Analysis of the Effectiveness of Taser in Police Intervention and Overview of the Main Causes of Failure

Karolina Kocurkova [1], Martin Hrinko [2]

[1] *Faculty of Safety Engineering, VSB TUO, Ostrava, Czech Republic*
[2] *Department of Security Studies, CEVRO Institute, Prague, Czech Republic*

Abstract **– An inappropriately chosen tactical procedure and means during a police intervention against highly dangerous subjects may lead to an escalation of the conflict and to further threats to the interveners and to the subject against whom the intervention is conducted. The main objective of this article is to analyse the effectiveness of the technical device Taser, which uses an electrical discharge to temporarily incapacitate a human subject, identify the main causes of failure of it, and its implications in practice at the incident level. The paper is based on the presentation of current scientific evidence in available electronic databases (Web of Science, Scopus; using keyword taser), and the data are compiled into a clear graphical form through the principles of the Fault Tree Analysis (FTA). A set of potential failure causes was identified from the human factor, the role of technology, and environmental influences. The taser was found to be a conditionally effective technological device with a wide and difficult to determine range of effectiveness depending on the method chosen. The findings have implications for training and education with a focus on minimising the risks of service intervention in terms of the effectiveness of this type of law enforcement agent.**

DOI: 10.18421/TEM1340-27
https://doi.org/10.18421/TEM134-27

Corresponding author: Karolina Kocurkova,
Faculty of Safety Engineering, VSB TUO, Ostrava, Czech Republic
Email: karolina.kocurkova.st@vsb.cz

Received: 23 August 2024.
Revised: 30 October 2024.
Accepted: 07 November 2024.
Published: 27 November 2024.

Keywords **– Taser, conducted electrical weapon (CEW), efficiency, failure, police use of less-lethal force.**

1. Introduction and Background

Armed and security forces must constantly respond to the security challenges of the 21st century, in terms of the considerable variability of conditions, newly emerging threats, and their often unpredictable nature, especially in the context of changes in the security environment in connection with the global mobility of the world's population and the consequent different demographic parameters of the population, including the ever-increasing aggression in confrontational incidents [1]. These forces exercise state power on the basis of laws issued to protect freedom, justice, legal certainty, and other security interests of the state. For this reason, it is necessary to equip forces, which play a key role in ensuring internal security, with the latest technologies, armaments and equipment so that they can respond adequately and be able to protect the values of the democratic rule of law and use them in the event of a threat to protected interests [2]. The latest means of modern policing are focused on the area of less-than-lethal weapons, with one of the most controversial options in this category being the CEW device. The CEW device uses high-voltage, ultrashort, low-current electrical pulses to temporarily incapacitate a subject by stimulating peripheral efferent motor neurones, resulting in the induction of skeletal muscle spasms. Kunz and Krys [3] mention, that due to stimulation of afferent sensory neurones, pain is also induced in the subject.

The scientific research initiative and discussion of CEW have focused primarily on the health aspects of the impact on exposed individuals and the existing risk of fatal consequences, a component of the safety of the device that, however, correlates significantly with its effectiveness.

CEWs can generally be more effective and less dangerous than other force options in certain circumstances.

However, there are concerns about the effectiveness of the device and the potential for its failure as the chosen means of coercion for a given confrontational situation and the resulting negative consequences. The overview of the main causes of failure and the consequences of it will be presented below. Only a tiny proportion of studies have examined the general effectiveness of CEWs in the field, although operators' awareness of the risk of potential ineffectiveness of the device and knowledge of the causes, are clearly not only necessary.

Den Heyer [4] says that research to date includes three ways that define the effectiveness of CEW use, namely:

- effectiveness as the ability to temporarily immobilize a potentially violent individual,
- the effectiveness of the device in reducing the use of lethal force (firearms),
- and the effectiveness of equipment in reducing injuries to intervening and exposed subjects.

One of the first studies by Ho *et al.* [5] to directly evaluate the effectiveness of CEW X26 (legacy TASER model, *Axon Enterprise Inc*., Scottsdale, Arizona, USA) in terms of tracking a number of variables under experimental conditions observed the effectiveness of incapacitating highly motivated human subjects, with the target nature of motivation being the completion of a device deactivation task or a 3.4 m away suspended martial arts dummy using a training knife. The authors of the publication scored subject controllability by degree of incapacitation. The findings of this study are consistent with findings of more recent study by Kunz *et al.* [6], which concluded that, in general, more effective incapacitation is observed when targeting the back, probably due to the presence of larger muscle groups in this anatomical region. This study also looked at comparing the CEW effectiveness of different models, with the most recent models showing the highest expected result of standard effectiveness.

A study by White and Ready [7] looked at identifying predictors of CEW effectiveness based on an estimate of the affected subject's ability to continue resistance (in percentage terms) and the overall assessment of the actual incident by specific interveners with this enforcement agent. The results of this and another study by Womack *et al.* [8] suggest that several factors are associated with reduced effectiveness of the agent, including suspect body weight or long-term use of drugs and alcohol use.

The efficacy of CEW on a broad scale in terms of success in achieving the goal of obtaining subject compliance was also evaluated in a study by Somers *et al.* [9].

CEW is classified as an effective agent, but its effectiveness varies depending on a number of important variables (multivariate models to predict the probability of effectiveness and develop potential correlations of effectiveness). This research focused on the efficacy of the device based on a sample of field use cases in terms of mode and method of deployment, that is, mode of implementation, with higher efficacy observed in contact mode than in distance mode, which is contrary to the best practice guidelines lists for CEW deployment, where distance mode is recommended primarily due to induction of neuromuscular incapacitation. (In the contact mode, the flow of electrical current is limited primarily to the dermis, the superficial layer of the skin, subcutaneous adipose tissue and superficial muscle layers [12]. Thus, there is no risk to the underlying deeper organs with this type of application [3] and no incapacitating effect is induced.) The study also looked at the variable in terms of the characteristics of the affected subjects: their gender (lower efficacy noted in the male gender), weight (paradoxically higher efficacy in the higher-weight individual), and subject height (significant negative relationship observed with the induction of temporary incapacitation). Lower efficacy was demonstrated in the presence of intoxication, and lower efficacy was reported in subjects showing signs of mental illness or emotional upset, indicating possible interactions with comorbidities not only in terms of potential health harm, but also in terms of the efficacy of the agent. Furthermore, the study also looked at variables of the intervener‘s characteristics - with respect to intervener gender, higher effectiveness was reported for incidents where male interveners used CEW (up to three times more likely to be effective for an unexplained reason). This publication by Somers *et al.* [9] considers CEW a relatively effective tool to gain compliance or gain control over citizens based on the data analysed; however, the range of effectiveness can be high and interveners must necessarily be prepared to use alternative methods of force. It was noted that the differences in the study's results in reported device effectiveness compared to previous publications may have been due to the nature of the data used, which was obtained from force report forms, and thus may have contained various biases (e.g., officer judgment regarding subject height and weight) or captured only certain, and thus may have been incomplete.

Furthermore, the larger data sample of CEW use in a given investigation or the inability to account for the distance between the subject and the intervener (sinceall incidents were not similarly situated, and therefore the effectiveness in the deployment mode could not be objectively compared) may explain possible differences from previous research findings [9].

Some studies have looked at the effectiveness of CEWs by comparing their effectiveness with other types of law enforcement. In a study by Jauchem [10] CEWs were mentioned as the most effective tool to end confrontation with subjects. The findings of another study by Stevenson and Drummond-Smith [11] suggested that firearms were the most effective tactic based on the survey (97% effectiveness) and the least effective was the irritant spray with 54% effectiveness. The overall operational effectiveness of CEW was reported to be relatively high (68%), more effective than baton (but only 1 %) and irritant spray [11], which is also supported by the result of an article by Deuchar *et al.* [13] based on field intervention findings. The study by Stevenson and Drummond-Smith [11] also reported that the tactic associated with the highest proportion of officer injuries was irritant spray (16%) and then the lowest proportion of intervener injuries was shown by firearms (0.5%), which was in correlation with their demonstrated high effectiveness. Firearms potentially provide the greatest distance from a dangerous subject, and operations with them are usually well securized. A study by Stevenson and Drummond-Smith [11] also reported fewer officer injuries associated with CEW use (4%) compared to other common uses of force, including irritant spray, baton, physical confrontation, or service dog intervention. Furthermore, a study by Brandl and Stroshine [14] reported that CEW is generally more effective than irritating pepper spray in ensuring compliance of the subject. Historically, an older study by O'Brien *et al.* [15] reported an effectiveness and efficacy value of 75% for the use of CEW during a trial period of law enforcement testing in New Zealand, where a positive change in subject behaviour was observed, such as increased cooperation and general alleviation of an unstable situation, or immediate incapacitation of the subject at a distance. However, this study worked with a very limited sample, a total of 8 cases of CEW deployment in the field, so its results are limited by the apparent small sample of cases.

This review article, based on qualitative research, aims to answer the following formulated research questions through a systematic search of publications from the international peer-reviewed literature and their reference lists dealing with the topic of CEW effectiveness:

Q1 What are the root causes of the failure (ineffectiveness or limited effectiveness) of an electrical restraint when deployed against a dangerous subject?

Q2 What are the specific security implications of these failures at the incident level?

2. Material and Methods

Based on the current scientific evidence (the first two publication used are from 2010, while the two most recent are from 2024), through the methods and scientific approaches of analysis and synthesis, a 'fault tree' was constructed as a graphical deductive risk analysis method to determine the causes of CEW equipment ineffectiveness in field use.

The FTA risk analysis method is a deductive method that searches for individual system failures and determines the causes of these events. FTA is a graphical model of the various combinations of equipment failures and human errors that can result in a major undesirable system failure called a *TOP Event*. The model is based on Boolean algebra (*and, or*, and other gates) in finding the minimum failure leading to a *TOP Event*, where the result is the failure types and quantitatively assigned probabilities of system failures when the probabilities of the root causes are known. The method is not suitable for the early stages of design, is time-consuming, requires intensive knowledge and experience, and increases in difficulty as the complexity of the system increases. FTA method was developed for electrical engineering needs, has been further developed in aerospace, and has also found wide application in the nuclear power and process industries [16].

Before starting the analysis, it is necessary to precisely define the analyzed *TOP Event*, while the description must be precise and adequate, not too vague, and at the same time not too specific and detailed. Based on the description of the event to be monitored, it is necessary to determine what circumstances/conditions, or combination of circumstances/conditions, must occur for the event to proceed.

Highly improbable circumstances need not be taken into account in the analysis. It is also necessary to define the boundaries of the system and the event to be addressed and to predefine the level of detail of the analysis, which may be influenced by both the requirements of practice and the requirement to quantify the event tree based on the availability (known or potentially obtainable) data and the reliability characteristics of the data.

If the reliability characteristics are known, the probability of failure of individual elements can be determined, as well as the probability of a major adverse event. The actual construction of the logical unit of the fault tree has several steps. It starts from the *TOP Event*, which is further analysed. In the next steps, the possibilities of precursors of the peak event/failure in the individual subsystems and *basic events* that contribute/lead to the *TOP Event* are sought. The phase of dividing the system into elements is always a purposeful matter. An important step is then the assessment of the logical relationship between the *basic events* and the *TOP Event* - the assignment of the *logical operator*. If the *TOP Event* occurs only if all *basic events* occur simultaneously (parallel ordering), the logical operator *and* is used in the graphical display. If a *basic event* results in a *TOP Event* (serial ordering), the logical operator *or* is used [16].

3. Basic Conditions for the Efficiency and Effectiveness of Paralysis

In the case of a CEW intervention in the distance mode of application (electrodes are shot into the target body at different angles depending on the effective range, and subsequently an electric field is generated in the capture zone and the electric current cycling between the anode and cathode) is optimal, electrically induced neuromuscular incapacitation is induced in aggressive individuals such that the subject is unable to complete or continue the offending action for the duration of the current application [17], is temporarily immobilized and unable to attack or escape [18], he or she should cease to resist and thus it is further easier to use conventional methods of physical restraint or other types of coercion to ensure the subject's compliance with instructions and end the violent confrontation [19]. However, this definition of the parameters of effective incapacitation reflects an ideal situation that may not always occur in field use given the circumstances.

The main requirement determining the achievement of the desired goal of incapacitating the subject is the existence of a reliable path for conducting the discharge into the body of the subject. The stable anchoring of electrodes equipped with a sharp end part in ideally soft non-sensitive tissues (superficial layers of the skin except for sensitive areas - head, face, eyes, genitals, bone, etc. Individual differences in tissue density and the high elastic limit of the target body region can also significantly reduce the risk of probe penetration and entrapment on impact [27] of the target's body so that an electrical circuit is closed.

The electrical pulses are sent into the body through contact points on the skin of the target subject [20].

In field application research, one or both electrode spikes have been found to become stuck in clothing and do not reach the skin in approximately up to 30 % of cases [21], which can lead to the so-called electrical discontinuity [22].

In addition to the requirement of trapping the probes in the target medium and closing the electrical circuit, the second main factor is the location and distance of the probes as a condition of device efficiency [23], as the voltage field increases depending on the location of the hit and the distance between them. The spread between electrodes is then a function of the firing distance [24]. To achieve effective neuromuscular incapacitation, immediate loss of neuromuscular control and avoid purposeful and intended movements [25], [26], an approximate minimum distance between probes has been estabilished to ensure device effectiveness (induction of incapacitation) at 20 - 30 cm (30 cm for frontal hit, 20 cm for back hit), which corresponds to hitting from a distance depending on the model and type of cartridge due to manufacturers' efforts to optimize and maximize the range of device functionality [22] according to variations to suit different operational needs [13]. Wider probe angles allow for more effective electrical discharge in closer ranges, while smaller angles are designed for use in longer ranges [28]. Effective incapacitation of a subject as a manifestation of the desired effect is a function of probe spread [25], and thus the effectiveness of incapacitation depends on the location of the hit and the distance between the electrodes, and increases with the maximum distance from probe to probe [6], conversely, the effectiveness decreases as the probes are closer together, where a narrower probe spread can only cause a certain degree of incapacitation. The finding that the minimum effective spread between probes correlates with the range of device effectiveness is an important finding not only for the end user of the device [5]. There has been shown that operators tend to deploy CEWs at a distance less than the minimum distance required from the target, resulting in insufficient electrode spread (based on the predefined probe spread angle of a given model) and just less effective incapacitation of the subject [28].

The resulting effect of the application in terms of incapacitation efficiency, always beyond the direct influence of the position (anatomical target area) and distance of the electrodes, also depends on the electrophysiological properties of the current, organic resistance, applied voltage, current intensity, type of clothing, exposure time, physical constitution (body structure), and psychological state of the affected person [6], [29], as well as the subject's level of resilience and pain tolerance [30].

Other factors such as drug and alcohol use, level of violence, resistance, motivation, and behaviour responses of the subject can also play a role in the effectiveness of the device [31]. However, it is the location (localization) and distance of the electrodes that is the primary factor that can be influenced in terms of the final effect and effectiveness of the intervention, at the level of human factors (thein skills) according to Kunz *et al.* [6], among others, and the related observation that the experience of the interferers, derived from the length of time on duty and the number of training sessions received, is undoubtedly an important variable in the objective effectiveness of the intervention [7].

4. Results and Presentation of Findings

Failure of the device means its insufficient (limited) efficiency and effectiveness when deployed in the distance mode (firing of the probe-electrodes), i.e., there is insufficient incapacitation (suboptimal incapacitation) of the subject, who is able to continue resistance (continues to resist) because the optimal generalized effect of temporary whole-body paralysis and immobilization has not occurred.

Based on the knowledge obtained from the conducted search of the peer-reviewed international scientific literature and the algorithm for constructing a fault tree as a method to analysethe risk of failure of the CEW device during the intervention to achieve the desired incapacitation of the offending subject, individual causes leading to the ineffectiveness of the device are identified. As the actual values of the frequency of occurrence of each underlying event are not known, the method is incomplete as it has not been quantified (in terms of probability), and thus only identifies possible causes of failure of the electrical distancing enforcement device during interventionfield.

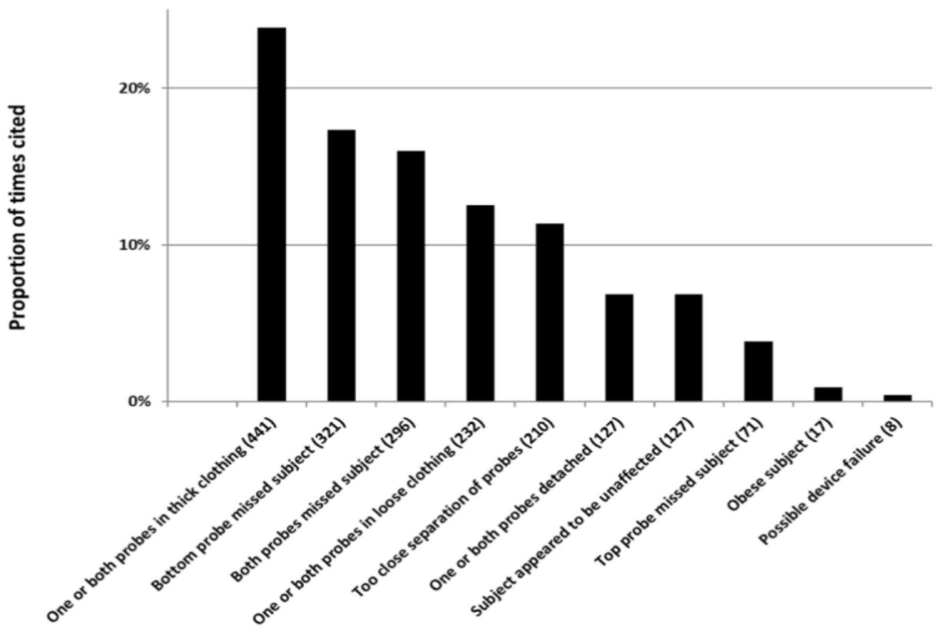

Figure 1. The most common causes of CEW failure based on data analysis from previous research by Sheridan and Hepper [22]

The symbol of a truncated square in the fault tree indicates events that are not further developed, where the analysis ends at this level and the element faults are not further analysed due to their complex nature (they are not the subject of the analysis).

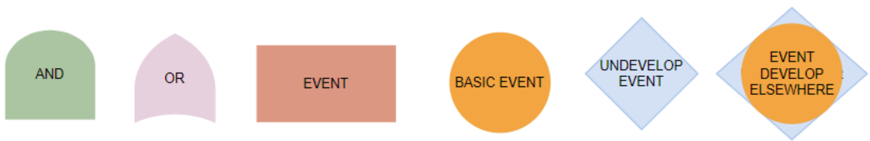

Figure 2. Symbols used in the FTA method

All identified causes have a negative impact on the effectiveness of law enforcement. In addition to these causes, as mentioned earlier in the text, the duration of exposure, the mode of implementation, and the anatomical target area of electrode capture (their localization) also affect the effective incapacitation of the subject. A steep probe angle (suboptimal oblique exposure) may result in poor initial attachment. Insufficient probe dispersion at close exposure means an ineffective distance from the intended target (insufficient probe spread angle).

The subject condition has also been cited as one of the causes, although the level of endurance of the subject (tolerance) should not directly depend on it for the incapacitation effect [27]. CEWs are also not precision-guided weapons and probes can deviate in flight, thus the flight trajectory and impact location are affected by many factors.

A sudden movement of the subject, such as a sudden head turn, can cause the probes to fall outside the targeting area (it is not always within the power of the interceptor to accurately hit the target when the subject is in motion), according to Kroll *et al.* [32].

As stated above, the intensity of the effect is primarily dependent on whether both electrodes hit the target and their dispersion and localization [33]. All identified causes of potential device failure influence the process of constant and instantaneous reassessment of options and risks by the intervener in a particular incident. For example, based on an assessment of the subject's clothing type, the intervener can reduce the potential risk of CEW ineffectiveness by selecting a more appropriate tactical option [4].

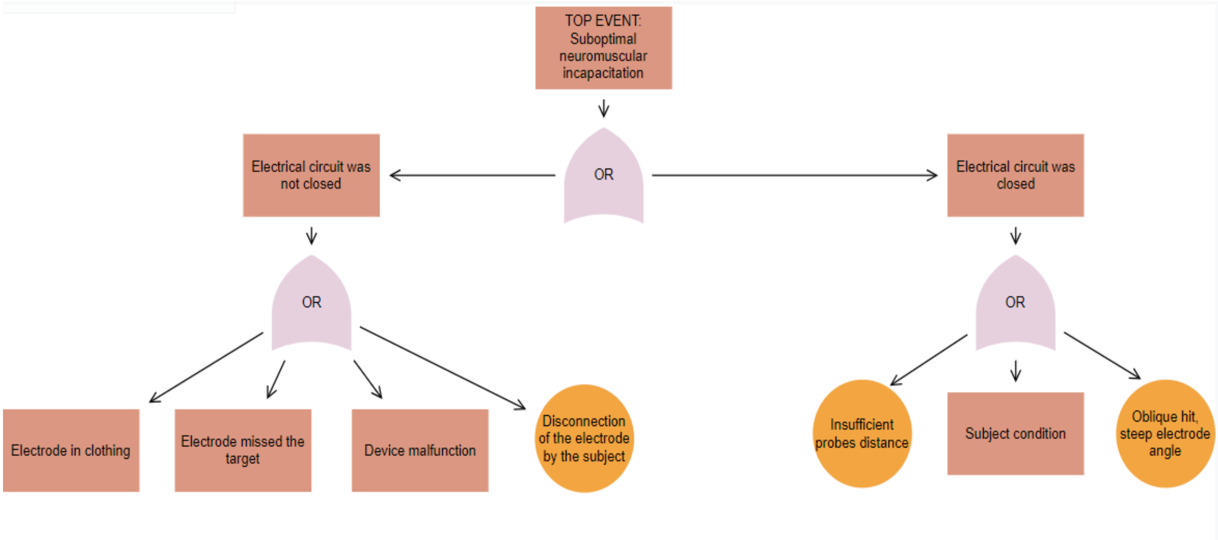

Figure 3. Basic FTA of CEW failure

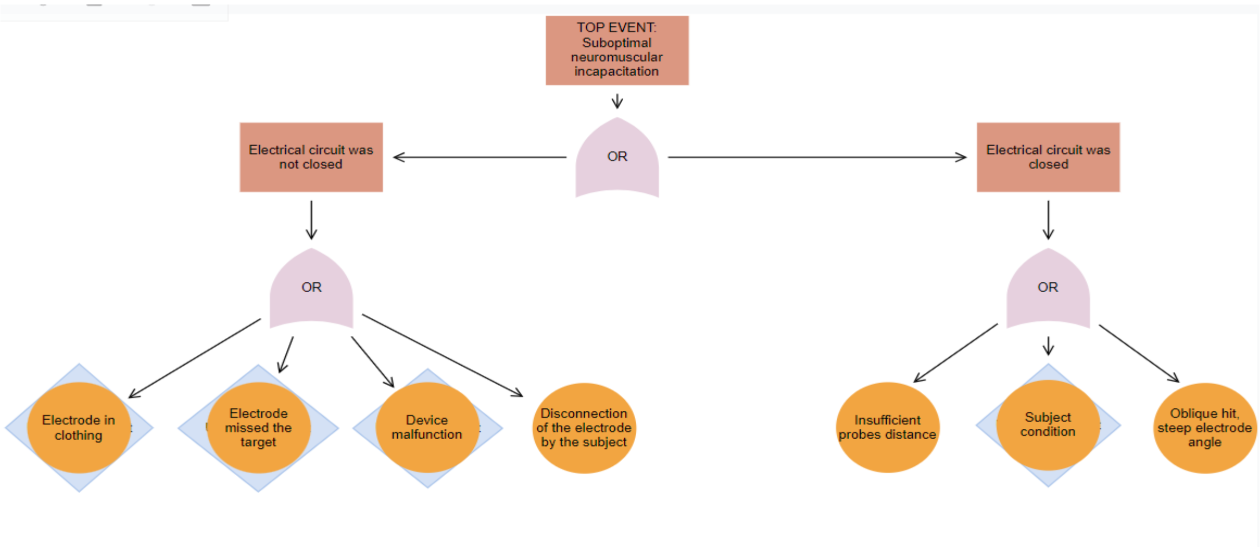

Figure 4. The final FTA of CEW failure and identified causes

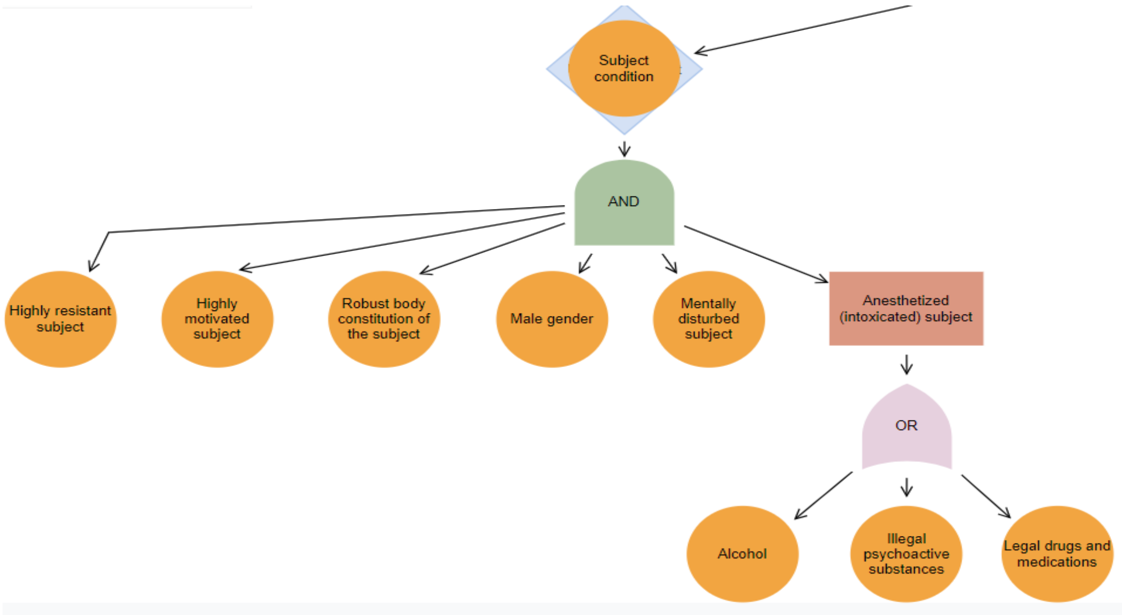

Figure 5. Develop event – causes of subject condition

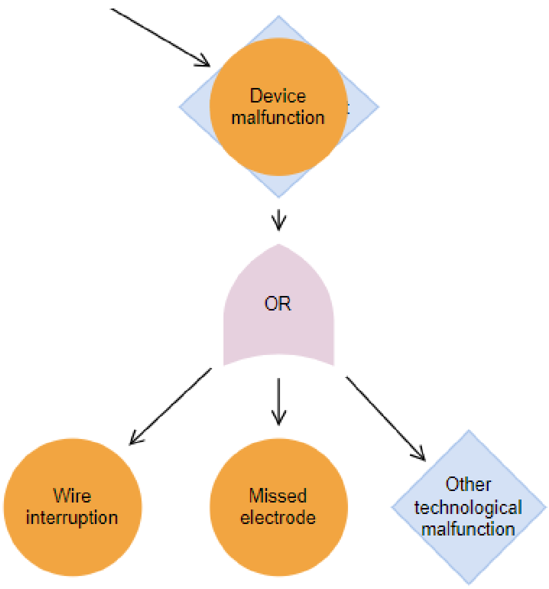

Figure 6. Develop event – device malfunction causes

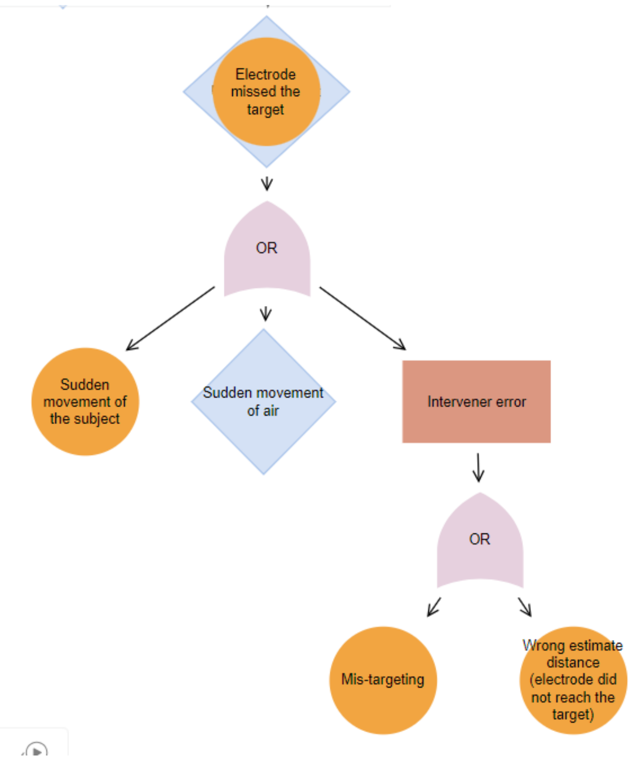

Figure 7. Develop event – electrode missed the target causes

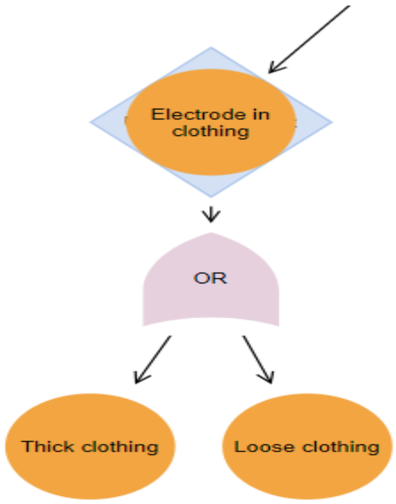

Figure 8. Develop event – electrode in clothing causes

4.1. Risks Arising from CEW Failure and Existing Measures to Minimise Them

Based on the analysis and synthesis of findings from the international literature with respect to the topic and focus of the paper, it was found that the effectiveness of a CEW intervention is defined by a number of variables and circumstances of a particular incident at the level of environmental factors and characteristics, human subjects (interveners and those affected), as well as at the level of technology and the role of equipment. Failure of CEW enforcement during an intervention can have adverse consequences and create additional risk situations and threats not only for the offending actors as the intended targets of the intervention, but especially for the interveners and often for other parties not directly involved in the incident.

A study by Williams *et al.* [34] investigated the risks and causes of fatal firearm incidents due to previous ineffective and inefficient CEW applications, determining a failure rate of field devices in subduing violent subjects in up to 47% of applications (or a failure rate of 15% to 47 % or 50 to 150 thousand ineffective uses per year, according to Vaughn *et al.* [35]), finding 1,349 fatal incidents in the United States alone (from 1985 to 2020) in which citizens (mostly those with some minority affiliation) died as a result of firearm use just after a previous failure of CEW technology, and also noting 14 cases since 2004 in which violent actors shot 16 police officers after ineffective CEW applications.

The study by Taylor *et al.* [36] then reports that in 2015 alone, a total of 84 unarmed people were shot by law enforcement officers in the U.S., with 27% of the cases involving the deployment of a firearm after a previous ineffective CEW intervention. Therefore, the most serious consequences of ineffective deployment arise in the context of the inevitable use of a generally superior form of force (firearms), which is often a lethal option, precisely because the deployment of less lethal means, such as CEWs, may not always be advantageous or successful in force encounters, where they may not provide the desired results in suppressing aggression and resistance. Thus, ineffective application can, in effect, pose a serious threat to the safety of interveners and citizens, regardless of the location of the CEW on the use of force continuum (justification for use policy). Therefore, avoiding or mitigating the need for lethal force in law enforcement can have dramatic consequences for society as a whole [34].

There is also the unusual but critical risk of a shooting after the subject has gained control of the electrical weapons in the intervening officers' equipment, a risk associated with disarming and unauthorized use of the intervening officer's equipment [18]. There have been a total of 131 incidents (124 in the U.S., 2 in Australia, 2 in England, 2 in Wales, and 1 in Canada) of subjects attempting to obtain or gaining control of the CEW of an intervening police officer between 2004 and 2020, 53 of which resulted in a shooting. Therefore, the use of electric weapons that did not lead to effective management of the confrontational situation represents a rare but real risk of injury and death by gunfire after the subject attempts to gain control of the intervenor's weapon [19].

The risk of failure of this type of enforcement is real, and is not insignificant. The effectiveness of CEW devices is contingent (potential) and is created by the interaction between technology, responders, and members of the public [23]. The unlimited trust in technology and weapon effectiveness can make intervening operators more vulnerable and can lead to potentially more dangerous confrontational situations [23]. Therefore, it is important to raise awareness of this risk and the subsequent, often fatal consequences, while it is necessary to project this knowledge into the educational and training process, which must necessarily reflect the reality faced by participants in confrontations.

The need for sufficient knowledge and awareness of police officers on the mechanism of action and effect of the discharge is defined, the practical deployment of the tactic, as well as its limited effectiveness (as a standard part of the content of the thematic units of training programmes), and the associated undesirable events hen subduing suspects during highly dangerous force clashes is defined, where the criticality of this knowledge to the general use-of-force safety at the incident level is evident. Understanding how often and under what conditions CEWs are ineffective can influence an officer's judgment and decision whether to use a CEW in a given situation or to consider and choose another form of enforcement from the wide range of options available. Optimizing training for this enforcement tool through the use of effective training methods contributes to the professionalization of force use and the general readiness of the forces to use alternative options in law enforcement [37]. This set of measures falls into the preventive security level in the area of influence of human factors (personnel measures), since the responsibility for the professional, effective, and safe use and handling of force means rests on the final link of the chain,[1] that is, on the police officer himself, as the CEW is considered such as a neutral instrument [38]. It has also been suggested that the current education and training policy system for police use of CEW should be further investigated [39], but this is hampered by the nature of the classified approach to the police use of force training research.

Increasing the effectiveness and efficiency of the intervention using CEW is also possible due to the technological improvement of individual device models and the existence of the current generation of SMART CEW models with the intention of avoiding the main cause of failure, that is, to ensure optimal dispersion of electrodes [40] and at the same time minimising health risks for exposed individuals (increase cardiac safety profile, according to Dawes *et al.*) [41]. These measures fall into the technological category, where SMART CEW models generally have the ability, in case of small dispersion of the probes, to provide the required level of incapacitation due to the backup shot hen expanding the electric field, unlike previous generation weapons that used paired probes with fixed take-off angles. The latest generation of CEWs is characterized by their technological advantage, when the electrode could be fired again without the need to recharge, offering the possibility of making the intervention more efficient [2].

These are especially the latest CEW TASER T7 and T10 models (*Axon Enterprise Inc.,* Scottsdale, Arizona, USA).

The CEW TASER T7, like the second generation X2, has two cartridges (or pairs of probes) that provide a backup shot, when this feature was a technological improvement over the single cartridge of the X26E as the *gold standard* prevalent in law enforcement agencies arend the world. In the X2, the cartridges worked independently unless one probe was connected, the T7 has new technology that allows an adaptive *cross-connect* between the two positions where the weapon evaluates and senses the return current (detects bad current paths) and adjusts the path between all possible positive and negative current paths to optimize the connection [42]. If a second shot occurs due to failure or too little distance, the individual electrodes in the T7 can communicate with each other. In such a case, the device selects the anode-cathode combination with the highest resistance and thus the greatest distance. This also applies if the contact mode is used in addition to the penetrating electrodes [3]. Therefore, the new adaptive cross-connect function with two pairs of probes simultaneously deployed demonstrates a significant improvement in efficiency compared to the X2 model in incapacitating the subject in small electrode gap scenarios (close contact exposure) according to Ho *et al.* [40].

The unique ability of the latest SMART model T10 to place multiple probes in a specific target area to create the desired spread of the probe is a technological advantage over all previous models, showing potentially greater effectiveness in the field, as each probe can also be fired independently, instead of the two paired shots previously [6]. The T10 uses an independently targeted probe scheme with a floating dynamically changing polarity, so any two probes on the body can make an electrical connection, and thus the weapon is more effective due to the different configuration of the probes and the variability of their placement (based on an algorithm that determines which probes have between with the greatest distance and the best connection). Due to the technology of multiple independent shots of a single cartridge with up to ten probes, it is also possible to implement new target zones and modify the incapacitation effect, where, for example, hitting both legs will cause blocking and paralysis of the lower limbs while maintaining the ability to move the upper limbs (and secondarily mute and offer the possibility of controlling the fall), in the case of a left/right lateral intervention, contraction of all muscles and the entire body is unlikely, and electrodes can also be placed on the opposite (front and back) side of the body, which in the experiment [6] resulted in complete (generalized) temporary incapacity.

[1] "*Every chain is only as strong as its weakest link.*" Arthur Conan Doyle, J. Watson - Valley of Fear.

This is a significant technological advantage over the earlier SMART models, where the X2 and T7 models had two cartridges but fired simultaneously, so the probes could not be placed on two opposite sides of the body (the T7 only has two shots with four combined probe placements; with each shot, two electrodes are released, and only a paired shot of two probes is possible). The results and findings of the research by Kunz *et al.* [6] confirm that the most effective shots are shown with a wide spread of probes and ideally include exposure of the upper and lower extremities or an intervention in the front of the body and, at the same time, in the back area.

5. Discussion

It is believed that less-than-lethal weapons can avert serious injury to citizens and police officers by providing safer and more effective options than other methods at the upper end of the police use-of-force continuum [43]. However, not all CEW use-of-force studies are in agreement. Study by Boehme *et al.* [39] reported that officers may perceive CEWs to be less effective than firearms during high-risk encounters. Furthermore, a study by Maguire and Paoline [44] concluded that some methods and types of force used by the police, such as practical tactics and the use of CEWs, can increase the risk of injury to police officers due to their potentially low effectiveness and efficiency.

It must be taken into account that CEW, like any other form of force, may be ineffective certain circumstances. The existence of a certain risk of device failure, when the desired goal of incapacitating the subject is not achieved, must be taken into account by responders during theoretical preparation (training and education), but also during its practical deployment in the field. CEW can be used with this risk, which is acceptable compared to other types of coercion, to achieve incapacitation in a given situation. Risk must always be assessed and evaluated in a contextual framework, which is based on the balance between the degree of resistence risk and the possible harm caused, the availability and possibility of variants of the use of force, their effectiveness appropriateness for the given specific situation [10]. The potential benefits of using this device should reasonably outweigh its risks, both with regard to its safety and its effectiveness, that is, the components that ineract directly with each other. The effectiveness of CEW as a means of coercion in intervention and increasing the safety of the interveners cannot be assessed in isolation, but on the contrary in an integrated manner.

The decision-making process of interveners in a specific situation under certain circumstances and conditions about the type and form of force used is essentially decision-making under a state of risk and uncertainty (the intervener does not know all specific aspects of the subject's condition, but should be aware of the risks of the technology used based on training). If CEW is used, the likelihood of its effectiveness or its potential negative effect on the exposed subject may not be known due to the multifactorial nature of the incident event, dependent on many interacting components and variables [31], [45]. It is necessary to take into account a certain level of subjects‘ stress and the presence of other simultaneously acting factors, due to which the application of CEW can have a variable range of effectiveness and a possible fatal outcome. In a confrontation, the safety of all parties involved is always important – interveners, suspects (detainees), and third parties, not directly involved, and the ineffectiveness of the chosen tactics can have consequences for all participants in the incident.

If CEWs are to be legitimately used only in situations requiring lethal force, then they may not be preferable to firearms, as they may be less effective, which has a potential negative consequence for responder safety in particular. Therefore, the use of CEW is called primarily in cases where it represents a truly safer alternative [43] than a firearm and, at the same time, a more effective means of managing and terminating a highly dangerous situation than other coercive means ranked in the power continuum under CEW. Although there is a risk of device failure, its undoubted utility as a new advanced coercive technology and form of force for law enforcement is not excluded [46].

6. Limitations

The biggest obvious limitation of the review article is the lack of data for the chosen FTA method as a device failure risk analysis, where the frequencies of individual causes of device failures are unknown. The scheme of the FTA diagram can thus only serve as a model or educational training aid of possible causes, when only based on the improvement of the monitoring system and records of the effectiveness of the CEW equipment from the field as a future recommendation, then real data can be added, and final probabilities determined. The article is thus only a theoretical level by performing an analysis, synthesis, and comparison of knowledge derived from the existing literature, when no objective value of the effectiveness of the device is established and proven as an opinion and the final opinion of the review article.

Also, the list of causes of failure in the field may not be exhaustive, and a complete discussion of agent efficacy is clearly beyond the scope of this systematic review.

7. Conclusion

Law enforcement authorities are authorized to overcome the resistance of persons to achieve compliance by various methods and techniques, including the use of coercive means. The review article specifically focused on one of the forms of less-than-lethal weapons, the remote electroshock weapon, and the pitfalls of its use in intervention if it was not effective and efficient on the detained person, i.e., if the desired goal of optimal intervention of sufficient neuromuscular temporary incapacitation of the subject was not achieved, which can thus continue to commit illegal acts, including purposeful and originally intended movements, which leads to further escalation of the confrontational situation and exposure of the parties involved to risks arising from ineffective application, which can also be the use of a higher form of lethal force (firearms). The requirement for a minimum safety effective distance from the subject was identified as a basic condition for the effectiveness of the device in order to capture the electrodes in a specific target area of the body (closing the electrical circuit) to create the desired dispersion of the probes. The evidence-based effectiveness rate of CEW devices in the field is not very high and is dependent on many variable factors (human and technological) of the specific situation, the intervention conditions (environmental factor), and the identified variables may further interact with each other. The review article is based on the synthesis of knowledge from the existing international scientific literature, where, based on the method of analyzing the risk of device failure, the causes of failure were identified, which may have a potentially negative relationship.

Available and existing measures to reduce the risk of asset failure in order to maximize its effectiveness in service were presented. In the analyzed publications dealing with the evaluation of the effectiveness of the device from the point of view of its intention to cause a certain degree of incapacitation, a highly variable range of the resulting value of the effectiveness of the device was found, also due to different scientific approaches, chosen methods and data sources of individual studies. For the purposes of this overview article, it was not possible to find enough concrete, relevant and objective statistical data indicating the frequency of failure of the device due to individual causes during the real deployment of CEW in the field, which could be further compared and a conclusion made.

The limited availability of information as a current systemic problem at the international level appears to be a current gap, and a desirable subject of future research. The goal should be the standardization of monitoring and the registration of complete records of the CEW application as a data source for research based on searches in the police use of force database. From this database, thanks to a retrospective survey of events, it will be possible to find out, among other things, how often and in what circumstances the CEW is ineffective (to specify the causal conditions associated with the result, to reduce uncertainties and to better understand the mechanism of the emergence of ineffectiveness), and whether a specific type of coercive means has a positive effect on shortening the duration of the confrontational situation. Due to this, it is then possible to better predict the probability of effectiveness and further contribute to the decision-making process regarding the choice of the appropriate type of coercive means given the circumstances. The evident limits of the article findings thus limit its contribution, when a theoretical overview of the causes of CEW ineffectiveness without probability values can be provided, which can be used as a clear educational aid during training on the risks of intervention with this type of coercive means, so, to incorporate the knowledge gained into the general principles of its use for prevention the emergence and escalation of risky encounters for the parties involved in the conflict situation.

References:

[1]. Policejní prezidium České republiky. (2020). *Koncepce rozvoje PČR do roku 2027*. Policejní prezidium České republiky. Retrieved from: https://www.policie.cz/soubor/koncepce-rozvoje-policie-cr-do-roku-2027-pdf.aspx [accessed 18 June 2024].

[2]. Radosta, M. (2019). Pokročilé nesmrtící technologie v boji proti terorismu, extremismu a kriminalitě. [PhD Thesis]. *Praha: Policejní akademie ČR.* Retrieved from: https://katalog.polac.cz/Record/POLAC.114781 [accessed 19 June 2024].

[3]. Kunz, S. N. & Krys, L. F. (2022). Elektroschockdistanzwaffen Taser® X2 und T7. *Notfall + Rettungsmedizin*, *25*, 1-9. DOI: 10.1007/s10049-020-00791-8

[4]. Den Heyer, G. (2020). An analysis of the effectiveness and use by the New Zealand Police of the TASER from 2009 to 2017. *International Journal of Police Science & Management,* 22(4), 356-365. DOI: 10.1177/1461355720947779

[5]. Ho, J., Dawes, *et al.* (2012). Conducted electrical weapon incapacitation during a goal-directed task as a function of probe spread. *Forensic Science, Medicine, and Pathology*, *8*, 358-366. 1547-769X. DOI: 10.1007/s12024-012-9346-x

[6]. [6]. Kunz, S. N., Ho, J. D., Dawes, D. M., & Knack, S. K. (2024). Effectiveness of a New-Generation CEW in Human Subjects with a Goal-Directed Task. *Human Factors and Mechanical Engineering for Defense and Safety*, *8*(1), 1. Retrieved from: https://assets.researchsquare.com/files/rs-3592989/v1/31fb39e0-b774-4b80-af44-a257830b2d0c.pdf [accessed 18 June 2024].

[7]. White, M. D., & Ready, J. (2010). The impact of the Taser on suspect resistance: Identifying predictors of effectiveness. *Crime & Delinquency*, *56*(1), 70-102. DOI: 10.1177/0011128707308099

[8]. Womack, V. G., Morris, R. G., & Bishopp, S. A. (2016). Do changes in TASER use policy affect police officer injury rates?. *Police quarterly, 19*(4), 410-434. DOI: 10.1177/1098611116629796

[9]. Somers, L. J., Terrill, W., Rossler, M. T., & Ingram, J. R. (2020). Examining the effectiveness of TASERS® at gaining citizen compliance. *Criminal Justice Policy Review*, *31*(8), 1234-1255. DOI: 10.1177/0887403419897953

[10]. Jauchem, J. R. (2015). TASER® conducted electrical weapons: misconceptions in the scientific/medical and other literature. *Forensic science, medicine, and pathology*, *11*(1), 53-64. DOI: 10.1007/s12024-014-9640-x

[11]. Stevenson, R., & Drummond-Smith, I. (2020). Medical implications of conducted energy devices in law enforcement. *Journal of Forensic and Legal Medicine*, *73*, 101948. DOI: 10.1016/j.jflm.2020.101948

[12]. Kroll, M. W., *et al.* (2019). Benefits, risks, and myths of TASER® handheld electrical weapons. *Human Factors and Mechanical Engineering for Defense and Safety*, *3*, 1-13. DOI: 10.1007/s41314-019-0021-9

[13]. Deuchar, R., Frondigoun, L., Densley, J. A., & Davidones, C. (2024). Taser Use in Scotland: a Qualitative Study of Police Officer and Community Perspectives. *European Journal on Criminal Policy and Research*. DOI: 10.1007/s10610-023-09569-3

[14]. Brandl, S. G., & Stroshine, M. S. (2017). Oleoresin capsicum spray and TASERs: A comparison of factors predicting use and effectiveness. *Criminal justice policy review*, *28*(3), 279-306. DOI: 10.1177/0887403415578732

[15]. O'Brien, A. J., McKenna, B. G., Thom, K., Diesfeld, K., & Simpson, A. I. (2011). Use of Tasers on people with mental illness: A New Zealand database study. *International journal of law and psychiatry*, *34*(1), 39-43. DOI: 10.1016/j.ijlp.2010.11.006

[16]. Bernatík, A. (2019). *Principy a metody analýzy rizik. Studijní opora*. VŠB TUO Ostrava, Fakulta bezpečnostního inženýrství.

[17]. Kunz, S. N., & Adamec, J. (2018). A comparative brief on conducted electrical weapon safety. *Wiener Medizinische Wochenschrift (1946)*, *169*(7-8), 185-192. DOI: 10.1007/s10354-018-0616-4

[18]. Wunderlich, T., *et al.* (2018). TASER—a problem in emergency medicine?. *Notfall+ Rettungsmedizin*, *21*, 673-681. DOI: 10.1007/s10049-018-0544-2.

[19]. Kroll, M. W., Ross, D. L., Brave, M. A., & Williams, H. E. (2021). Police shootings after electrical weapon seizure: homicide or suicide-by-cop. *International journal of legal medicine*, *135*, 2547-2554. DOI: 10.1007/s00414-021-02648-2

[20]. Thiel, M. A. & Kaufmann, C. (2020). Eyeshot: Ocular Injuries caused by TASER pistols. *European Heart Journal*, *41*, 3984-3985. DOI: 10.1093/eurheartj/ehaa684

[21]. Clarke, C., & Andrews, S. P. (2014). The ignitability of petrol vapours and potential for vapour phase explosion by use of TASER® law enforcement electronic control device. *Science & Justice*, *54*(6), 412-420. DOI: 10.1016/j.scijus.2014.04.004

[22]. Sheridan, R. D., & Hepper, A. E. (2022). An analysis of officer-reported TASER X2™ probe discharge effectiveness in the United Kingdom. *Journal of forensic and legal medicine*, *91*, 102417. DOI: 10.1016/j.jflm.2022.102417

[23]. Dymond, A. (2020). Towards a socio-technical understanding of discretion: a case study of Taser and police use of force. *Policing and society*, *30*(9), 998-1012. DOI: 10.1080/10439463.2019.1660338

[24]. Kunz, S. N., & Adamec, J. (2017). Cardiac aspects of conducted electrical weapons (CEW). *Rechtsmedizin*, *27*, 79-86. DOI: 10.1007/s00194-017-0147-0

[25]. Bleetman, A., Hepper, A. E., & Sheridan, R. D. (2023). The use of TASER devices in UK policing: an update for clinicians following the recent introduction of the TASER 7. *Emergency medicine journal*, *40*(2), 147-150. DOI: 10.1136/emermed-2022-212521

[26]. Worley, V. B. (2018). Smart use of smart weapons: jail officer liability for the inappropriate use of tasers and stun guns on pretrial detainees. *Security Journal*, *31*, 726-748. DOI: 10.1057/s41284-018-0127-4.

[27]. Kunz, S. N., *et al.* (2013). Wound ballistic evaluation of the TASER® XREP ammunition. *International Journal of Legal Medicine*, *127*(1), 119-126. DOI: 10.1007/s00414-011-0628-8

[28]. Zhou, Y. R., Liscio, E., Ruffo, H. E., Doucette, C. M., & Cao, W. (2023). TASER CEW distance determination for models X26P, X2, and TASER 7. *Forensic science international*, *342*, 111520. DOI: 10.1016/j.forsciint.2022.111520.

[29]. Kunz, S. N., Monticelli, F., & Kaiser, C. (2012). Death by conducted electrical weapons: Diagnosis by exclusion?. *Rechtsmedizin*, *22*, 369-373. DOI: 10.1007/s00194-012-0848-3

[30]. [Sytsma, V. A., Laming, E., & Pohl, E. (2022). Situational and ecological predictors of conducted energy weapon application severity. *Canadian journal of criminology and criminal justice*, *64*(1), 99-126. DOI: 10.3138/cjccj.2021-0019

[31]. Ariel, B., *et al.* (2019). The "less-than-lethal weapons effect"—introducing TASERs to routine police operations in England and Wales: A randomized controlled trial. *Criminal justice and behavior*, *46*(2), 280-300. DOI: 10.1177/0093854818812918

[32]. Kroll, M. W., Ritter, M. B., Kennedy, E. A., Silverman, N. K., Shinder, R., Brave, M. A., & Williams, H. E. (2018). Eye injuries from electrical weapon probes: incidents, prevalence, and legal implications. *Journal of forensic and legal medicine*, *55*, 52-57. DOI: 10.1016/j.jflm.2018.02.013

[33]. Sanford, J. M., Jacobs, G. J., Roe, E. J., & Terndrup, T. E. (2011). Two patients subdued with a TASER® device: cases and review of complications. *The Journal of emergency medicine*, *40*(1), 28-32. DOI: 10.1016/j.jemermed.2007.10.059

[34]. Williams, H. E., Reinhard, D., & Oriola, T. B. (2022). Fatal officer involved shootings following the use of TASER conducted energy weapons. *The Police Journal*, *95*(4), 713-733. DOI: 10.1177/0032258X211030322

[35]. Vaughn, P. E., Greene, C., & Klinger, D. (2024). Revenge Effects and Electronic Control Weapons: A Cautionary Tale about the Unintended Consequences of Technology in the American Justice System. *Journal of Criminal Justice*, *90*, 102144. DOI: 10.1016/j.jcrimjus.2023.102144

[36]. Taylor, P. L., Sipe, P., & Bartel, L. (2023). Lost in transition: The effects of transitioning between firearms and electronic control devices (ECDs) on perception-response times (PRTs). *The Police Journal*, *96*(1), 103-116. DOI: 10.1177/0032258X211044135

[37]. Alpert, G. P., & Dunham, R. G. (2010). Policy and training recommendations related to police use of CEDs: Overview of findings from a comprehensive national study. *Police quarterly*, *13*(3), 235-259. DOI: 10.1177/1098611110373993

[38]. Dymond, A. (2016). *Police Use of Taser in England and Wales, 2004 – 2014*. [PhD Thesis. England: University of Exeter]. Open Research exter. Retrieved from: https://ore.exeter.ac.uk/repository/handle/10871/28097 [accessed 27 June 2024].

[39]. Boehme, H. M., Martin, A., & Kaminski, R. J. (2022). Evaluating the 4th Circuit's decision to limit officer use of Tasers: A descriptive and time-series approach. *Police practice and research*, *23*(5), 523-538. DOI: 10.1080/15614263.2021.1982713

[40]. Ho, J., Dawes, D. M., Kunz, S. N., Satpathy, R., Klein, L., Driver, B., & Stang, J. L. (2020). A comparative study of conducted electrical weapon incapacitation during a goal-directed task. *Forensic Science, Medicine and Pathology*, *16*, 613-621. DOI: 10.1007/s12024-020-00284-7

[41]. Dawes, D. M., Ho, J. D., Halperin, H. R., Fink, S. J., Driver, B. E., & Klein, L. R. (2021). A comparison of three conducted electrical weapons in a surrogate swine cardiac safety model. *Journal of forensic and legal medicine*, *77*, 102088. DOI: 10.1016/j.jflm.2020.102088

[42]. Ho, J. D., Dawes, D. M., Kunz, S. N., Klein, L. R., Driver, B. E., DeVries, P. A., ... & Stang, J. L. (2020). The physiologic effects of a new generation conducted electrical weapon on human volunteers at rest. *Forensic Science, Medicine and Pathology*, *16*, 406-414. DOI: 10.1007/s12024-020-00249-w

[43]. Sheppard, K. G., & Welsh, B. C. (2022). Can police use of less-than-lethal weapons reduce harm during violent police-citizen encounters? A systematic review and directions for future research. *Aggression and violent behavior*, *64*, 101748. DOI: 10.1016/j.avb.2022.101748

[44]. Maguire, E. R., & Paoline III, E. A. (2023). Non-fatal injuries among police officers during use-of-force encounters. *Occupational medicine*, *73*(8), 479-483. DOI: 10.1093/occmed/kqad101

[45]. Boyd, K. A., Dymond, A., Melendez-Torres, G. J., & Fleischer, D. N. (2023). Pathways to TASER discharge: qualitative comparative analysis of police use of force. *Policing: A Journal of Policy and Practice*, *17*, paad048.DOI: 10.1093/police/paad048

[46]. Grove, N., Grove, C., Peschel, O., & Kunz, S. N. (2016). Wohlfahrtseffekte der Substitution traditioneller ballistischer Schusswaffen durch nichtletale Alternativen: Medizinisch-ökonomische Vergleichsbetrachtung. *Rechtsmedizin*, *26*, 418-424. DOI: 10.1007/s00194-016-0117-y