

Excited delirium syndrome (ExDS): Situational factors and risks to officer safety in non-fatal use of force encounters



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ABSTRACT

Study objective: Police use of force (UoF) encounters include individuals with Excited Delirium Syndrome (ExDS) with some frequency. Situational factors and risks to officer safety associated with these encounters have not been well studied. We examined the likelihood that subjects displaying various concomitant features of ExDS were under the influence of drugs and/or alcohol. We also examined the extent of subject violence, and the impact of this behaviour on the encounter (e.g., the odds of a struggle). Greater understanding of the prevalence of ExDS and the specific risk it represents to law enforcement officers and the subjects they encounter will guide appropriate policy and response strategies.

Methods: A prospective evaluation of a consecutive cohort of subjects involved in UoF encounters with police was conducted. Data were collected from January 2012 to December 2015. Consistent with previous research, the presence of six or more features was used to identify probable cases of ExDS. The odds that subjects in a state of probable ExDS were under the influence of drugs and/or alcohol was calculated and compared against subjects who exhibited less than three features of ExDS. In addition, the violent nature of subjects (e.g., the odds of a subject being in possession of a weapon) displaying various concomitant features of the syndrome was examined. The number of sudden and unexpected arrest-related death (ARDs) was documented.

Results: UoF occurred in 9006 of 10.9 million police–public interactions (0.08%). Of the UoF encounters, 156 (1.7%) subjects displayed six or more features of ExDS. With four recorded sudden and unexpected ARDs of violent and agitated subjects in our cohort, up to 6.3% of these subjects experiencing probable ExDS could be expected to be at risk of sudden death. Logistic regression analyses indicated that there were significantly higher odds that subjects exhibiting more features of ExDS (e.g., six or more) were under the influence of drugs. On the other hand, there were significantly lower odds that individuals exhibiting ExDS were under the influence of alcohol alone. In addition, those displaying a greater number of features demonstrated higher odds of engaging in assaultive behaviour, presenting a threat of grievous bodily harm or death, and being involved in a struggle that went to the ground with an officer. A slight increase in the presence of weapons was observed in encounters with probable ExDS.

Conclusion: Our study provides important information to guide the development of policy and procedure in law enforcement. Police encounter a subject with ExDS 1 in every 58 UoF incidents (1.7%). Those individuals are at higher odds of being intoxicated with drugs according to officers' assessments and at risk of being further exerted during a struggle on the ground, both of which appear to play a major role in deaths associated to ExDS. There is a demonstrable increase in risk to officers and public safety from the violent behaviour displayed by subjects presenting a greater number of features of ExDS. Our data suggests that up to 6.3% of subjects in a state of ExDS could succumb to ARDs; however, we cannot comment on the prevalence of death for persons with ExDS who do not encounter police. Further research is needed to determine which force options optimize outcome for police and subjects. Additionally, research surrounding pathophysiology leading to death should focus on subjects with six or more features of ExDS. Ultimately, a better understanding in this area will contribute to improving the outcomes of these encounters for those suffering from ExDS and those tasked with assisting them.

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1. Introduction

Sudden and unexpected arrest-related death (ARD) in the context of police use of force (UoF) encounters has been discussed for >30 years in the modern medical literature. Studies of these deaths began when [Wetli and Fishbain \(1985\)](#) documented noticeable likenesses in the presentation of individuals intoxicated with cocaine who died during police UoF incidents, such that they believed a new syndrome had been identified. They coined this syndrome “excited delirium,” which has since been defined as “...a state of extreme mental and physiological excitement, characterized by extreme agitation, hyperthermia, hostility, exceptional strength and endurance without apparent fatigue” ([Morrison & Sadler, 2001](#), p. 46). Probable cases of ExDS are based on the presence of at least six of the following 10 potential criteria for ExDS: pain tolerance, constant/near constant activity, not responsive to police presence, superhuman strength, rapid breathing, does not fatigue, naked/inappropriately clothed, sweating profusely, tactile hyperthermia, and glass attraction/destruction ([American College of Emergency Physicians Excited Delirium Task Force, 2009](#); [Baldwin, Hall, Bennell, Blaskovits, & Lawrence, 2016](#); [Hall & Votova, 2013](#); [Vilke et al., 2012](#)). It has been argued that exhibiting six or more of these features indicates that an individual is in a highly abnormal state, one that could only be described as a medical emergency ([Hall & Votova, 2013](#)).

Examination of the observed symptoms across documented cases of ExDS has contributed to the evidence for the development of a case definition of ExDS ([Baldwin et al., 2016](#); [Gonin, Beysard, Yersin, & Carron, 2017](#)). However, numerous co-factors are often involved in these deaths, including substance use, mental illness, abrupt cessation of psychiatric medication, poor physical health, psychological and physiological stress, as well as a prolonged struggle ([Coyne, Ly, & Vilke, 2017](#); [Vilke, Debard, et al., 2012](#); [Vilke & Payne-James, 2016](#)). As a result, ExDS, with its unknown and varying pathophysiology, has remained a “contested diagnosis” in the medical field ([Jutel, 2011](#)). An investigation of common situational factors is required for a greater understanding of the onset of ExDS and one's relative risk of ARD. Importantly, this understanding could also lead to more appropriate response protocols (e.g., in terms of training, interventions, and/or policy development), and ultimately support the recognition of ExDS by the American Psychiatric Association ([American Psychiatric Association, 2000](#)) and the World Health Organization ([Ranson, 2012](#); [World Health Organization, 2008](#)).

Moreover, while previous research has shown that violent behaviour is a common feature of ExDS (arguably too common, in fact, to be distinguishing; [Baldwin et al., 2016](#); [Hall & Votova, 2013](#)), the nature of this violence, and the extent to which it varies in severity depending on the presence of ExDS symptoms, has not been studied. The risk to first responders, primarily police officers, who are tasked with engaging and attempting to de-escalate these individuals is important to understand. If officers were more aware of the type of danger that could ensue upon encountering individuals in a state of ExDS, and be better equipped to recognize the features, then ARDs, as well as subject and officer injuries, could potentially be mitigated. For example, if a subject presenting a high number of the features of ExDS is assessed as a potential medical emergency, it will help ensure appropriate emergency medical services (EMS) are immediately requested to attend the scene.

1.1. ExDS and intoxicants

It has been shown that substance use, particularly chronic use of stimulants such as cocaine and methamphetamine, often precedes the onset of, and deaths associated with, ExDS ([Coyne et al., 2017](#); [Vilke, Debard, et al., 2012](#); [Vilke & Payne-James, 2016](#)). In fact, a review of the literature indicated that almost nine out of 10 subjects in a state of ExDS were under the influence of some sort of substance ([Grant, Southall, Mealey, Scott, & Fowler, 2009](#); [Mash et al., 2009](#); [O'Halloran & Lewman, 1993](#); [Stratton, Rogers, Brickett, & Grunzinski, 2001](#)). Stimulants, particularly cocaine, were the most prevalent ([Grant et al., 2009](#);

[Mash et al., 2009](#); [Pollanen, Chiasson, Cairns, & Young, 1998](#); [Ross, 1998](#); [Ruttenber, McAnally, & Wetli, 1999](#); [Stratton et al., 2001](#)). Given that alcohol is a depressant, it is not surprising that there is a much lower prevalence of it in subjects (28% rate of alcohol use was observed across all known studies); although, for the majority of these cases, subjects had ingested both alcohol and stimulants ([Mash et al., 2009](#); [Ross, 1998](#); [Ruttenber et al., 1997](#); [Stratton et al., 2001](#)).

1.2. ExDS and physical exertion

A risk factor for subjects experiencing ExDS is strenuous physical exertion. A struggle between an officer and subject, particularly one with a subject who is already agitated and displaying the symptomology of ExDS, would be expected to increase the risk of the subject experiencing ARD. For example, [Ho et al. \(2010\)](#) conducted a study where they simulated physical resistance and fleeing; this led to increased metabolic acidosis (too much acid in bodily fluids) and a catecholamine surge. They concluded that acidosis and/or surges in catecholamines can act as contributing or causal mechanisms in sudden deaths. [Vilke, Debard, et al. \(2012\)](#) have also noted that metabolic acidosis appears to contribute to cardiovascular collapse in fatal cases of ExDS.

Hyperthermia is a distinguishing feature of ExDS ([Baldwin et al., 2016](#)), and has been described as a harbinger of death ([Hall et al., 2013](#); [Vilke & Payne-James, 2016](#)). Hyperthermia is defined as an elevated body temperature due to failed thermoregulation ([Vilke, Bozeman, Dawes, Demers, & Wilson, 2012](#)). A prolonged and strenuous struggle with an overheating subject can contribute to increases in core body temperature and exacerbate a hyperthermic state ([Vilke & Payne-James, 2016](#)). An intense struggle would also further delay the administration of treatment, such as sedatives and cooling measures ([Vilke, Bozeman, et al., 2012](#); [Vilke & Payne-James, 2016](#)), potentially resulting in even higher risk for the subject.

It has been argued that there is a “period of peril” wherein a spike in both epinephrine and norepinephrine occurs following strenuous exercise ([DiMaio & DiMaio, 2006](#); [Dimsdale, Hartley, Guiney, Ruskin, & Greenblatt, 1984](#)). During this period, there is an increased risk of cardiac arrhythmias and ischemia. Individuals with a “higher degree of chronic stress (with higher long-term levels of catecholamines) tend to have higher mortality rates during acute episodes of severe stress” ([US Department of Justice, 2011](#), p. 17). Excessive strenuous movement in combination with heavy drug use, dehydration, or poor nutrition can also cause rhabdomyolysis ([Vilke & Payne-James, 2016](#)). This occurs when “...muscle fibers break down releasing chemicals, namely myoglobin, into the blood that are harmful to the kidneys” ([International Association of Chiefs of Police, 2014](#), p. 3). Therefore, even if a subject is resuscitated, the risk of a fatal outcome due to renal failure remains ([Mash et al., 2009](#); [Ruttenber et al., 1999](#)).

1.3. Risks to officer safety

Due to the agitated, violent, and erratic state displayed by individuals suffering from ExDS, the police are almost invariably involved in encounters with them. In one study that looked at fatal cases of ExDS within custodial settings, law enforcement represented 66% of the cases ([Grant et al., 2009](#)). It is also not surprising that many, if not all encounters, involved some sort of forceful struggle, although only two articles have specifically reported on this ([O'Halloran & Lewman, 1993](#); [Stratton et al., 2001](#)). In both studies, a forceful struggle ensued between officers and subjects (100% of cases). Police UoF is often required in order to gain control of individuals suffering from ExDS. However, given the nature of ExDS symptomology (e.g., pain tolerance, constant/near constant activity, superhuman strength), typical UoF interventions (e.g., physical control, oleoresin capsicum [OC] spray) that rely on pain compliance or manual force may be rendered ineffective ([Blaskovits, Baldwin, Hall, Bennell, & Lawrence, 2017](#)), which would

likely prolong the struggle and potentially increase the risk to officer and subject safety.

There are obvious risks to officer and subject safety if individuals in a state of ExDS are more likely to be in possession of a weapon and/or engage in a prolonged and violent struggle. A struggle between an officer and subject has been shown to increase the odds of officer injury during UoF encounters (Baldwin, Walker, Blaskovits, & Bennell, 2017). In fact, physical resistance by the subject has one of the largest associations with officer injury (Castillo, Prabhakar, & Luu, 2012). Accordingly, subject behaviour is also a significant factor associated with officer-involved injury (Castillo et al., 2012; MacDonald, Kaminski, & Smith, 2009).

1.4. The current study

To date, only two prospective epidemiologic studies examining cases of ExDS involved in UoF encounters have been carried out (Baldwin et al., 2016; Hall et al., 2013). While the latter of the two studies discussed the presence of drugs and alcohol as demographic characteristics, neither have examined the actual nature of the association between drugs and/or alcohol with the presence of ExDS. The risk of a continued struggle on the ground with police has also yet to be explored. Lastly, while it is anecdotally understood that interactions with individuals in a state of ExDS are violent, a clear understanding of the actual nature and risk of that violence is essential to determine appropriate response strategies, and the policies and training that guide them. This prospective study was designed not only to examine the association between the presence of ExDS and intoxicants, but also to examine the nature of the risk of violence and physical struggle in police encounters with subjects suffering from ExDS.

2. Material and methods

2.1. Study design and selection of participants

Data for the study was collected over a four-year consecutive time period from January 1, 2012 to December 31, 2015 through standardized reporting in a large Canadian law enforcement agency. The agency polices a vast geographical area, that includes urban, suburban, rural, and remote communities, that on average see higher rates of violent crime than the rest of Canada. In that agency, it is policy for law enforcement officers to generate post-incident reports of police UoF in their Subject Behaviour/Officer Response (SB/OR) database. Based on previous research, the SB/OR was revised by the authors prior to data collection to enable prospective documentation of the ten features of ExDS during the UoF encounter. As indicated previously, these features have been consistently identified as characteristic of ExDS within the literature (American College of Emergency Physicians Excited Delirium Task Force, 2009; Baldwin et al., 2016; Hall et al., 2013). Officers gained access to the list of features when they indicated in the agency reporting system that the subject they encountered was suffering from a perceived emotional disturbance; at that point a drop-down menu opened and each of the ten features could be checked off as present or absent.

All data are self-reported by officers and are based on their perceptions at the time of the incident. Multiple reports are required if more than one officer applied force during an incident and reports can include multiple subjects and/or multiple UoF applications on the subject. Data were included for analysis in this study if any UoF above the application of physical control “soft” occurred (physical control soft includes pressure points, joint locks, and come-along techniques). Furthermore, only actual applications of force, and not the use of interventions as deterrents (e.g., draw and display of a firearm), were included in the analysis. For a ‘major police incident’ such as a death or serious injury, other investigative and reporting processes are initiated; an SB/OR report for these incidents may not be completed until the potentially lengthy

investigative process is concluded. As a result, incidents undergoing investigation do not appear in the sample.

When merging report data for an individual subject, the highest value indicated across reports was selected (i.e., number of police officers on scene, number of features of ExDS, subject behaviour) and any perception of comorbidities or risk factors across reports was selected (i.e., perceived presence of drugs and/or alcohol, a struggle going to the ground, perceived possession of a weapon). Dummy variables were then created for subject behaviour (aggregating cooperative and resistant behaviours due to the low count in the target population), perceived presence of drugs and/or alcohol, and the categories of features of ExDS displayed by the subject. These categories were developed by aggregating the number of features displayed into three categories (i.e., less than three, three to five, and six or more). This is consistent with previous research (American College of Emergency Physicians Excited Delirium Task Force, 2009; Hall et al., 2013; Hall & Votova, 2013; Vilke, Debar, et al., 2012) and are used for comparative and analytic purposes.

The research was deemed exempt by the agency's institutional review board and the anonymized data were subsequently obtained through a Research Application and Undertaking (Privacy Act, 1985). The research was conducted following approval from Carleton University's Research Ethics Board (REB #16-105,365).

2.2. Primary data analysis

Data were prepared for analyses using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp, Released, 2013). Most analyses were conducted at the subject level; multiple data checks and merges were performed to ensure each subject was only represented once. The use of drop-down menus and checkboxes in the SB/OR means that responses were constrained and hence, no outliers were observed. The variables used in the analyses were mandatory for completion of the SB/OR report; thus, no missing data were observed. When merging report data from multiple officers for an individual subject, all UoF and/or features of ExDS documented by any officer involved in the interaction were aggregated to ensure all information was included. Logistic regression was used to model the data.

3. Results

3.1. Characteristics of the data

During the study period, 9887 SB/OR reports were completed by 4387 officers. The reports contained 11,237 UoF events involving 9006 subjects. The number of police-public interactions during the four-year time period was 10.9 million, indicating a 0.083%, 95% CI [0.081, 0.084] UoF per police-public interactions rate (i.e., force is applied in approximately one in every 1200 police-public interactions). Subjects undergoing police UoF were predominantly male (90.9%), had a mean age of 32 (SD ± 11.4), and were violent (65.9%).

3.2. Prevalence of ExDS

Out of 9006 subjects on which the police applied force, 2836 (31.5%) were perceived to be emotionally disturbed and a drop-down menu for the ExDS features became available for completion. The majority of subjects undergoing police UoF were not perceived to be emotionally disturbed or were not documented in the database as exhibiting any features of ExDS (n = 6170/9006, 68.5%). Overall, 10.1% (n = 906/9006) of subjects displayed three or more features of ExDS and 1.7% (n = 156/9006, 95% CI [1.483, 2.023]) of subjects displayed six or more features. A very small number of subjects (2/9006; 0.02%) presented with all ten features of ExDS.

There were four (n = 4/9006, 0.044%; 95% CI [0.017, 0.114]) sudden and unexpected ARDs of violent and agitated subjects during this

period. Documentation for these incidents could not be included in this analysis due to external investigative processes that are invoked under these circumstances. Thus, the number of features of ExDS displayed by these individuals prior to their death, whether officers assessed the presence of drugs and/or alcohol, and the UoF interventions used could not be reported here. However, the cause of death for these four subjects were available through public record and listed as: 1) acute cocaine toxicity combined with ExDS; 2) anoxic brain injury with toxicology results revealing blood levels of stimulants within the range where toxic effects have been reported; 3) ExDS as a consequence of cocaine toxicity; and 4) acute cocaine toxicity during restraint. In all cases stimulant use was documented and it is intuitive that some individuals would have demonstrated features of ExDS, particularly the two individuals who had ExDS listed as a cause of death.

3.3. Demographics

The majority of subjects displaying six or more features of ExDS were male (94.9%) with a mean age of 31 (SD ± 10). A one-way between subject analysis of variance (ANOVA) was conducted to compare subject age of those who were not perceived to be emotionally disturbed, or did not exhibit more than two features of ExDS, with those who displayed three to five features of ExDS, as well as with those who presented with six or more features of ExDS. A significant difference in age across the three categories was observed, $F(2, 9003) = 3.37, p = 0.035$. A Tukey post hoc test was conducted and it was determined that subjects displaying <3 features had a significantly lower age ($M = 31.7, SD \pm 11.4$) than those displaying between three to five features ($M = 32.7, SD \pm 11.4$; mean difference = 1.1, $p = 0.038$). While statistically significant, this difference is not clinically relevant. There was also a significant difference in the number of officers across the three categories, $F(2, 9003) = 22.1, p < 0.001$. A Tukey post hoc test determined that subjects displaying six or more features had a significantly higher number of officers on scene ($M = 3.5, SD \pm 2.9$) compared to those displaying less than three features ($M = 2.6, SD \pm 2.3$; mean difference = 0.86, $p < 0.001$). This is consistent with more dangerous circumstances attracting a more substantial police response.

3.4. Odds of intoxicants for subjects with ExDS

The presence of drug and/or alcohol use assessed by officers involved in the encounter was examined across each of the three categories of displayed features of ExDS. Overall, approximately 88.5% of all probable cases (i.e., those exhibiting six or more features of ExDS) were perceived to be under the influence of drugs and/or alcohol. In order to determine whether or not subjects with larger clusters of features were more likely to be perceived as under the influence of drugs and/or alcohol, those cases exhibiting less than three features were compared to those exhibiting three to five features and six or more features (i.e., probable cases; see Table 1).

Approximately 44.2% of subjects exhibiting less than three features were perceived to be under the influence of alcohol only. The assessment of alcohol intoxication decreased substantially across the other categories of features (i.e., as the number of features of ExDS increased). More specifically, of the subjects displaying three to five features, 15.5% were perceived to be under the influence of alcohol only, and of the probable cases of ExDS, only 4.5% were perceived to be under the influence of alcohol only. Drug intoxication demonstrated an inverse pattern. Approximately 9.3% of subjects exhibiting less than three features were perceived to be under the influence of drugs only, and this prevalence increased substantially as the number of features of ExDS increased. Specifically, 27.2% of the subjects displaying three to five features were perceived to be under the influence of drugs only, while nearly 43% of probable cases of ExDS were perceived to be under the influence of drugs only.

In order to determine whether the presence of alcohol and/or drugs was related to the number of ExDS features present, odds ratios across the categories of ExDS were calculated (see Fig. 1). All of the logistic regression models were significant, even when controlling for all other variables in the models. We found that individuals exhibiting probable ExDS had 3.6 times higher odds of being perceived to be under the influence of drugs in combination with alcohol, compared to the same assessment for an individual exhibiting less than three features of ExDS. The odds of someone with ExDS (i.e., six or more features) being perceived as being intoxicated by drugs alone was 9.4 times higher than those exhibiting less than three features. For alcohol alone, subjects

Table 1
Odds ratios of situational factors with displayed features of ExDS.

Situational and risk factors	Displayed Features of ExDS											
	Less than three (n = 8100)		Three to five (n = 750)		Six or more (n = 156)		Less than three v. three to five ^a		Less than three v. six or more ^b		Three to five v. six or more ^c	
	No. (%)	No. (%)	No. (%)	OR	95% CI	OR	95% CI	OR	95% CI			
Subject perceived to be under the influence of drugs and/or alcohol												
No drugs or alcohol	2152 (26.6)	149 (19.9)	18 (11.5)	1.00		1.00		1.00				
Alcohol only	3581 (44.2)	116 (15.5)	7 (4.5)	0.39	0.30–0.51	0.19	0.08–0.45	0.50	0.20–1.23			
Drugs only	757 (9.3)	204 (27.2)	67 (42.9)	3.55	2.82–4.47	9.44	5.56–16.03	2.76	1.57–4.86			
Drugs and alcohol	1610 (19.9)	281 (37.5)	64 (41.0)	2.02	1.63–2.50	3.57	2.09–6.10	1.88	1.07–3.30			
Was there a struggle that went to the ground												
No	2449 (30.2)	129 (17.2)	18 (11.5)	1.00		1.00		1.00				
Yes	5651 (69.8)	621 (82.8)	138 (88.5)	1.95	1.60–2.39	2.93	1.77–4.84	1.55	0.91–2.64			
Subject behaviour												
Cooperative/resistant	2904 (35.9)	135 (18.0)	28 (17.9)	1.00		1.00		1.00				
Assaultive	4208 (52.0)	445 (59.3)	91 (58.3)	2.44	1.98–3.00	2.37	1.52–3.69	1.12	0.69–1.79			
Grievous bodily harm or death	988 (12.2)	170 (22.7)	37 (23.7)	3.59	2.80–4.62	3.79	2.25–6.36	1.24	0.70–2.18			
Subject perceived or believed to be in possession of a weapon												
No	4833 (59.7)	412 (54.9)	87 (55.8)	1.00		1.00		1.00				
Yes	3267 (40.3)	338 (45.1)	69 (44.2)	0.91	0.77–1.09	0.77	0.53–1.10	0.88	0.60–1.28			

Adjusted for the other variables in the model.

^a Model $\chi^2(7) = 591.12, p < 0.001$; Cox & Snell $R^2 = 0.07$, Nagelkerke $R^2 = 0.15$; Hosmer & Lemeshow $\chi^2(8) = 17.26, p = 0.016$.

^b Model $\chi^2(7) = 283.36, p < 0.001$; Cox & Snell $R^2 = 0.03$, Nagelkerke $R^2 = 0.20$; Hosmer & Lemeshow $\chi^2(8) = 3.94, p = 0.862$.

^c Model $\chi^2(7) = 34.04, p < 0.001$; Cox & Snell $R^2 = 0.04$, Nagelkerke $R^2 = 0.06$; Hosmer & Lemeshow $\chi^2(8) = 1.88, p = 0.984$.

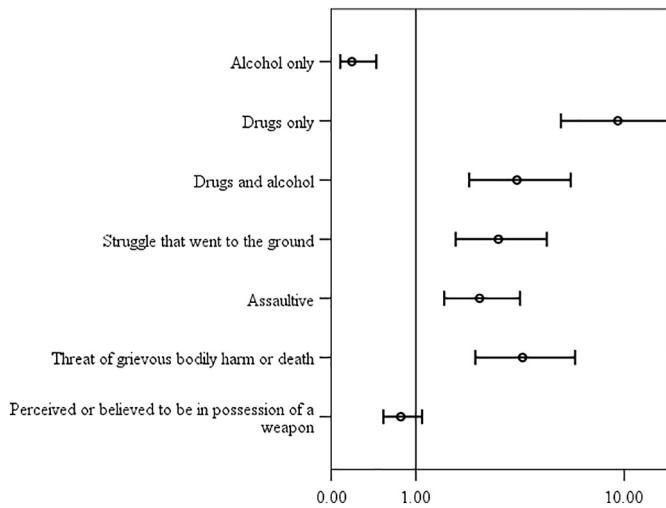


Fig. 1. Odds ratios of situational and risk factors comparing subjects displaying less than three features of ExDS against those displaying six or more (i.e., probable cases).

with ExDS had 81% lower odds of being perceived as being under the influence, relative to subjects displaying less than three features of the syndrome.

3.5. Odds of a ground struggle with ExDS

Approximately 88.5% of all probable cases of ExDS engaged in a struggle with an officer that went to the ground; this prevalence was lower for subjects displaying three to five features (82.8%), and for those displaying less than three (69.8%; see Table 1). Encounters with probable ExDS that did not result in a struggle on the ground (11.5%) typically involved subjects ceasing resistance once on the ground, or multiple officers effectively controlling the subject to the ground, thus negating further struggle. In order to determine whether engaging in a ground struggle was related to the number of ExDS features present, odds ratios across the categories of ExDS were calculated (see Fig. 1). Compared to those with less than three features of ExDS, the odds of a struggle continuing after going to the ground were nearly three times higher for probable cases of ExDS.

3.6. Odds of risks to officer safety with ExDS

There was an increase in the subject's assaultive behaviour with a greater number of observed features of ExDS (see Table 1). More specifically, 52% of subjects displaying less than three features engaged in assaultive behaviour against an officer, whereas approximately 58.3% of subjects displaying probable ExDS displayed assaultive behaviour. An increase across the categories of ExDS was also observed for the threat of grievous bodily harm or death (GBHD). Only about 12% of individuals who displayed less than three features presented a threat of GBHD. However, 22.7% of those displaying three to five symptoms were perceived as a threatening GBHD, and 23.7% of subjects displaying probable ExDS did so. The findings also indicated that there was a slight increase in the prevalence of subjects perceived to be in possession of a weapon across the categories of features (see Table 1). For example, 40.3% of those displaying less than three features were perceived to be in possession of a weapon, in comparison to 44.2% of probable ExDS cases. In the case of probable ExDS, these were generally weapons of opportunity, such as impact weapons (e.g. hammer, shovel, metal bar, piece of wood) and edged weapons (e.g., broken glass), as opposed to typical instrumental weapons such as knives and firearms possessed by subjects who exhibited less than three features of ExDS.

In order to determine whether the nature of the subject's violent behaviour was related to the number of ExDS features present, odds ratios

across the categories of ExDS were calculated (see Fig. 1). The odds of persons in a state of probable ExDS behaving in an assaultive manner were 2.4 times higher than those subjects displaying less than three features. Individuals in a state of ExDS had 3.8 times higher odds of presenting a threat of GBHD. While weapons were more often encountered with subjects who exhibited ExDS, this difference across the categories of features was not statistically significant when controlling for all other variables in the models.

4. Discussion

There is a dearth of research examining the situational factors and risks to officer safety associated with non-fatal cases of ExDS. This limits the ability to understand the nature of these encounters, and the resultant threat to officer and public safety from individuals under such physiological conditions. The current study is the largest prospective epidemiologic study of police UoF encounters involving probable cases of ExDS. Consistent with previous research (Baldwin et al., 2016; Bozeman et al., 2018; Hall et al., 2013), UoF is rarely applied in North America, and individuals with large numbers of features of ExDS are infrequently encountered in day-to-day policing. However, on the rare occasions when force is used, subjects with multiple features of ExDS are much more commonly encountered.

4.1. Epidemiology

Building on our previous work and the work of others, we have increased the precision of the estimate of prevalence of ExDS in the law enforcement environment. Previous research has determined that the frequency with which individuals with six or more features of ExDS are encountered in police UoF encounters was between 1.5 and 2.3% (Baldwin et al., 2016; Hall et al., 2013; Hall & Votova, 2013). With over 10 million police-public interactions in our current study and over 9000 UoF incidents, we can say with confidence that the prevalence of ExDS in UoF events is 1.7%; with a 95% confidence interval of 1.5% to 2%. Law enforcement agencies can anticipate encountering a highly abnormal, violent subject in at least 1 in 67 UoF encounters, based on the upper confidence limit. We argue that the epidemiology of these encounters is firmly established. Additional large-scale study is unlikely to refine the prevalence of these events in a clinically meaningful way.

In our cohort, there were four recorded sudden and unexpected ARDs of violent and agitated subjects. While information from the database is not available due to external investigative processes that are invoked under these circumstances, publicly available autopsy results found the cause of death in each of these ARDs to include stimulant intoxication. In two of these cases, ExDS was included in the cause of death. From knowledge that each subject was under the influence of stimulants and was involved in a UoF encounter, we can estimate the general risk of ARD for our cohort. As a worst-case scenario, if we assume that each of the four subjects who died were in a state of ExDS (with six or more concomitant features of ExDS), then ARD has occurred in 2.5% of probable cases of ExDS ($n = 4/160$, 2.5%; 95% CI [0.976, 6.251]). This finding indicates that up to 6.3% or 1 in 16 subjects with six or more features of ExDS could be at risk of sudden and unexpected ARD during a police UoF incident. As few as 1 in 100 could be at risk of ARD by this estimate. As a best-case scenario, if one assumes that those four subjects had only three or more features of ExDS ($n = 4/910$; 0.44% 95% CI [0.171, 1.125]), then as few as 2 in 1000 persons and as many as 1 in 100 persons with 3 or more features of ExDS could be expected to suffer ARD in a police UoF encounter.

Even if the best-case scenario is accepted, with hundreds of thousands of UoF incidents occurring annually in North America (Garner, Hickman, Malega, & Maxwell, 2018), our study indicates that up to 0.1% or 114 in every 100,000 subjects involved in a UoF encounter may be at risk of sudden and unexpected ARD ($n = 4/9006$, 0.044%;

95% CI [0.017, 0.114]). It is possible to identify persons at risk with simple recognition of ExDS features. Prudent development of policy and protocols aimed at early identification of these medical emergencies will enable police and first responders to modify response strategies appropriately to avoid subject and officer injury, and to expedite medical care of the subject.

4.2. Intoxicants

Consistent with previous literature which indicates that alcohol and/or drugs are often involved in cases of ExDS (e.g., Grant et al., 2009; Hall & Votova, 2013; Mash et al., 2009), the current research found that nearly 9 in 10 probable cases of ExDS were perceived to be under the influence. However, when the influence of alcohol and drugs were teased apart, it became apparent that probable cases of ExDS were significantly more likely to be under the influence of drugs, and significantly less likely to be under the influence of alcohol alone. Similar rates of drugs and alcohol use have been reported in fatal cases of ExDS (Mash et al., 2009; Ross, 1998; Ruttenber et al., 1997; Stratton et al., 2001); thus, our findings underscore the physiological risk for these subjects.

Instead of simple stimulant drug overuse, ExDS has been described as “The Perfect Storm,” in which there is a “confluence of events caused by psychoactive stimulant abuse” (US Department of Justice, 2011, p. 18). Prior chronic drug use may predispose individuals to sudden cardiac death in the event of physical stress as a result of a concentric enlargement of the heart and scar tissue in the heart (US Department of Justice, 2011). The prevalence of stimulant use in cases of ExDS gives rise to the dopamine hypothesis, in which these individuals suffer from dopamine transporter (DAT) dysregulation and are unable to regulate the reuptake of this neurotransmitter (Hall et al., 2013; Mash et al., 2009; Vilke, Debard, et al., 2012; Wetli, 2006). Dopamine dysregulation is linked to psychosis (Howes & Kapur, 2009; Laruelle & Abi-Dargham, 1999) and is also believed to affect thermoregulation, underpinning the hyperthermic state in ExDS, particularly in fatal cases (Hall et al., 2013; Mash et al., 2009; Vilke, Debard, et al., 2012; Wetli, 2006).

Interestingly, a post-mortem toxicological analysis of cocaine-related ExDS deaths noted that the “blood level[s] of cocaine... [were] similar to levels found in recreational cocaine users and lower than levels found in people who died from cocaine intoxication” (Pollanen et al., 1998, p. 1603). Dysregulation of dopamine, rather than dopamine mimicry by sympathomimetics, is believed to be at play. Dopamine dysregulation, along with an excess of the other two catecholamines in the brain, epinephrine (adrenaline) and norephinerine, which “prepare[s] the body for the fight or flight response by increasing the heart rate, blood pressure, and glucose levels” (International Association of Chiefs of Police, 2014, p. 3) creates a dangerous convergence. Acute stimulant use increases dopamine in the striatum and nucleus accumbens, which is directly linked to increased locomotor response and stereotyped behaviour (Meyer & Quenzer, 2013). Sympathomimetic drugs, like cocaine, induce increased heart rate, vasoconstriction, hypertension, and hyperthermia. Cocaine, methamphetamine, and amphetamine directly interact with the DAT and alter its function to increase dopamine (Meyer & Quenzer, 2013). The resulting effect of this catecholamine surge is the manifestation of the commonly displayed features of ExDS (e.g., superhuman strength, pain tolerance, extreme endurance), and can also potentially trigger a lethal syndrome called stress cardiomyopathy, where the heart contracts abnormally (Goudge et al., 2013).

Mash et al. (2009) have demonstrated that in cases of fatal ExDS, dopamine receptors dysregulation is present in the vast majority, if not all cases. It is unknown at which point the chaotic dopamine signaling occurs and then death ensues. In our cohort, not only did police officers assess the subjects in a state of ExDS to be drug intoxicated more than alcohol intoxicated, but the four subjects who suddenly and unexpectedly died in our cohort all had evidence of cocaine intoxication. Our findings indicate that drug intoxication (stimulants in particular) may

play a role, either as a trigger or a contributing factor to the generation of, or sustenance of, a state of ExDS.

Alcohol use alone has not been identified as a common antecedent in cases of probable ExDS (e.g., Vilke, Debard, et al., 2012). Our study is consistent with this finding, with a staggering decrease in the odds of alcohol intoxication alone assessed by police officers when probable cases of ExDS were encountered. Biochemically, alcohol use alone would not be anticipated to induce a highly agitated state. In brief, acute alcohol use increases gamma-aminobutyric acid (GABA), the main inhibitory neurotransmitter (NT) in the brain, while simultaneously decreasing glutamate, the main excitatory NT (Meyer & Quenzer, 2013). Accordingly, GABA and the sedative effects of alcohol are positively related (Grobin, Matthews, Devaud, & Morrow, 1998). It is important to note that alcohol can also have stimulant effects through its activation of dopaminergic neurons; however, this only occurs at lower doses (Pohorecky, 1977). Thus, individuals exhibiting ExDS would not be expected to be under the influence of alcohol alone due to its predicted sedative effects. While alcohol intoxication alone was not found to be a specific risk factor for ExDS, this may not be practically important as officers rarely have the advantage of knowing the amount or type of intoxicants present in the subject they are dealing with. In those assessed as being under the influence of drugs in combination with alcohol, it is unknown at which point the effects of stimulants may override the depressant effects of alcohol when they are mixed (Hall et al., 2013).

Not all subjects who display features of ExDS are intoxicated. In our study, the majority of individuals (88.5%) who displayed probable ExDS were perceived to be under the influence of drugs and/or alcohol. However, while drugs may act as a catalyst for ExDS, they are not necessarily a prerequisite. Our finding is consistent with previous literature that demonstrates that 11% of fatal cases of ExDS did not have drugs or alcohol in their system (Grant et al., 2009; Mash et al., 2009; O'Halloran & Lewman, 1993; Stratton et al., 2001). It is understood that ExDS can be brought on by other means than drugs, such as psychiatric illness or abrupt cessation of psychiatric medication (Coyne et al., 2017; O'Halloran & Lewman, 1993; Pollanen et al., 1998; Vilke & Payne-James, 2016).

We believe that further study aimed at uncovering the pathophysiology of ExDS can be targeted in the 1.7% of police UoF subjects who demonstrate ExDS, but who are still alive. Comparative analyses between fatal and non-fatal cases of ExDS may provide insight into the risk factors observed in individuals who die as a result of ExDS, and those who do not. This would assist in determining whether specific factors (drug-related or otherwise) uniquely predict sudden ARD. However, whether a person is suffering from a psychiatric emergency, or an emergency due to intoxication, early recognition, appropriate response protocols, and immediate transport for medical care are all facilitated by a detailed understanding of who is at potential risk and how to identify them. Our study, combined with earlier literature, provides that guidance.

4.3. Physical struggle and risks to officer safety

In addition to examining the frequency of ExDS and its association with intoxicants, we also assessed the nature of subject behaviour as a consequence of ExDS. This included the risk of a continued struggle on the ground during police encounters with these individuals. This type of struggle is likely to result in physical exertion, which is a significant risk factor for subjects experiencing ExDS (DiMaio & DiMaio, 2006). Our findings indicated that 88.5% of all probable cases of ExDS involved a struggle with an officer that went to the ground.¹ This rate was

¹ While most UoF encounters end up with a subject on the ground for tactical advantage (i.e., control and restraint), there is a key distinction between a *subject* going to the ground and a *struggle* going to the ground. The former, can include a subject complying with lawful commands and/or may occur as a result of a successful UoF deployment (e.g., OC spray, CEW). However, this analysis specifically examines the latter, as a *struggle* going to the ground can have particularly serious consequences for responding officers and a subject experiencing ExDS.

significantly higher than those displaying less than three features of ExDS. A prolonged or strenuous struggle with a subject experiencing ExDS can result in acidosis, hyperthermia, rhabdomyolysis, and/or surges in catecholamines, which can play a critical role in fatal ExDS (Ho et al., 2010; Mash et al., 2009; Ruttenber et al., 1999; Vilke, Debard, et al., 2012; Vilke, Payne-James, & Karch, 2012); thus, a prolonged struggle could put these subjects at an increased risk of ARD. Officers are also at an increased safety risk, as continued physical resistance by a subject has one of the largest associations with officer injury (Castillo et al., 2012).

Subject behaviour is also a major factor associated with officer-involved injury (Castillo et al., 2012; MacDonald et al., 2009). We have found that individuals in a state of ExDS are more likely to represent a significant threat to officers through their violent behavior. The vast majority (82%) of subjects in a state of ExDS displayed assaultive behaviour or presented a threat of GBHD. We also found that there was a small increase in the prevalence of subjects perceived to be in possession of a weapon when a subject displayed a large number (i.e., six or more) features of ExDS. Violence, and the nature of it, is an important consideration. When the police encounter a subject who is presenting a substantial threat to them or the public, and no lesser options are available to prevent such a threat, an officer may be justified in stopping the threat by means of lethal force. These results underscore the risk that these encounters often present.

The situational importance of these findings in policing is high. From our findings, it follows that those individuals in a state of ExDS who are at high risk of drug intoxication and violent behaviour, and by definition are delirious and unable to make appropriate cognitive decisions, are unlikely to comply with verbal direction. Response protocols can be amended to include this knowledge to anticipate the threat level and act accordingly. The increased risk involved in these situations clearly emphasizes the need for intervention strategies that promote multiple member responses and effective intervention options to quickly and efficiently control these subjects, when necessary. Such strategies will facilitate a reduction in the extent of struggle involved and allow for more expedient monitoring of vitals, as well as immediate medical intervention, thus reducing risk of harm to the subject, officers, and any potential bystanders.

In these incidents, officers should consider intervention options that provide greater time and distance from the subject (e.g., probe-deployment of conducted energy weapon [CEW]), and also have lower injury rates when compared to the use of physical control (Baldwin et al., 2017; Bozeman et al., 2018). Given the nature of ExDS symptomology (e.g., pain tolerance, constant/near constant activity, superhuman strength), typical UoF interventions (e.g., physical control, pepper spray) that rely on pain compliance or manual force may be rendered ineffective, which should also be taken into account by responding officers (Blaskovits et al., 2017). In the past, ExDS deaths have been suggested to be a consequence of OC spray, the CEW, or the use of neck restraints on subjects (DiMaio & DiMaio, 2006). However, no study to date has established a causal relationship between these less lethal intervention options and fatal subject outcomes (e.g., Goudge et al., 2013; Michalewicz et al., 2007; Mitchell, Roach, Tyberg, Belenkie, & Sheldon, 2012; Petty, 2004).

Once on the ground, judicious restraint of these subjects will prevent ongoing use of the large muscle groups (e.g., legs), which consumes oxygen and contributes to acidosis, hyperthermia, rhabdomyolysis, and surges in catecholamines (Ho et al., 2010; Mash et al., 2009; Ruttenber et al., 1999; Vilke, Bozeman, et al., 2012; Vilke, Debard, et al., 2012; Vilke, Payne-James, & Karch, 2012). It is recommended that this be achieved through biomechanical advantage, which involves the coordinated isolation and leveraging of the subject's limbs to reduce their ability to generate power (Force Science Institute, 2007). This approach can also limit excessive weight or compression to the subject's chest, neck, or head and circumvent the restriction of breathing (International Association of Chiefs of Police, 2014). As soon as possible, officers should

continuously monitor the subject's vitals and face to assess their airway, breathing, and circulation (DiMaio & DiMaio, 2006; International Association of Chiefs of Police, 2014). Increasing evidence also suggests that prehospital administration of Ketamine by authorized medical personnel (e.g., EMS) may be an optimal sedative for the treatment of ExDS, due to its quick onset and more complete behavior control (Ho et al., 2013; Linder, Ross, & Weant, 2018; Schepke, Braghiroli, Shalaby, & Chait, 2014; Takeuchi, Ahern, & Henderson, 2011; Vilke & Payne-James, 2016). Given the large number of these incidents that result in a continued struggle on the ground, efficient subject control that minimizes the physiological stress on the subject should improve the outcome for both the subject and the involved officers.

Training for first responders that provides the education and skills needed to manage individuals in a state of ExDS is necessary (e.g., containment, multi-officer response strategies). To help ensure police officers and dispatchers request EMS to the scene as soon as possible, training must recognize ExDS as a medical emergency. Training may be integrated into existing modules on mental health, crisis-intervention, de-escalation, First Aid, CPR, and the UoF to ensure that relevant linkages between concepts are learned. As new research on ExDS emerges and best practices are identified, training should be updated accordingly. Collaboration among the various parties (e.g., paramedics, emergency physicians, hospital security, correctional officers, dispatchers, etc.) who repeatedly come in contact with probable cases of ExDS, may also help inform intervention strategies. Given the importance and necessity of training, policy that supports it is also essential. For example, law enforcement policy that enforces mandatory ExDS training for officers and dispatchers could be developed.

4.4. Limitations

In our study, only actual applications of force, and not the use of interventions as deterrents (e.g., draw and display of a firearm), were included in the analysis. Our study was not designed to test the effectiveness of force options or deterrents but rather to document and study the population where police UoF occurred, since this is the population in which death and injury occurs. Given the nature of subjects in a state of ExDS (i.e., with six or more concomitant features) and their extremely abnormal cognition, it is highly unlikely that they will comply with a simple deterrent and thus, have not been considered in our study. As support for this statement, our findings of ExDS prevalence are very consistent with other authors who included UoF deterrents in their cohort (Hall et al., 2013; Hall & Votova, 2013).

This study was also limited to police UoF encounters; therefore, we can only estimate the prevalence of ExDS in law enforcement settings. We cannot comment on the prevalence of ExDS in the community when law enforcement is not involved. We know of no mechanism by which ExDS can currently be estimated robustly in the community without adaptation of consistent terminology. We believe the epidemiology of ExDS in police UoF encounters is now fully defined. Our study could also only examine the number of deaths for subjects exhibiting ExDS that occurred in our cohort of law enforcement encounters; we cannot estimate the number of deaths that occur in communities or in hospitals without law enforcement involvement. Despite acceptance of the term Excited Delirium by the National Association of Medical Examiners (NAME) in the USA, there is no standardized use of the term by coroners and medical examiners in North America. Thus, it is impossible to conduct even retrospective evaluation of coroners' records to determine the number of deaths for subjects in a state of ExDS that have occurred without police involvement. However, our study does mirror other large-scale prospective studies, and our results add to the knowledge of the prevalence of ExDS and subsequent sudden death in a police UoF environment (Hall et al., 2013; Hall & Votova, 2013). We believe that significant refinement of the prevalence of ExDS in police-public interactions will not occur, even with further comprehensive study. However, there is certainly merit in further large-scale studies focused on

subjects with ExDS, the underlying pathophysiology of those subjects, and the impact of various force options and techniques to limit struggle and adverse outcomes for subjects and officers.

Additionally, there are limitations to the nature of data collection, even in a systematic, prospectively defined database like the one we relied on, which was designed to capture both the elements of UoF and the subjects exposed to that force. The standardized reporting system used was developed primarily to assist police officers in articulating their actions surrounding a UoF incident. Reports are completed from an officer's perspective and are based on their subjective interpretation of the events at the time of the encounter, which may contain biases. Police officers receive annual training on conducting continuous risk assessments, which are based on the officer's experiences and perceptions, as well as situational factors and the subject's behaviour. Additionally, the agency mandates that all officers take a one-hour on-line course on ExDS. The training describes the features of ExDS and how to recognize someone who might be suffering from this syndrome. However, they are not trained to diagnose subjects and would not typically confirm alcohol or drug intoxication under these circumstances (i.e., a standardized field sobriety test and/or breathalyser would typically not be utilized in such instances). Future research should attempt to validate the accuracy of these perceptions against toxicology results and medical assessments, including compliance with psychiatric medication. In the absence of such clinical studies, first responders' perceptions of subjects displaying a large number of features of ExDS continue to provide valuable and previously unreported insights into the operational realities of dealing with these medically high-risk encounters.

Since reports cannot be created contemporaneous to a UoF incident, and completion of data records even immediately after the event are subject to recall bias, data can be limited due to memory errors and stress, which have been found to impede recall (e.g., Yuille, Davies, Gibling, Marxsen, & Porter, 1994). However, these reports are typically completed in close proximity to the event (i.e., within 48 h), which may decrease memory impairment issues (e.g., Geiselman, 2010). While post-incident reporting is an obvious limitation, it would be impossible to complete a report during the event. Furthermore, the results of the present study, which are based on a large sample of cases, correspond closely to the results reported by Hall and Votova (2013), suggesting consistency in standardized police reporting in spite of potential biases and the influence of stress on recall. Future studies should validate officer perceptions from retrospective recall against more objective sources, such as body worn camera (BWC) footage, which is becoming more readily available as BWCs are adopted by law enforcement agencies (Ariel, Farrar, & Sutherland, 2015; Dawes et al., 2015).

In our study, due to the construct of the database, the features of ExDS were only collected if the subject was perceived by the responding officer to be emotionally disturbed. All subjects *not* perceived to be emotionally disturbed by officers received missing values for the features associated with ExDS. Although one could assume that most, if not all, probable cases of ExDS would be perceived as emotionally disturbed, capturing the information in this way biases our study against documenting all potential cases of ExDS, thereby underestimating its true prevalence. It is anticipated that the number of missing cases of extreme agitation is small. Hall and Votova (2013) collected ExDS identifiers for all subjects regardless of their perceived emotional state, and thus found slightly different (namely higher) prevalence rates. The use of drop-down menus and checkboxes in the SB/OR also means that responses were constrained and hence captured only what the database allows. This may also represent a source of bias.

Lastly, when merging report data for an individual subject, all recorded features of ExDS were recorded regardless of whether all involved officers included the same features. Due to the dynamic and prolonged nature of these incidents, study investigators did not attempt to judge which officer's report was "most correct," but rather included

all variables if they appeared. Evidence that this procedure did not significantly bias the results is found in the fact that >90% of subjects are recorded as having less than three features of ExDS during the UoF encounters, even when the highest possible number of features recorded was utilized.

4.5. Conclusion

Our study provides important information to guide the development of policy and procedure in law enforcement. Police encounter a subject with ExDS 1 in every 58 UoF incidents (1.7%). Those individuals are at higher odds of being intoxicated with drugs according to officers' assessments and at risk of being further exerted during a struggle on the ground, both of which appear to play a major role in deaths associated to ExDS. There is a demonstrable increase in risk to officers and public safety from the violent behaviour displayed by subjects presenting a greater number of features of ExDS. In our cohort, all four subjects who died had evidence of stimulant use. Our data suggests that up to 6.3% of subjects in a state of ExDS could succumb to ARDs; however, we cannot comment on the prevalence of death for persons with ExDS who do not encounter police. Further research is needed to determine which force options optimize outcome for police and subjects. Currently, ExDS is not yet a universally recognized syndrome in the medical community and, as such, there remains a lack of awareness and training for first responders who engage with afflicted individuals. Research surrounding pathophysiology leading to death should focus on subjects with six or more features of ExDS. Ultimately, a better understanding in this area will contribute to improving the outcomes of these encounters for those suffering from ExDS and those tasked with assisting them.

Disclaimer

The views expressed in the submitted article are the authors' and not an official position of Carleton University, the Royal Canadian Mounted Police, or the Vancouver Island Health Authority.

Simon Baldwin and Dr. Christine Hall conceived the study. Simon Baldwin designed the study, obtained the data, managed the data (including quality control), and analyzed the data. Dr. Craig Bennell and Dr. Christine Hall provided statistical advice on study design and analysis of the data. Chris Lawrence provided advice on operational policing and the criminal justice system. Dr. Christine Hall provided advice on emergency medicine. Brittany Blaskovits, Tori Semple and Simon Baldwin drafted the manuscript, and all authors contributed substantially to its revision. Simon Baldwin takes responsibility for the paper as a whole.

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