Review of Bladed Weapon Threats

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Abstract. Knife crime is prevalent in the UK with the Office of National Statistics recording 50,510 bladed weapon offences in the year ending March 2024. Hence, bladed weapon attacks are a significant threat to the public and policing, with background knowledge of these types of attacks being highly relevant to law enforcement. There is a considerable body of published work ranging from academic studies investigating the mechanics of knife attacks and real-world injury profiles, as well as open-source reporting of incidents. This study summarises relevant publications, whilst offering a perspective from the Metropolitan Police Service of the current threat. Finally, it proposes areas of future development to improve the preparedness of frontline responders to bladed weapon threats.

1. INTRODUCTION

This paper draws on government funded, national statistics to quantify the motive and frequency of knife attacks within the UK. To contextualise the blade weapon threat, these statistics will be compared with data for known threats, such as firearm attacks. Furthermore, national statistics and a case study from a major trauma centre emphasise the clinical consequences of bladed weapon attacks on the public and the emergency services.

There is a considerable body of published work ranging from academic studies investigating the mechanics of knife attacks and real-world injury profiles, as well as open-source reporting of incidents. The principal aim of this paper is to outline key issues relating to reported knife attacks and the supporting academic literature. This study summarises relevant publications, whilst offering a perspective from the Metropolitan Police Service of the current threat. Finally, it proposes areas of future development to improve the protection of frontline responders to bladed weapon threats.

2. POLICE STATISTICS FOR BLADED WEAPON ATTACKS

According to police data recorded in England and Wales, published by the Office of National Statistics (ONS), knife-enabled crime in the year ending March 2024 saw a four percent increase to 50,510 offences, from 48,409 in the previous recording year.

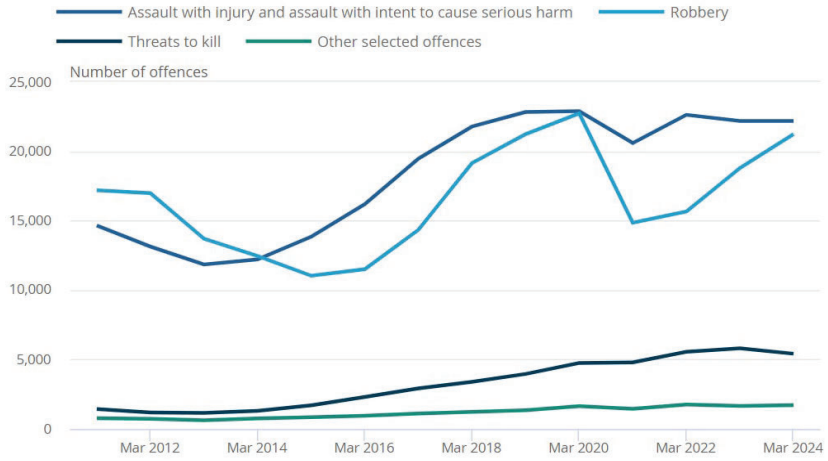

Figure 1. Graph reproduced from the ONS website detailing knife-enabled crime [1]

The majority of knife crimes, in year ending March 2024, were categorised as “assault with injury and assault with intent to cause serious harm” (n=22,617), this is closely followed by “robbery”

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(n=21,226) which has steeply risen by 13 percent, compared with the previous year. Finally, reported "threats to kill" (n=5,411) were 7 percent lower, compared with March 2023 (n=5,801) [1].

2.1 Offences involving firearms

The ONS also publish police data relating to recorded offences involving firearms. These statistics include various weapon types including imitation firearms, handguns and shotguns. In the year ending March 2024, in England and Wales, there were 6,268 reported offences involving firearms [2]. Hence, when comparing UK recorded data for offences involving firearms with offences involving knife-enabled crime, firearms offences are approximately one eighth in frequency.

3. CLINICAL STATISTICS FOR BLADED WEAPON ATTACKS

In the UK, the National Health Service (NHS) has published counts of inpatient finished admission episodes (FAEs) with a cause code of 'assault with a sharp object' [3]. Figure 2 below illustrates data, between years ending 31st March 2013 to 31st March 2022, namely the total number of "assaults with sharp object" and the proportion of these assaults on persons under 25. In this dataset, patients under 25 represent 38.2 to 41.8 percent of the total FAEs [3].

Furthermore, it is interesting to note that that, although the police and clinical data sets are from different sources, the typical frequency of "assaults with sharp object" is circa one tenth of the total data recorded by police for knife-enabled crime.

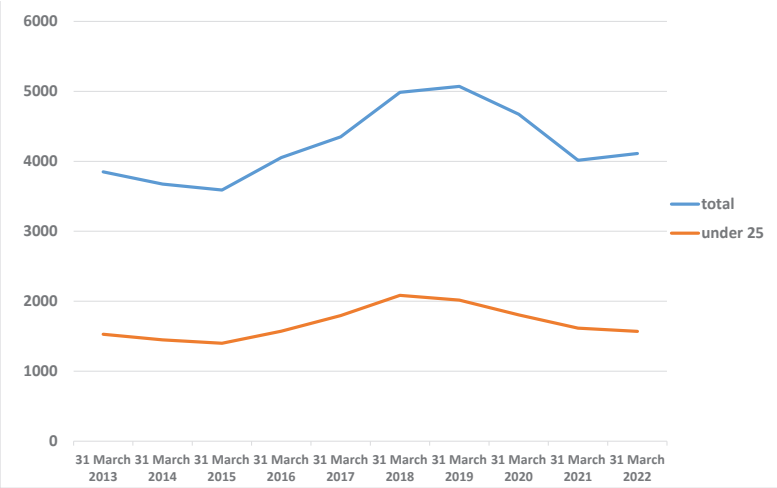

Figure 2. Graph reproduced from NHS data for 'assault with a sharp object' [3]

3.1 Case study of bladed weapon attacks from a UK trauma centre

A research paper by Malik et al, published in EClinicalMedicine in 2020, concludes that knife injuries constitute nearly 13 percent of a UK trauma centre workload (Birmingham, UK) [4]. Reoccurring trends include recidivism, violent, intoxication in males, (who constitute 93 percent of the patients). Domestic violence was predominated in females, constituting the remaining 7 percent of patients. This paper also includes data relating to the age of the patient. For the three years considered under 25s were 39 percent, 38 percent and 51 percent, respectively, of the reported population.

Malik et al plot the time of arrival of patients with knife injuries to the Trauma Centre and there were higher frequencies of patients on Friday evening from 1930 to 0030, on Saturday evening from 2130 to 0330 and Sunday evening from 2230 to 0530 [4].

The description of the type of bladed weapon in patient records was often ambiguous, as in 63.7 percent of cases the bladed weapon was described as a "knife". Household knives were specifically mentioned in 9 percent of patient records and small folding blades were cited as a causative weapon in less than 3 percent of patients. Machetes were named as the cause of knife injuries in 14 percent of UK major trauma centre patients [4].

Finally, the estimated financial cost of treatment for a stab victim is £4375 (£2574 to £8490; circa 2020) [4].

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4. UK LAWS ON CARRIAGE AND POSSESSION OF KNIVES

In the UK, with the exception of non-locking folding pocket knives no longer than 3 inches, it is illegal to carry most knives in public without a good reason [5].

Acceptable reasons include carrying knives for work (such as a chef or deer manager) or for religious reasons (for instance a Sikh carrying a kirpan). However, some knives in the UK law are deemed prohibited to possess, sell or hire out, lend or give, or bring into to the UK. Examples of such knives include a:

- belt buckle knife
- butterfly knife or balisong
- cyclone or spiral knife
- disguised knife
- flick knife / gravity knife
- push dagger
- stealth knife
- zombie knife [5].

4.1 Metropolitan Police Service Bladed Weapon Data

In the Metropolitan Police Service (MPS), Physical Protection Group (PPG) conduct physical counts of confiscated bladed weapons within Criminal Exhibits. This work is to determine the types of bladed weapons seized within the Metropolitan Police District, ie nominally Greater London. Over the last 15 years, the majority of knives impounded are domestic, ie kitchen knives as illustrated in figure 3 [6].

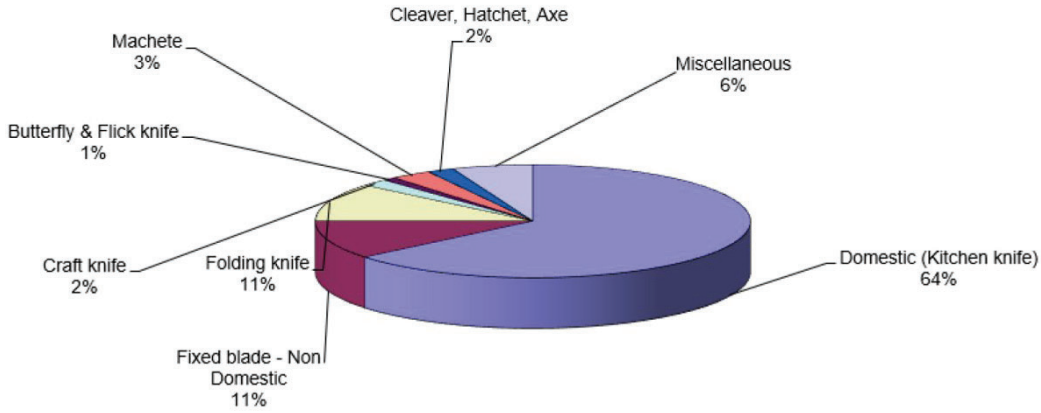

Figure 3. Pie chart illustrating MPS bladed weapon analysis 2022 reproduced from reference [6]

In the latest blade weapon analysis, the length of each knife was also measured. A summary of the data showed that 56 percent of knives were less than 150mm (6”) in length [6] and, therefore, easy to conceal.

5. CONCEALED CARRIAGE AND GRIP OF KNIVES

5.1 Concealment of knives

A study by Mahoney et al [7] investigating the use of concealable and disguised knives, reports that a concealed knife, or knives, are typically carried at various points on a person’s body including in:

- a belt
- a boot
- a trouser leg
- around the neck
- up a sleeve
- across the back [7].

However, it is the clothing worn over the concealed knife that determines the ease of accessing and drawing the knife. Loosely worn garments, ie a shirt or t-shirt, which are not tucked into a waistband are far easier to “clear” than tight fitting garments, which may be hindered by the interaction with other garments. This enables the person carrying the knife to minimise the time taken to move layers of clothing, and prevent snagging, thus enabling the bladed weapon to be accessed and drawn most efficiently [7].

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5.2 Perspective from frontline policing

During conversations with a serving frontline police officer, the locations reported by Mahoney et al [7] were confirmed as accurate and applicable to frontline policing in London. Furthermore, most concealed knives are thought to be carried around the belt / waistband, or hip pockets of an assailant [8].

5.3 Effect of grip

Consideration of the concealment position is important, as this influences the type of grip used to draw and hold the knife, thereby influencing the angle of attack used by the assailant (see figures 4, 5, 6) [9]. Research into the motion of knife attacks by Miller et al [10] concluded that the maximum speed generated during stabbing is influenced by **the way the knife is held**.

Figure 4. Capped grip to stop hand slipping from the weapon handle to the blade. Image reproduced from reference [9]

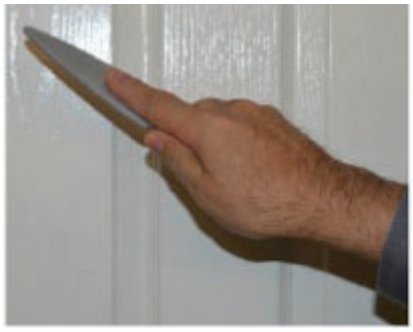

Figure 5. Finger point grip increases accuracy of bladed weapon attack. Image reproduced from reference [9]

Figure 6. Hand thrust, with full body weight behind, increases the force applied behind the bladed weapon. Image reproduced from reference [9]

6. MOTION OF BLADED WEAPON ATTACKS

6.1 Stabbing with a bladed weapon

6.1.1 University of Wales Institute

In 1996 Miller et al [10], at the University of Wales Institute, studied the kinematics (motion) of ten right-handed subjects (9 males, 1 female) using four methods of stabbing, namely:

- **Long Over** – where the subject's feet are immediately behind a line 1.25 m from the target, using an overarm motion in which, when gripped, the blade of the knife emanates from the ulnar aspect of the hand. Subjects aim for an upper target.
- **Long Under** – same setup as 'Long Over', but using an underarm movement, whereby the blade emanates from the radial aspect of the hand. Subjects aim for a lower target.
- **Short Over** – same setup as 'Long Over', ie using an overarm motion, but where the subject's feet are behind a line 0.50 m from the target.
- **Short Under** – same setup as 'Long Under', ie using an underarm motion, but where the subject's feet are behind a line 0.50 m from the target.

The upper and lower targets were mounted on a punch bag. Each subject was instructed to stab as hard and fast as possible, and were allowed to take one step forward (with the opposite foot to their knife holding hand) for the 'long over' and 'long under' methods of stabbing [10].

Data was captured using a video recorder and analysed using proprietary software. The bladed weapon tip speeds and standard deviation are summarized in table 1 below [10].

Unsurprisingly 'long over' and 'long under' motions produced greater entry speeds, than the corresponding 'short over' and 'short under', due to these stabbing methods enabling extra speed to be built up over the longer acceleration path of the knife.

From the results of this study Miller et al suggest that there are two independent kinematic (motion) strategies employed by subjects, one for overarm, and the other for underarm patterns [10].

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Table 1. Bladed weapon tip speeds, extract of data from reference [10]

	Long over		Long under		Short over		Short under	
	Entry speed (m/s)	Peak speed (m/s)	Entry speed (m/s)	Peak speed (m/s)	Entry speed (m/s)	Peak speed (m/s)	Entry speed (m/s)	Peak speed (m/s)
Bladed weapon tip	9.2	11.4	6.3	8.2	8.5	10.4	5.8	7.9
Std dev	2.03	1.04	0.89	0.74	1.72	1.89	1.34	1.57

Finally, Miller et al conclude that the maximum speed generated during stabbing is influenced by the way the knife is held [10].

6.1.2 Strathclyde University

In 1999 the Scottish Executive Central Research Unit published a comprehensive research programme (led by Strathclyde University), entitled "investigation of knife stab characteristics". In part I the "biomechanics of stab attacks" are examined [11].

Twenty subjects (17 males, 3 females) performed three types of stabs against a target comprising of a 10mm thick body armour (28 layers of Kevlar) mounted onto 30mm thick foam (density 33kg/m^2) on a box of plasticine. (Preliminary trials mounted the body armour directly onto the plasticine and the authors considered the plasticine did not sufficiently mimic the response of flesh, hence foam was added between the armour and the plasticine) [11].

The three stabs consisted of a:

- short thrust forward (abbreviated to **thrust** in tables 2 and 3)
- horizontal sweep around the body (abbreviated to **sweep** in tables 2 and 3)
- overhand stab (abbreviated to **overhand** in tables 2 and 3) [11].

Each subject repeated the three types of stabs, five times, using an instrumented knife.

Table 2. Energy of system before impact (joules (J)), extract of data from reference [11]

Target → Type of stab ↓	Body armour + FOAM + plasticine			Body armour + plasticine		
	Max (J)	Min (J)	Mean (J)	Max (J)	Min (J)	Mean (J)
Thrust	61	14	39	85	9	40
Sweep	90	17	45	103	15	73
Overhand	78	12	38	72	7	35

Table 3. Knife velocity prior to impact (m/s), extract of data from reference [11]

Target → Type of stab ↓	Body armour + FOAM + plasticine			Body armour + plasticine		
	Max (m/s)	Min (m/s)	Mean (m/s)	Max (m/s)	Min (m/s)	Mean (m/s)
Thrust	7.6	3.4	5.2	8.1	3.2	5.2
Sweep	8.8	4.2	6.5	9.2	3.8	6.6
Overhand	8.3	3.6	6.0	8.6	2.6	5.9

It is interesting to note that the mean velocities, particularly for the overhand stab, are lower than those reported by Miller et al [10] and the range of velocities increases with a larger sample size.

6.1.3 Horsfall

A PhD study undertaken by Horsfall [12] includes stabbing performance data for a large number of subjects, as summarised in table 4 below. Furthermore, peak forces of 800 newtons (N) are cited.

An instrumented knife, measuring force and velocity, was used to impact a 12 layer Aeroflex sheet (plain woven aramid encapsulated in a thromplastic binder) mounted onto Plastalina modelling clay. Photographs of the test set up show a vertical target for underarm stabs (nominally at chest height), whereas the overarm stabs are onto a horizontally positioned target (nominally at waist height).

It is considered by the authors that the horizontal orientation of the target has an influence on the human stabbing performance for overarm impacts and, when compared with the maximum energies

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and velocities recorded by Strathclyde University [11], the data recorded by Horsfall is considerably higher [12].

Table 4. Summary of human stabbing performance data**,** extract of data from reference [12]

Stab type	Number	Mean energy (J)	Maximum energy (J)	Mean velocity (m/s)	Maximum velocity (m/s)
Underarm	310	27.5	83.5	6.1	11.5
Overarm	200	37.1	114.9	9.0	12.3

Finally, Horsfall observes that there is a significant difference in performance between male and female subjects, as the mean energy (detailed in table 5) for underarm stabs is 29.1J and 10.6J respectively.

Table 5. Human stabbing performance data for underarm stabs from male and female subjects**,** extract of data from reference [12]

	Number	Mean energy (J)	Maximum energy (J)	Mean velocity (m/s)	Maximum velocity (m/s)
Male underarm	283	29.1	83.5	6.2	11.5
Female underarm	27	10.6	30.9	4.8	7.9

6.1.4 University of Greenwich

During a scoping study in May 2024, unpublished data using a male subject (trained in boxing) to undertake an underarm stabbing motion (a thrust) resulted in a mean velocity of 6.47m/s (SD 0.47m/s) for eighteen stabs [13]. This velocity is 0.27m/s higher than the mean velocity data reported by Horsfall [12] for males (6.2m/s). During this study a high consistency of stabbing velocity was observed. Furthermore, the time to draw and stab a target at 1.25m from the subject was determined to be 0.7 seconds.

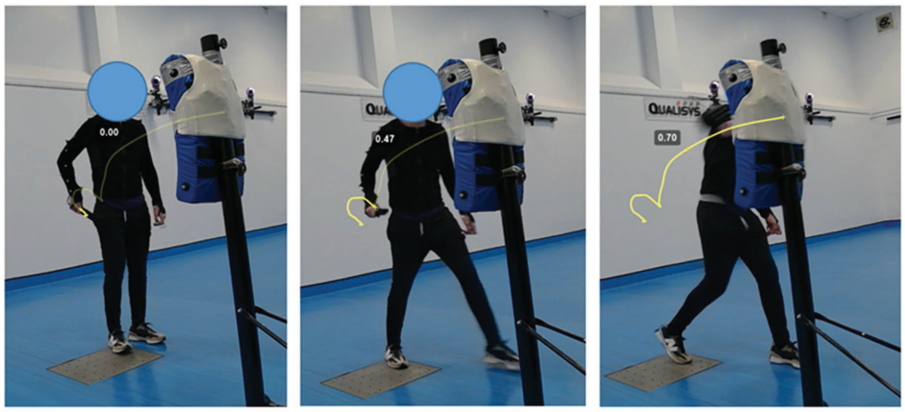

Figure 7. Timeframe images from drawing a knife to stabbing a target at a distance of 1.25m [13]

Distance from target	1.25m (approximately)
Time of event – draw to impact	0.7 seconds
Velocity of stab	6.4 m/s

6.2 Slashing with a bladed weapon

6.2.1 Cranfield University

In a research paper by Bleetman et al in 2003 87 (79 male; 8 female) untrained subjects attacked a white cartridge paper mounted on a Kevlar/elastomer, vertical target. This paper categorises slash events into two groups, namely i) **chop and drag** and ii) **sweep** motions in which the forces and velocities are detailed table 6 below [14].

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Table 6. Human stabbing performance data for slashes**,** extract of data from reference [14]

Type of slash	% of sample population	Mean peak force (N)	Maximum peak force (N)	Mean velocity (m/s)	Maximum velocity (m/s)
Chop and drag	26	124	212	6.44	13.30
Sweep	74	97	178	5.88	14.88

Bleetman et al noted [14] that the mean and maximum peak forces are 124N and 212N newtons, respectively, which is far lower than the 800N recorded in earlier trials by Horsfall into stabbing performance [12]. This can be attributed to the very different mechanisms in stabbings and slashes.

7. LOCATION & FREQUENCY OF INJURIES CAUSED BY BLADED WEAPON ATTACKS

7.1 Non-terrorist related blade weapon attacks

7.1.1 Bleetman

In 2000, Bleetman published his PhD in which the injuries of 431 patients [405 male; 26 female] with open wounds were analysed [15]. All patients in this study had been admitted to the Accident and Emergency department of Glasgow Royal Infirmary, between 1993 and 1996, with penetrating trauma. Each patient record was analysed to determine the location of all penetrating injuries, and these were defined and marked onto anatomical figures. The wounds were categorised in accordance with the following definition and in accordance with the abbreviated injury scale (AIS):

i) minor - not a threat to life or limb (average AIS score of 1);
ii) major - wounds that resulted in major blood loss, threat to life, tendon damage, bone involvement, major neurovascular injury or permanent major cosmetic deformity (average AIS score of 3);
iii) devastating - fatal or near-fatal (patients in the near-fatal category arrived at hospital in cardiac arrest or in a moribund state) (average AIS score of 5) [15].

Table 7. Distribution of wounds by region and severity**,** reproduced from reference [15]

Region	Minor wounds	Major wounds	Devastating wounds	Total wounds
head (face and scalp)	203	29	0	232
neck	45	10	12	67
shoulders	25	3	0	28
left chest	29	92	29	150
right chest	31	37	14	82
right abdomen	27	21	18	66
left abdomen	21	39	2	62
right groin	0	3	2	5
left groin	0	3	2	5
thighs	61	21	0	82
buttocks	47	4	0	51
right arm	80	21	1	102
left arm	87	18	0	105
TOTAL (approx %)	**656** (63%)	**301** (29%)	**80** (8%)	**1037**

Of particular note is the predominant distribution of injury to the patients' left side from attacks by right-handed assailants.

7.1.2 Barnes-Warden and Mahoney

This study (by the authors) reviewed a dataset of 75 postmortem reports of deaths due to bladed weapon assaults in 2019, within the Metropolitan Police District (Greater London). It included anatomically correct body maps to illustrate the location of the injuries and identified the principal location of fatal injury, from a bladed weapon assault, to be the torso. Furthermore, it attributed the main causes of death from a knife attack to be due to catastrophic damage of an organ, great vessel, or both, within the torso [16].

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Statistics are presented with regards to the depth of the fatal stab wound and blade type. In Bleetman's [15] and the author's study [16] over double the number of wounds are located on the front of the victim's body, compared with their back.

7.2 Terrorist blade weapon attacks

7.2.1 Merin

Merin et al [17] compares injuries from terrorist and non-terrorist related knife attacks in Israel, and précised research by Mayo et al, to conclude that there are significantly more body regions injured in terrorist attacks compared to non-terrorist ones. Merin refers to research by Kluger et al (2004, cited in [17]) which determines that victims of terrorist knife attacks have a higher injury severity score compared with non-terrorist attacks. In addition, Merin also refers to Heldenberg et al (2014, cited in [17]) who observed that vascular injuries are more than 9 times more frequent in terror attack victims (almost 10%), than among non-terrorist trauma victims (1.1%), and that the injuries tend to be more complex [17]. Merin [17] states that "exceptional force is used in terror incidents" and that "traditional stab wounds (…) tend to have a lower lethality":

7.2.2 Rozenfeld

Rozenfeld et al [18] compare the injuries sustained from interpersonal stabbings (IPS) and terror related stabbings (TRS) in Israel. These attacks were predominantly on Jews during the Knife Intifada circa 2015-16 [18].

It concludes that TRS are more severe attacks, on a different demographic to IPS, with differing anatomical locations of the injuries (such as more injuries to head and neck during TRS). [18]
There are some interesting statements about stabbing technique and power as the TRS victims tended to exhibit wounds to chest, and much higher proportion of head and neck injuries, compared with IPR victims. Furthermore, terrorists predominantly attacked using the more powerful ''overhand'' grip, thrusting downwards with the knife. Whereas IPS attacks often use the less powerful ''underhand'' grip.

7.2.3 London Bridge attacks

On the 3rd June 2017, during the London Bridge attacks, a van was deliberately driven at pedestrians on London Bridge, which resulted in the death of three victims. The three terrorists inside the van then proceeded on foot to Borough Market with knives strapped to their wrists. In total, the terrorists murdered eight people and injured forty eight. It is reported that a witness to the attack, Gerard Vowls, told the BBC [19] "…they stabbed this girl maybe 10 times, 15 times" describing the ferocity of the bladed weapon attack.

Figure 8. image of a knife strapped to a terrorist's wrist in the London bridge attacks, reproduced from the BBC news online, reference 20

7.2.3 Fishmongers Hall attacks

At the Fishmongers Hall attacks, on the 29th November 2019, Usman Khan murdered two people and injured three others in a terrorist knife attack. Khan used multiple knives and tape (see figure 8) to secure the knives to his wrists. He also was wearing a fake suicide vest [20].

Figure 9. image of a knife strapped to the terrorist's wrist in the Fishmongers Hall attacks, reproduced from Sky news website, reference 20

Thus, in both of the above UK attacks, bladed weapons were strapped/taped to an assailant's hand, thereby making him more difficult to disarm, and influencing the angles of attack that can be used.

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8. DISTANCE FROM A BLADED WEAPON ATTACK

The "21-foot rule" (created by Lieutenant John TUELLER in the US in the 1980s) was declared a safe distance to deal with potentially dangerous suspects armed with knives. However, modern research by Sandel et al (2020) [21] addressed i) how fast can a suspect run 21 feet (approx. 7m)? ii) is an officer able to respond (draw and fire) before the suspect can move 21 feet? iii) is there anything that an officer can do to provide more reaction time?

On average individuals charging at an officer were able to cover a distance of **21 feet in 1.5 seconds**, and run times ranged from 1.24 seconds to 1.83 seconds [21]. US officers trained in firearms, under sterile (no stress) conditions, **on average took 1.8 seconds** to fire a single shot at a silhouette target, using a conventional firearm [21]. Furthermore, when evaluating the effect of tactical movement by an officer being charged at, the most effective tactical movement is to sidestep [21].

Finally, the conclusion from this study is that 21-feet is an ineffective distance for officers to draw and fire their weapon at a charging assailant [21].

9. CURRENT THREAT & FUTURE PROTECTION SCHEMES

Bladed weapon attacks remain a principal threat for MPS frontline officers and staff.

From the statistical data, academic research and the open-source reporting of incidents summarised within this paper, we have shown that bladed weapon attacks are typically fast-time events and, in non-terrorist related attacks, domestic (kitchen) knives are commonly used. Furthermore, in untrained subjects the speed of a bladed weapon attack is highly variable. Increasing the area of armour protection is likely to be beneficial for frontline staff safety, particularly if this does not impact on mobility. In 2024 a new concept of supplementary knife resistance (SKR) was introduced into MPS service, by enhancing body armour designs in "difficult to protect areas" [16]. Furthermore, SKR has been well received by the user.

Future proposals are to seek designs for neck protection, as this is a highly vulnerable area to bladed weapon attacks. Additional tactics and/or protection should be considered for terrorist related attacks.

10. CONCLUSIONS

Knife enabled offences are prevalent within England and Wales, with annual figures of 50,510 (year ending March 2024), with the main motives being "assault with injury and assault with intent to cause serious harm", followed by "robbery". These attacks are a threat to the public as well as frontline policing and have clinic consequences for the NHS.

UK law prohibits the carriage of knives over 3 inches without a good reason. MPS data from confiscated blade weapon analysis shows that over the last 15 years, the majority of knives impounded are domestic, ie kitchen, knives. Knives are easy to obtain and conceal, and are typically carried around the belt / waistband, or hip pockets of an assailant. The location of a concealed bladed weapon can determine the grip used to draw then hold the knife, which in turn can influence the velocity of attack.

Multiple studies into the motion of knife attacks have shown that knife attacks are typically fast time events, with a scoping study measuring 0.7 seconds as the time to draw and stab a target at 1.25m. There is much variation in the reported velocities of stabs and slashes by untrained subjects. However, overarm stabs are typically reported at higher velocities than underarm stabs. Slash attacks have also been observed to be highly variable in velocity.

In non-terrorist related bladed weapon injury data, the torso and neck are highly likely to receive devastating wounds. Furthermore, the main cause of death due bladed weapon injury is catastrophic damage of an organ, great vessel, or both.

In terrorist related bladed weapon attacks there are significantly more body regions that were injured compared to non-terrorist ones and, typically, greater force is used. The overhand grip and downward thrusts are cited in terrorist attacks. In the London Bridge and Fishmongers Hall attacks there was evidence of strapping of the knife to the terrorist's wrist making the blade harder to disarm and influencing the angle of attacks.

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Since the 1980s the "21-foot rule" has been deemed to be a safe distance from a suspect armed with knives. However, this distance is now considered to be too close for the majority of (armed) officers to react (with a conventional firearm).

In 2024 a new concept of supplementary knife resistance (SKR) was introduced into service, by enhancing body armour designs in "difficult to protect areas". Furthermore, SKR has been well received by the user. Future proposals are to seek designs for neck protection in frontline policing, as this is a highly vulnerable area to bladed weapon attacks. Additional tactics and/or protection should be considered for terrorist related attacks.

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