than criminal incidents in New Zealand. The increased number of discharges to individuals under the influence of stimulants, or experiencing mental health emergencies, may be indicative of the higher pain tolerance under these conditions, and/or an altered mental status with a subsequent reduced efficacy of CEDs in subduing dangerous behaviours.

Injuries associated with Conducted Energy Device use

Primary Complications

The induction of potentially fatal cardiac arrhythmias (ventricular tachycardia and ventricular fibrillation) secondary to exposure to a CED electrical discharge has been contested both within the literature and US courts (Kim & Franklin, 2005; Kroll, Lakkireddy, Stone & Luceri, 2014; Naunheim, Treaster & Aubin, 2010; Swerdlow, Fishbein, Chaman, Lakkireddy & Tchou, 2009; Zipes, 2012; Zipes, 2014); the attribution of a CED to induce these arrhythmias is obfuscated by the rapid deterioration of such rhythms to asystole (no electrical activity of the heart) and the many other factors that may precipitate the generation of fatal ventricular rhythms.

DOMILL (2002) noted that the technological evolution of CEDs resulted in a reduction in the ability to induce extra ventricular beats (in isolated heart tissue): *"the risk of a life-threatening event arising from the direct interaction of the currents of the X26 Taser with the heart, is less than the already low risk of such an event from the M26 Advanced Taser".* A statement later released by DOMILL (2007) made specific reference to the increased vulnerability of children and those of small stature due to smaller body weights, extrapolating from data on the body weight of pigs.

Extreme physiological exertion, with an overload of circulating adrenaline may lead to sudden death (c.f. acute behavioural disturbance); underlying genetic risk factors, structural heart abnormalities and stimulant drug use may all contribute to an increased risk of fatal arrhythmia generation (DOMILL, 2005). Acute stress-related cardiomyopathy (Takotsubo's cardiomyopathy) resulting from severe emotional distress and raised adrenaline levels is a recognised phenomenon characterised by a 'dilated pocket' of heart muscle, postulated as a cause of death in arrest-related deaths after CED exposure (Cevik, Otahbachi, Miller, Bagdure & Nugent, 2009). Multerer, Berkenbosch, Das & Johnsrude (2009) published a case report featuring a sixteen-year-old who was found to have the heart rhythm atrial fibrillation (often referred to as an 'irregular heart beat') after the use of an earlier generation M26 CED. Myocardial infarction (in a twenty-year-old anabolic steroid user) has been reported one-and-a-half hours after being subdued with a CED (Baldwin et al., 2010). Whilst arrest-related cardiac arrest is normally a fatal event, Schwarz, Barra & Liao (2009) describe the successful resuscitation of a seventeen year-old male who was found to have no cardiac electrical activity (asystole) for twenty minutes when emergency medical services arrived.

For persons who have a pacemaker or implantable cardioverter-defibrillator, concerns have been raised by medical professionals that the device may be damaged by or detect the CED electrical current as an abnormality requiring (inappropriate) activation. The few case reports on this subject have not found this to be the case (Haegeli, Sterns, Adam & Leather, 2006; Paninski, Marshall & Link, 2013); Cao, Shinbane, Gillberg, Saxon & Swerdlow (2007) report electrical stimulation of the heart measured by a pacemaker but caution whether this was a property of the CED *per se*, or only in association with cardiac devices in situ. DOMILL (2011) stated awareness of a single incident in which a seizure was trigged in a person with epilepsy and a death secondary to severe coronary artery disease after exposure to a CED. A single report of a stroke occurring in a 32-year-old male with schizoaffective and bipolar disorder after CED discharge was reported by Bell, Moon & Dross (2014); a persisting speech abnormality and right-sided weakness was noted and a work-up for the common risk factors for stroke were negative other than a history of smoking.

Mehl (1992) often cited case report of miscarriage following CED exposure in the United States, describes a female heroin user who was eight-to-ten weeks pregnant when a CED was used on her for failing to undress in front of male guards; she began spotting blood the day after, with a resulting miscarriage fourteen days later.

Gleason & Ahmad (2015) reports rhabdomyolysis (muscle breakdown) and subsequent kidney failure in a subject who was combative, agitated and subsequently subdued with a CED. Whilst an electrical 'shock' may lead to muscle death, an alternative cause could be the acute behavioural disturbance leading to the outcomes reported; at the lesser end of the spectrum this has been reported in two patients with psychosis who were agitated (Sanford, Jacobs, Roe & Terndrup, 2011).

As with attributing any agent to an outcome in humans, simple temporal association does not necessarily imply causation; rigorous evaluation of all contributory factors involved is necessary to avoid inappropriate, or even incorrect attribution of police actions leading to a deleterious event. Jauchem (2015) describes in his narrative paper various sources of misconceptions, with exaggeration or over statement of the incapacitating effects and association of CED with deaths.

Secondary Complications

The darts of CEDs are designed to penetrate the skin or clothing of an individual to allow the delivery of the electrical current; of the 3.3 million darts that have penetrated human skin, none have resulted in any reported infections (Kroll, Ritter, Guilbault & Panescu, 2016). Designed to tether within the skin layer, complications may arise from the inadvertent probe impact onto an area of the body other than the primary target areas. Due to the often highly emotive and agitated state of the subject relative to the police officer, recall of events, timings, verbal communications and actions of those present can be impaired, thus when reviewing such injuries this must be taken into account; the use of body-worn cameras are invaluable in providing additional evidence to the officer's subjective experience.

Injuries to the head and face from the probes may result in fractures to the often paper-thin bones (de Runz, Minetti, Brix & Simon, 2014); penetration of the skull bones has been demonstrated (Chandler, Martin & Graham, 2013; Kaloostian & Tran, 2012; Le Blanc-Louvry, Gricourt, Toure, Papin & Proust, 2012; Lewis & Lewis, 2016; Rehman, Yonas & Marinaro, 2007) with no long-term complications reported.

The eye is particularly vulnerable to damage from the probes with permanent visual impairment or blindness (Han, Chopra & Carr, 2009; Li & Hamill, 2013; Sayegh, Madsen, Adler, Johnson & Mathews, 2011) or even removal of the eye necessary (Rafailov, Temnogorod, Tsai & Shinder, 2015; Teymoorian, San Filippo, Poulose & Lyon, 2010); although with advanced surgical techniques penetration of eye may not necessarily lead to blindness (Chen, Richard, Murthy & Lauer, 2006; Jey, Hull, Kravchuk, Carillo & Martel, 2016; Ng & Chehade, 2005). In the case report by Seth, Abedi, Daccache & Tsai (2007), cataract formation with a linear burn across the eyelid was associated with a CED exposure.

Puncture of the throat (Al-Jarabah, Coulston & Hewin, 2008), trachea – resulting in air within the chest cavity (Maher, Beck & Strote, 2015), and chest wall – with subsequent lung collapse (Hinchey & Subramaniam, 2009) are more likely to occur in very thin individuals.

Testicular penetration by a dart with associated haemorrhage has been recorded (Theisen, Slater & Hale, 2016) or torsion (Ordog, Wasserberger, Schlater & Balasubramanium, 1987); whilst impaction into the finger may necessitate surgical excision and tendon repair (Dearing & Lewis, 2005; Dunet, Erbland, Abi-Chahla, Tournier & Fabre, 2015).

Given the nature of incapacitation, it is to be expected that falls from standing height may be associated with head injury; retained probe tip, facial fractures and brain haemorrhage may result from such falls (Mangus, Shen, Helmer, Maher & Smith, 2008). The use of CED presents a small increased risk of fatal traumatic brain injury, with increased age an independent risk factor for fatal brain injury (Kroll et al., 2016).

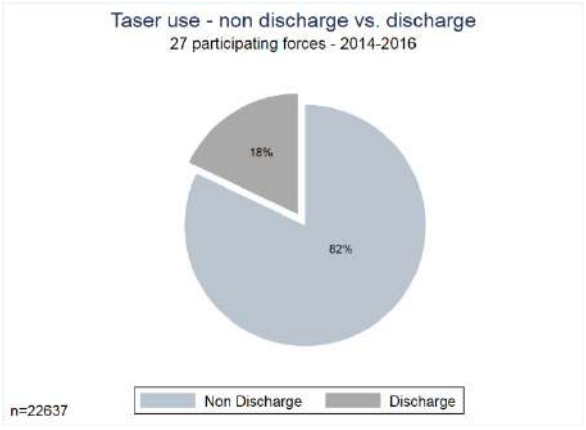
Finally, ingestion of the probe post CED discharge has not shown to result in harm (Koscove, 1987).

UK Police Data:

Evaluating the effectiveness of CED by the police requires consideration of many factors; the operational implementation of the device itself (determined by the design, reliability and so forth) may be considered an independent control factor within the UK (that is when comparing different success and failure rates at incidents in differing forces), as the only model supplied to all police forces until 2017 was the TASER® X26™. The Taser XREP™ model, a shotgun style self-contained projectile was used once by Northumbria Police during the stand-off with Raoul Moat in 2010, which was supplied direct to Northumbria Police, not to the UK Home Office and was never approved for use in the UK (Gander, 2015). The newer TASER® X2™ was authorised for use by the Home Office in March 2017 (United Kingdom Home Office, 2017b) and many forces are now starting to convert to this new device.

Drawing on data published by the UK Home Office (United Kingdom Home Office, 2015; United Kingdom Home Office 2016; United Kingdom Home Office 2017d), figure 1 shows 22,637 uses of TASER® from 27 police forces, separated into non-discharge and discharge uses. This indicates that the majority of TASER® use by these forces did not lead to the discharge of electricity but were simply drawing, aiming or red dotting the device. This might suggest that these actions can be sufficient to deescalate a violent encounter and the non-discharge use of TASER® can prevent other, potentially more injurious, types of force being used, such as a police baton, irritant spray or physical confrontation. This data shows TASER® was only discharged to a subject on 18% of occasions it was ‘used’.

Figure one: *Proportion of TASER® discharge vs non-discharge.*



(NPCC, 2019)

This data is very useful, as most countries do not routinely report non-discharge use of TASER®; whilst this makes comparison with other countries difficult, it also provides a useful insight into how TASER® is actually used on the street, at least in the UK.

Woking with the NPCC, we wrote to fifty UK Police forces requesting data concerning their use of TASER® and injuries to both officers and subjects. The data covers various periods, as different forces presented different data sets, from 2016-2017 and therefore relates to the X26™ model of TASER®.

First, it was possible to determine from the data analysed the effectiveness of TASER® use in these cases. When completing the use of force data, officers are asked to report if the tactics used were effective. This is an inherently subjective measure, however the police have given the following guidance to their officers to measure effectiveness of tactics: "whether the technique achieved its tactical aim - or were further tactics necessary to achieve this outcome?" (NPCC, 2019). For example, if a violent subject was hit with a baton but this did not change their behaviour, meaning TASER® had to be used, the use of baton would be considered ineffective.

Twenty forces shared data concerning 59,401 uses of force, which were analysed for reported effectiveness of each tactic.

Table three*: Effectiveness of use of force by tactic*

Type of force (includes drawing/aiming equipment)	Effective	Ineffective	% Effective
Firearms	2,634	93	97
Police Dog	472	91	84
Physical confrontation	31,406	6,202	84
AEP	67	20	77
Taser	8,639	4,007	68
Baton	1,453	711	67
Irritant Spray	1,963	1,643	54
Total	46,634	12,767	79

(NPCC, 2019)

The data shows that firearms were the most effective tactics at 97%. Irritant spray was the least effective at 54%. The effectiveness of TASER® was reported as 68%, more effective than baton (by only 1%) and irritant spray.

In England & Wales, once a police officer uses force, they should record details of the incident using a national 'Use of Force Form' (NPCC, 2019). This form collects data on the various tactics used by the officers and any injuries received by officers and subjects. This data is somewhat limited: The form does not record how the injuries were caused and in some incidents multiple tactics are used; there is therefore an association between types of force used and injuries and no direct link can be inferred. Furthermore, our data covers all injuries and this would range from minor to life changing injuries; the injury may have been caused before, during or after the use of force (NPCC, 2019).

Twenty forces provided injury data from 2017 relating to police officers and the corresponding tactics used during the incident, a total of 38,355 uses of force. This data includes where devices, such as irritant spray or TASER® are simply drawn and not discharged. Further, during an encounter, multiple uses of force could be applied to a single subject; for example, if an officer uses irritant spray then holds the offender on the floor,

this would count twice in the data as two uses of force (irritant spray and ground restraint/physical confrontation). As such, each use of force is not mutually exclusive.

Table four: *Injuries to officers and associated tactics used during the incident.*

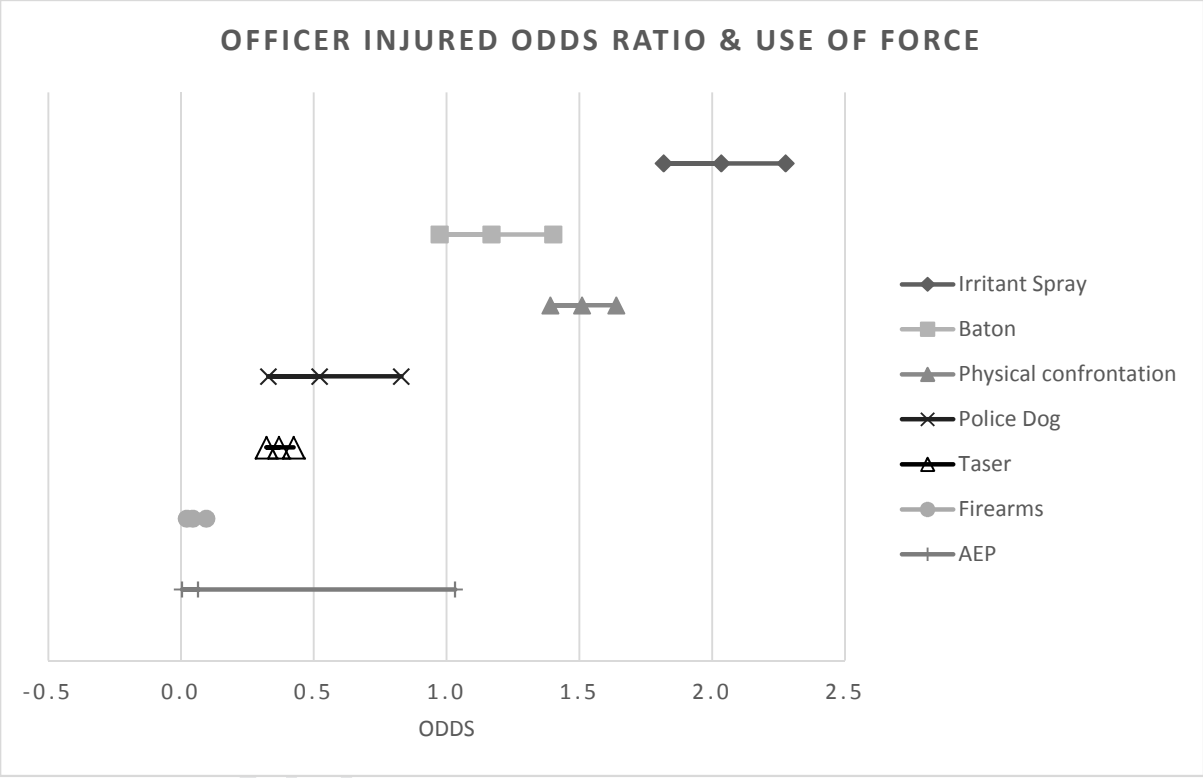
Type of force (includes drawing/aiming equipment)	Uses of force	Officer injured	% injured
Irritant Spray	2,465	403	16
Baton	1,274	135	11
Physical confrontation	27,077	2,761	10
Police Dog	374	19	5
Taser	5,619	225	4
Firearms	1,470	7	0.5
AEP	76	0	0
Total	38,355	3,550	

(NPCC, 2019)

The data includes use of the 'Attenuating Energy Projectile' (AEP) system, which is a less-lethal impact round system carried by all Armed Response Vehicles (NPCC, 2019). The data shows that the tactic associated with the greatest proportion of injuries to officers was irritant spray (16%), the lowest being firearms (0.5%) and AEP (nil). Firearms potentially provide the greatest stand-off distance and firearms operations are typically well resourced (NPCC, 2019). The data shows fewer injuries to officers associated with TASER® (4%) compared to other common uses of force, including irritant spray, baton, physical confrontation or police dog. Using this data, we were able to calculate the odds ratio for officers being injured.

Examining the odds ratios for the various use of force options (figure two) demonstrates that police dogs, firearms and TASER® results are less than 1.0 (indicative of reduced odds of officer injury, and with narrow confidence intervals, this is a relatively precise estimate for TASER® and firearms.) The NPCC (2019) state that TASER® frequently gives officers a greater stand-off distance from the subject than many of the other commonly available tactics. Greater stand-off distance may be associated with a reduction in the odds of injury, however the answer is most likely multi-factorial and would necessitate prospective study methods to identify.

Figure two. *Odds ratios for officer injury when use of force is employed*



Eighteen forces provided data from 2017 concerning injuries to subjects and the associated tactics, a total of 34,217 uses of force. Again, this data relates to the entire range of injuries, from minor to significant and would include injuries from the darts. It does not record when the injury was caused, so again may have been suffered prior, during or after the use of force by the police. Multiple tactics are sometimes used during an incident; where multiple tactics were used, the same injury would be recorded against each tactic, so again each use of force is not mutually exclusive. For example, if a subject was injured with a baton then later a TASER® was discharged at them, an injury sustained by the baton would be reported against both the baton and the TASER® (NPCC, 2019). Finally, this data includes where devices such as police dogs, baton or TASER® are 'drawn' not discharged.

The recording of dart punctures to the skin following the use of CEDs is currently documented by UK police forces; the classification of such marks as an injury or not has been the subject of academic debate: Terrill & Paoline (2012) are of the opinion that dart punctures to the skin are injuries and should be analysed as such; consequently the outcome of their study found that the use of CEDs resulted in an increased probability of subject injury compared to no use (although 58.4% of cases did not result in *any* injury). The inclusion of dart punctures as injuries secondary to police use of force is argued against by Kaminski, Engel, Roject Smith and Alpert (2015); in their study, they concluded that when dart punctures are excluded, injuries to suspects are benign or reduced. The injury data used in our study does include injuries from the darts.

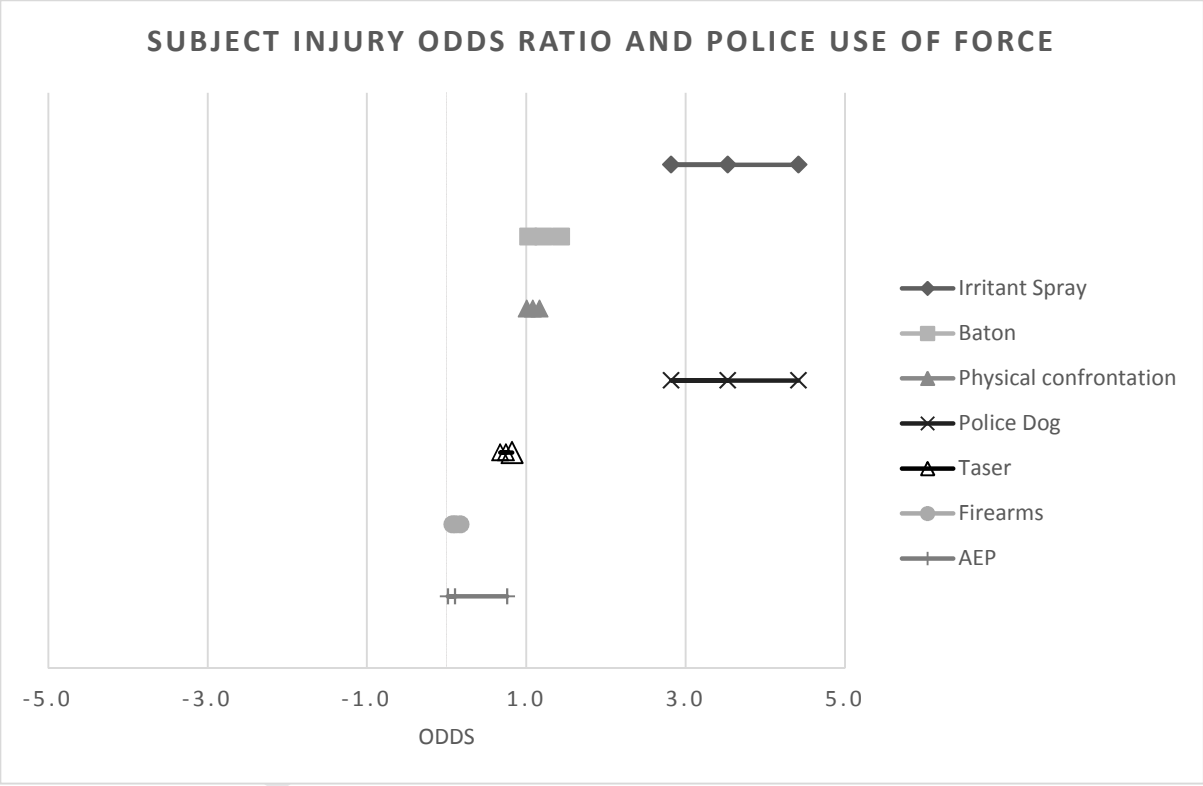
Table five: *Injuries to subjects and associated tactics used during the incident.*

Type of force (includes drawing/aiming equipment)	Uses of force	Subject injured	% injured
Police Dog	369	112	30
Irritant Spray	2,145	362	17
Baton	1,228	162	13
Physical confrontation	23,510	2,693	11
TASER®	5,444	485	9
Firearms	1,445	21	1
AEP	76	1	1
Total	34,217	3,836	

(NPCC, 2019)

Counterintuitively, firearms and AEP were associated with the least proportion of injuries, the NPCC (2019) state the British Police rarely discharge firearms and the analysis includes incidents where firearms and AEPs were merely drawn from holsters. Placing firearms and AEP aside, as a proportion of use, TASER® was associated with fewer injuries to subjects than other, perhaps more traditional use of force by the police, such as physical confrontation, baton, irritant spray and police dog. Calculating the odds ratio for subjects to be injured by the use of force, TASER® and firearms were associated with a lower odds for the subject, as was AEP use; perhaps unsurprisingly, use of police dogs and irritant spray were much more likely to result in injury to the subject (*figure three*).

Figure three: *Odds ratios for use of force and subject injury*



For the UK, until 2017, the police have categorised injuries in association with the deployment of a CED into three categories:

- Primary – Possibly caused by the direct effect of current flow.
- Secondary – as a result of an indirect delivery, such as from the barbs or falls;
- Co-incidental – Injuries received in the incident not directly related to Taser use, e.g. self-inflicted wounds, gunshot wounds, dog bites.

(NPCC, 2019)

Our study, working with the NPCC, examined X26™ TASER® use forms provided by twenty forces, concerning 5,839 uses of TASER® during 2016, which were scrutinised for qualitative data. On each form, officers were asked to record primary, secondary or coincidental injuries and provide a free text explanation of each injury. It was not possible to compare this data with other tactics, as physical confrontation, baton and irritant spray are not subject to this greater level of scrutiny (NPCC, 2019).

Of the 5,839 occasions that TASER® was used, the forms recorded discharge of TASER® on 948 occasions (16%); 159 attended Emergency Departments (ED) (3% of total use, or 17% of discharges). Examples include where barbs were bent upon falling and required professional removal as well as injuries from the fall, rapid pulse rate and one 'seizure' (NPCC, 2019). Whilst all forces recorded injuries and hospital visits, only sixteen forces recorded when the subject was admitted to hospital as an inpatient. These forces used TASER® on 417 occasions, of which TASER® was discharged on 61 occasions. Of these sixteen forces, only three hospital admissions were noted, one for a primary injury and two for a secondary injury. This represents 0.7% of all TASER® use and 4.9% of discharge.

The Royal College of Physicians Faculty of Forensic and Legal Medicine advise that, "All persons subjected to TASER® discharge must ultimately be examined and assessed by a registered medical practitioner – a doctor," (Payne-James & Sheridan, 2017). This is adopted by the College of Policing Approved Professional Practice, essentially the rule book to which the UK police work, which states, "All arrested persons who have been subjected to CED discharge must be examined by a forensic medical examiner (FME) [a doctor] as soon as practicable after arrival at the custody suite" (College of Policing, 2020). The recommendation that detainees are examined only by a doctor, when nurses or paramedics are often employed in UK custody suites, can be problematic to the police who must then attend the Emergency Department. This policy may confound our analysis and is perhaps why the data showed some subjects were taken to hospital with apparently no injuries. Considering the relatively low number of admissions to hospital following TASER® discharge and the relatively low number of injuries associated with TASER® use, the Faculty of Forensic and Legal Medicine might wish to consider broadening their advice to include appropriately trained nurses and paramedics. This may have an incidental benefit of revealing pressure on Emergency Departments.

Strote, Walsh, Angelidis, Basta & Hutson's (2010) retrospective analysis of CED use within Seattle, noted that 26.8% of subjects were seen in Emergency Departments within 24 hours, of whom one quarter of which had an altered mental state; a stark contrast to the much lower requirement for hospital attendance noted in the UK police data.

In 2012, a review of CED against one hundred subjects aged 13 to 17 reported no significant injuries other than 20 probe-related minor wounds (Gardner, Hauda & Bozeman, 2012); Bozeman, Teacher & Winslow (2012) published their retrospective review of 1,201 subjects who had been exposed to an CED, classifying 99.75% as having no injuries and 0.25% sustaining head injuries as a result of falls, and one case of rhabdomyolysis; two deaths occurred associated with prolonged combative behaviour. The most recent reported study used a prospective multi-centre observational method (Bozeman, Stopyra, Klinger et al, 2018) found after 504 CED uses there were no significant injuries reported.

Discussion

Bringing the evidence together, it is apparent that the use of CEDs as a police use-of-force may be associated with injury; the overwhelming majority of such are classed as minor. The inclusion of probe puncture wounds or contact superficial burns is accepted by the police as being of a high likelihood with the discharge of a CED. Death or the more severe injuries described in the medical literature are rare, given the number of CED deployments and with the advent of dual laser targeting in the TASER® X2™ to assist officers, might be reduced. Deaths occurring within temporal proximity to the use of a CED should be investigated thoroughly and the presentation of the individual carefully recorded; there is no *direct* evidence of a CED leading to a death during an episode of acute behavioural disturbance, a condition in itself that has an appreciable mortality when unrecognised. However, the increased physiological stress experienced by a person after being exposed to a CED should be appreciated; that said, given the lack of any current prehospital recognised strategy for the management of such a condition, the use of a CED should not be *precluded* should the risk-threat assessment prove necessary for management of the situation.

Many of the studies described have calculated risk or odd's ratio's for officer and suspect injuries; careful consideration as to the external applicability to other users of CEDs must be given to these figures. Additionally, what is clearly absent from any of the literature is a post-event study examining the subject's 'lived experience' of the event and a CED being deployed. Work of this nature may alleviate concerns regarding the use of CEDs and may allow comparison to other police use-of-force outcomes.

The collection of post-incident data provides evidence to the relative operational safety of the TASER® by the UK Police; it is accepted by the police that no use-of-force option is risk free, however data provided by the UK Police showed a greater incidence of injury to both the officers and subject, as a proportion of use, when baton, irritant spray or physical confrontation was used. As part of a governance structure for UK police, the open publication of anonymous and standardised data regarding the use of CEDs (and other use-of-force

options) can only help strengthen public (and officer) confidence with such strategies. Whilst the body of literature referred to earlier is representative of rare and severe injuries, the operational evidence indicates the overall relative safety of CEDs.

Our study of UK data examined 22,637 discreet uses of force, finding that TASER® was only discharged in 18% of occasions it was drawn from the holster; on other occasions it was drawn only, aimed, red doted or the warning arc was turned on as a deterrent. Effectiveness of various use of force tactics was measured across 59,401 uses for force: firearms were found to be the most effective tactic at 97%, TASER® was reported to be effective on 68% of occasions it was used, more effective than baton (by only 1%) and irritant spray, the latter being the most ineffective tactic at 54%.

Injuries to officers were examined across 38,355 uses of force and it was found that injuries associated with the TASER® tactic was noted on 4% of occasions when TASER® was used; this was much lower than irritant spray (16%), baton (11%), physical confrontation (10%) and police dog (5%). It was calculated that the odds ratio of an officer being injured where TASER® was used was less than 0.5, whereas irritant spray provided the greatest odds of injury, being around 2.

In a similar way, injuries to subjects associated with 34,217 different police tactics was examined; injuries were associated with 9% of use of TASER®, compared to police dogs (30%), irritant spray (17%), baton (13%) and physical confrontation (11%). The odds ratios calculated showed that the odds of a subject being injured when a TASER® was used was less than 1, while both police dog and irritant spray were greater than 3. Further data from 2016 examined 5,839 uses of TASER® found that 159 attended Emergency Departments (ED) (3% of total use, or 17% of discharges).

The UK data confirms our findings that whilst use of TASER® can cause injury in subjects, it is more often than not a minor injury and only found in a small percentage of use of the device; rarely does it lead to a hospital visit and even less frequently is the subject admitted to hospital. It would be fair to conclude from the data provided, that TASER® is associated with fewer injuries, as a proportion of use, than somewhat traditional police tactics, such as the use of irritant spray, baton or police dogs.

This study considered the advice from the Faculty of Forensic and Legal Medicine that all persons subjected to TASER® discharge must be examined by a doctor. Considering the relatively low number of admissions to hospital following TASER® discharge and the relatively low number of injuries associated with TASER® use, the faculty might wish to consider broadening their advice to include appropriately trained nurses and paramedics.

Analysis of TASER® use continues to be difficult as recording practices vary from country to country, however it was noted that arguably the UK has the most comprehensive and transparent recording mechanism of TASER® use in the world. However, the UK repotting should be developed, to identify the cause of injuries reported and when they occurred.

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Category	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Road traffic incidents	35	18	33	26	24	19	23	11	13	20	28
Fatal shootings	1	4	3	2	2	2	0	0	1	3	6
Deaths in or following police custody	27	22	15	17	21	15	15	11	18	14	14
Apparent suicides following custody	47	45	56	54	46	39	65	70	71	60	55
Other deaths following police contact*	21	30	33	37	49	37	20	41	43	101 **	121

* Change in definition of 'other deaths following contact' in 2010/11 to include only cases subject to an independent investigation.

** Expansion of IPCC investigative resource and capacity to conduct more independent investigations into serious and sensitive investigations.