Safety device use in UK: Changes since 2013 sharps regulations

Terry Grimmond FASM, BAgrSc, GrDpAdEd&Tr
Director, Grimmond and Associates, Microbiology Consultants, Hamilton New Zealand

Corresponding author: Terry Grimmond
Address: Grimmond and Associates, 930 river Road Queenwood Hamilton, 3210 New Zealand
Email: terry@terrygrimmond.com

Summary

Background. The 2013 UK sharps safety regulation require healthcare facilities to use safety engineered devices (SED) to protect staff. A recent increase in UK reported occupational exposures could indicate increased reporting but may also indicate increased exposures from sub-optimal SED use.
Aim. Examine sharps container contents to ascertain SED use in a sample of UK hospitals in 2013 and 2016.
Methods. Reusable sharps containers (RSC) were selected from 7 UK hospitals in 2013 and 7 in 2016. At licensed processing facilities, the operator, wearing protective apparel, decanted RSC, separated hollow-bore needles (HBN) from other sharps, and enumerated HBN into: capped/uncapped non-SED; activated/non-activated/tampered SED; and blunt draw-up SED. Probability, rate ratios, and 95% confidence limits were calculated using WinPepi v2.78.
Results. In 2013 and 2016 respectively: 2545 HBN were categorized from 22 RSC vs 2959 HBN from 33 RSC; 70% of HBN were SED vs 93% (p<0.001; RR1.33; CL1.30-1.37); of activatable SED, 32% were not activated vs 22% (<0.001; 0.67; 0.60-0.76); 41% of HBN were discarded "sharp" vs 20% (<0.001; 0.48; 0.44-0.52); 25% of HBN were uncapped-needles vs 6% (<0.001; 0.22; 0.19-0.26); 5% of HBN were capped-needles vs 1% (P>0.05); and 1% of SED were tampered with in both years (p>0.05). Hospital practices varied widely.

Conclusions. SED use and activation has increased significantly since 2013. Of concern is that in 2016, 22% of SED were non-activated and 20% of sharps were discarded "sharp". Increased training in SED handling, assiduous adherence to safe sharps work practices and a higher level of individual safety-ownership are indicated.

Keywords: Safety engineered devices, activation, sharps injury, needlestick, regulations, occupational, healthcare.

Introduction

Safety engineered devices (SED) were first used in 1988 [1] and can significantly reduce sharps injuries and thus reduce Bloodborne Pathogen (BBP) exposure risk in staff [1,2,3]. However, healthcare facilities in UK have been slower to adopt SED [4] than some other developed countries who have had SED-specific laws for a decade or more [1]. As early as 2003, UK national guidelines stated, "Needle safety devices must be used where there are clear indications that they will provide safer systems of working for healthcare personnel" [5]. However, in 2009 a survey ascertained that only 23% of UK hospitals had instituted SED policies [4].

In May 2013 the UK's Health and Safety (Sharp Instruments in Healthcare) Regulations 2013 became law [6], and together with government health and safety guidelines [7,8] require that:

- non-SED be replaced with SED where it is reasonably practical, i.e. where sharps injury (SI) risk is present and SED are commercially available and clinically appropriate;
- non-SED be removed from the facility once SED are in place;
- safer SED be evaluated at suitable intervals;
- needles not be recapped or removed;
- education and training cover correct use and disposal of SED.

However, following the enactment of law, a request by UNISON to the NHS Business Service Authority found that, of sharps purchased nationally in 2013 and 2014, the proportion that were SED was 24% and 28% respectively [9]. In late 2013 (after UK law enactment), a survey of SED policies among UK's 159 NHS acute trusts and boards revealed that 59% instructed staff to use safety devices 'wherever possible'; 8% made this instruction but also stated that SED are not yet available in some categories; and 33% of trusts did not make this instruction in their safety policy [4]. The 2013 study also found that 29% of hospital trusts mandate the use of SED in specific procedures (most commonly cannulation and phlebotomy), but 71% did not. Disturbingly, 47% of the trusts could not make an accurate estimation of SED usage in their trusts [4]. Adams and Elliott's UK crossover study showed that if SI rates are not falling, then insufficient use or incorrect use of SED are likely the reason [2].

In addition to SED, a second vital component in HCW sharps-protection is adequate education and training in SED use [2,10,11]. There are no recent UK SED-training studies to draw upon but in 2008, 45% of nurses stated they had not received training from their employer on safe needle use [12]. If facility sharps-safety policies are non-compliant or absent, then neither SED nor adequate training are likely available to workers. In 2015/16, in a targeted inspection of 40 UK health trusts and boards in England, Wales and Scotland by Health and Safety Executive inspectors, 83% were deemed non-compliant with sharps regulations and improvement notices were issued to 45% [13]. The inspection noted a failure to remove non-SED once SED are in place, and the two main regulatory breaches were SED availability and SED training [13]. The inspection confirmed that UK facilities were not at a high level of HCW sharps protection in late 2015, 2 years after sharps regulation enactment. The above studies, and the increase in BBP exposures over the years 2000-2013 [14], may indicate that use and activation of SED in UK may be suboptimal.

The frequency and correctness of SED use may be ascertained by examining the contents of sharps containers using post-disposal audits (PDA). Post-disposal audits have existed for several decades – the first published was Mendelson et al's 6-hospital U.S. PDA in 1993-95 which found that, following conversion to SED and with appropriate education, 89% of sharp devices were SED [15]. Alvardo-ramy et al in 1993-95 used PDA to compare activation rates of three SED in U.S. and found they varied from 58% (vacuum phlebotomy SED) to 82% (butterfly SED) [11]. Post-disposal audits of semi-auto, push-button devices found their activation rates were frequently above 95% [16,17]. Sohn et al, using PDA after institution-wide adoption of multiple SED, found overall activation rates rose from 64% 6-months after implementation, to 88% at 1-year [10]. "Before and after" PDA can

also be used to determine the impact of SED legislation. In the year prior to SED legislation in Ontario, Stringer and Haines in 2007 found SED comprised 55% of devices and 86% were activated [17]. A year after mandatory SED use was legislated in British Columbia, Stringer et al, in a large 6-hospital PDA, examined 25 910 devices and found 93% were SED, with 84% activated (with large variations between hospitals, SED brands and device-categories) [16]. Post-disposal audits can also highlight the need for SED legislation. In Australia where there is no SED-specific legislation, a PDA of 10,000 HBN from 27 hospitals country-wide, revealed that only 30% of HBN were SED [18]. UK legislation and guidelines prohibit needle recapping and needle removal [6-8], as do other countries [1,19] and PDA can include valuable information on these prohibited actions [16,17]. Post-disposal audits, in revealing the percentage of devices that are not SED and the percentage of non-activated SED, can also give an indication as to the efficacy of education and training [2,7,11,16] and may also lead to discovery of user-dissatisfaction through non-involvement in the selection process [2,20]. Also, hospital policy surveys [4] and purchasing reports [9] do not give an adequate indication as to the true level of SED use and activation, whereas PDA can.

This PDA study was conducted to ascertain the frequency and correctness of SED use in a sample of UK hospitals in 2013 immediately after enactment of the law, and again in 2016.

Methods

In 2013, 4 months after SED law enactment, reusable sharps containers (RSC) were selected from 7 UK hospitals in the North, Midlands and South regions. The sampling was repeated with 7 different hospitals in the North and Midlands regions in September 2016.

Approval was obtained from licensed processing facilities (Sharpsmart UK, Spennymoor and Stoke factories) to examine the contents of RSC (Sharpsmart, Sharpsmart UK) arriving at their factories on the day of the audit. Audits were conducted over a 10-hour period on one day at each UK factory. An isolated area was chosen in the factories and patient-room RSC were selected from transporters arriving from seven hospitals. Depending on availability, up to 5 RSC of 15 fill-line litres capacity were selected from each hospital. As UK SC are source-labeled, each RSC was chosen from a different clinical unit. Patient-room RSC were selected as clinical units have the highest availability and use of SED [1]. If the RSC contents were identified as laboratory or operating-room sharps, the RSC was closed and another chosen. The author was not aware of what hospitals were due to be serviced on the day of audit and author selection-bias was minimized by having a plant-operator select RSC from different clinical units from whatever hospitals arrived. Larger hospitals are serviced several times a week and therefore large hospitals had a higher probability of being selected on any one day of the week.

Using an established protocol for post-disposal audits (PDA) [16,18], the operator wore a face shield, long-sleeve gown, thick apron, covered leather shoes and heavy-duty gloves. Each RSC was opened and the contents gently decanted onto a large plastic-covered bench. 50mm vertical barriers were placed on the table-edges to prevent sharps spill-off, and for additional operator protection. Only hollow-bore needle (HBN) devices were enumerated as these have the greatest risk of BBP transmission [1,21]. Using long tongs, the contents of each RSC were sorted and devices categorized as per Table I.

Upon completion of the audit, all sharps waste was returned to the factory system for destruction and disposal. WinPepi v2.78 was used to statistically compare device sub-categories between years [22]. Pearson's $\chi 2$ test was used for the analysis of proportions; *P* values were 2-sided; statistical significance set at $P \leq .05$; and risk ratios (RR) calculated at 95% confidence limits (CL95). As no patients, patient data, patient specimens, staff names, staff data or hospital names were included in the study, ethical approval was not required.

Results

The number of hospitals, litres of contents, RSC, and clinical units are shown in Table II. Data on device numbers and percentages within total HBN and non-SED and SED sub-categories are shown in Table III. In 2013 the mean number of HBN enumerated from each hospital was 364, range 137-872, and in 2016, was 423, range 206-833. The mean, median and range of SED (activatable and non-activatable) as a percentage of total HBN for 2013 was 70%, 64% and 25-94% respectively, and for 2016 was 93%, 97% and 80-99% respectively. Statistical comparisons (p, RR, CL95) of device categories (Table IV) show that the rise in SED use, rise in percent of SED activated correctly, and fall in number of naked needles from 2013 to 2016 was highly significant ($p < 0.001$).

The results in Table III are presented in detail with non-activatable blunt draw-up SED separated from activatable SED so that device categories can be recalculated to suit other categorisation methods. It was visually obvious that many devices had been used for procedures involving blood.

Table I. Categorisation of sharps container contents

Hollow Bore SED	Activatable	• Correctly and fully activated • Partially activated or non-activated • Tampered with (safety mechanism removed)
	Non-activatable	• blunt draw-up needles/cannulae
Hollow bore Non-SED	Uncapped	• needles alone • SED connected by tubing to a non-SED needle • Other e.g. butterflies, Syringe-needles
	Capped	• Needles alone • Other e.g. Syringe-needles
Other sharps	Solid	(common examples) • Suture needles (SED or non-SED) • Scalpels (SED or non-SED • Sharp instruments (e.g. scissors, forceps) • Sharp vials, opened ampoules, broken glass • Lancets (SED or non-SED)
	Hollow bore	(common examples) • Unused/unopened SED or non-SED • Vacuum barrels with internal needle only • IV tubing with plastic Spicule
Non-sharps	e.g. wrapping, gloves, non-sharp vials, tubing, plastic tubes, syringes, trays	

SED safety engineered devices; IV intravenous

Table II. Number of litres of sharps, sharps containers, clinical units and hospitals in 2013 and 2016 samplings

	Region	Number hospitals	Litres sharps	Number sharps containers	Number clinical units (wards)
2013	North	1	47	2	2
	Midlands	5	219	17	17
	South	1	43	3	3
	Total	**7**	**309**	**22**	**22**
2016	North	3	189	13	9
	Midlands	4	290	20	14
	Total	**7**	**479**	**33**	**23**

Table III. Number and proportion of devices by year, hospital and device sub-category

Year	Hospital	Sharp Category	Non-SED					SED					
								SED requiring Activation					
			Uncapped needles	Uncapped Syr-needles	Capped needles	Capped Syr-needles	Total Non-SED	Activated correctly	Partially or Not activated	Tampered with	Total SED Activatable	Draw-up SED	Total HBN
2013	1 (Nth)	No. HBN(%)	3(2)	42(25)	0(0)	1(1)	46(27)	78(46)	44(26)	0(0)	122(73)	0(0)	168(100)
		% of sub-category	7%	91%	0%	2%	100%	64%	36%	0%	100%		
	2 (Sth)	No. HBN(%)	19(3)	11(2)	6(1)	4(1)	40(6)	203(31)	96(15)	0(0)	299(46)	308(48)	647(100)
		% of sub-category	48%	28%	15%	10%	100%	68%	32%	0%	100%		
	3 (Mdl)	No. HBN(%)	18(5)	28(7)	34(9)	4(1)	84(22)	116(30)	40(10)	5(1)	161(41)	146(37)	391(100)
		% of sub-category	21%	33%	41%	5%	100%	72%	25%	3%	100%		
	4 (Mdl)	No. HBN(%)	30(3)	277(32)	15(2)	9(1)	331(38)	287(33)	141(16)	2(0)	430(49)	111(13)	872(100)
		% of sub-category	9%	84%	5%	3%	100%	67%	33%	1%	100%		
	5 (Mdl)	No. HBN(%)	16(11)	77(51)	17(11)	4(3)	114(75)	18(12)	19(13)	0(0)	37(25)	0(0)	151(100)
		% of sub-category	14%	68%	15%	4%	100%	49%	52%	0%	100%		
	6 (Mdl)	No. HBN(%)	17(10)	64(36)	18(10)	7(4)	106(59)	27(15)	46(30)	0(0)	73(41)	0(0)	179(100)
		% of sub-category	16%	60%	17%	7%	100%	37%	63%	0%	100%		
	7 (Mdl)	No. HBN(%)	15(11)	26(19)	7(5)	1(1)	49(36)	85(62)	1(1)	2(2)	88(64)	0(0)	137(100)
		% of sub-category	31%	53%	14%	2%	100%	96%	1%	2%	100%		
	Total	**No. HBN(%)**	**118(5)**	**525(21)**	**97(4)**	**30(1)**	**770(30)**	**814(32)**	**387(15)**	**9(0)**	**1210(48)**	**565(22)**	**2545(100)**
		% of sub-category	**15%**	**68%**	**13%**	**4%**	**100%**	**67%**	**32%**	**1%**	**100%**		
2016	1 (Nth)	No. HBN(%)	3(1)	3(1)	0(0)	0(0)	6(2)	254(79)	43(13)	2(1)	299(93)	18(6)	323(100)
		% of sub-category	50%	50%	0%	0%	100%	85%	14%	1%	100%		
	2 (Nth)	No. HBN(%)	3(0)	15(2)	0(0)	0(0)	18(2)	312(37)	33(4)	0(0)	345(41)	470(56)	833(100)
		% of sub-category	17%	83%	0%	0%	100%	90%	10%	0%	100%		
	3 (Nth)	No. HBN(%)	6(1)	60(12)	28(6)	5(1)	99(20)	239(49)	34(7)	0(0)	273(56)	117(24)	489(100)
		% of sub-category	6%	61%	28%	5%	100%	88%	12%	0%	100%		
	4 (Mdl	No. HBN(%)	0(0)	9(2)	0(0)	0(0)	9(2)	220(37)	188(31)	5(1)	413(69)	177(30)	599(100)
		% of sub-category	0%	100%	0%	0%	100%	53%	46%	1%	100%		
	5 (Mdl)	No. HBN(%)	5(2)	21(9)	2(1)	5(2)	33(13)	106(43)	7(3)	0(0)	113(46)	101(41)	247(100)
		% of sub-category	15%	64%	6%	15%	100%	94%	6%	0%	100%		
	6 (Mdl)	No. HBN(%)	0(0)	36(18)	1(1)	1(1)	38(18)	107(52)	37(18)	13(6)	157(76)	11(5)	206(100)
		% of category	0%	95%	3%	3%	100%	68%	24%	8%	100%		
	7 (Mdl)	No. HBN(%)	5(2)	0(0)	0(0)	0(0)	5(2)	175(67)	50(19)	1(0)	226(86)	31(12)	262(100)
		% of sub-category	100%	0%	0%	0%	100%	77%	22%	0%	100%		
	Total	**No. HBN(%)**	**22(1)**	**144(5)**	**31(1)**	**11(0)**	**208(7)**	**1413(48)**	**392(13)**	**21(1)**	**1826(62)**	**925(31)**	**2959(100)**
		% of sub-category	**11%**	**69%**	**15%**	**5%**	**100%**	**77%**	**22%**	**1%**	**100%**		

Table IV. Statistical comparison of 2013 and 2016 results

	2013	2016	RR	CL95	p
Activatable SED					
Total (%)	1210 (100)	1826 (100)			
Correctly activated (%)	814 (67)	1413 (77)	1.15	1.10 - 1.20	<0.001
Partially or non-activated (%)	387 (32)	392 (22)	0.67	0.60 - 0.76	<0.001
Tampered with (%)	9 (1)	21 (1)	1.55	0.71 - 3.36	NS
All HBN					
Total (%)	2545 (100)	2959 (100)			
Uncapped needles & syringe-needles (%)	643 (25)	166 (6)	0.22	0.19 - 0.26	<0.001
Capped needles and syringe-needles (%)	127 (5)	42 (1)	0.82	0.60 - 1.12	NS
SED incl draw-up needles (%)	1775 (70)	2751 (93)	1.33	1.30 - 1.37	<0.001
Sharps discarded "sharp" (%)	1039 (41)	579 (20)	0.48	0.44 - 0.52	<0.001

SED safety engineered devices; HBN hollow bore needles

DISCUSSION

The principle results of the study are that: immediately after enactment of the UK 2013 regulations, the safe handling of sharps in the 7 study hospitals was sub-optimal by international standards; by 2016 the improvement in SED use and activation was significant; however the percentage of: non-SED used, non-activated SED, HBN discarded "sharp", and tampered SED, indicate that staff are still at an unacceptable risk of sharps injury.

Limitations of the study included: the exclusion of solid sharps (e.g. sutures, scalpels); the findings may not be reflect the hospital's sharps practices as a whole or be representative of hospitals regionally or nationally; hospitals sampled in 2013 were different from those in 2016; the finding of capped needles does not confirm these needles were recapped after use as capped-needles may have been removed from syringes to allow fitting of other needles; it was not possible to determine if some uncapped needles had lost their caps in the discard/decanting process; with some capped needles, syringe-needles and non-activated SED, it was not possible to tell if they had been discarded unused; also, it was not possible to know whether the sharp-user's risk assessment dictated that SED were not required, not appropriate or not available in certain procedures. Also, this study did not examine SED practices in non-hospital settings. Strengths of the study were: the number and selection of sharps containers from different clinical units and different hospitals; the number and geography of hospitals sampled; the chronological proximity of the Sept 2013 study to the May 2013 sharps legislature enactment; the 3-year gap in the two samplings; and the separate enumeration of blunt draw-up safety needles, tampered SED; and capped and uncapped needles.

Adoption of SED and safe work practices is associated with significant SI reduction when: SED usage rates approach 90% of devices [2,10,16,17]; SED activation rates approach 90% or higher [10,16,17,23,24]; and needle recapping or manual removal of needles from syringes approaches zero [16,17]. Cost is a barrier to SED adoption [10] and enactment of sharps safety laws can help remove this barrier [17,25]. Cause and effect cannot be demonstrated, however the changes in SED uptake and activation immediately post-law indicate that the UK law effected the change. Several HBN clinical procedures (e.g. some biopsy needles, paediatric sharps, pre-filled syringes) do not yet have commercially-available SED thus it is not yet possible to achieve "100% SED usage". However, not even a 100% score on SED usage may be acceptable as not all safety devices are safe

[7,17,26]. In the 30 years of SED development there have been several "generations" with each new generation being safer, commonly via one-handed, semi-auto, or fully automated activation [20,23,26]. It is prudent to note the 2013 UK regulations require hospitals to review their risk procedures, "…at suitable intervals… (as) new 'safer sharps' may have become available…" [7]. The U.S. law requires this annually [1].

The 22% SED non-activation rate in 2016 is a concern as it may indicate further attention is required in: SED selection; replacement of risk-prone Non-SED; the type, thoroughness and frequency of training; hospital policies; clinical unit practices; and individual attitudes and practices [2,10,17]. In particular, the importance of education and competency-training is stressed repeatedly [2,7,8,10,12,16,20,27,28]. As the decision to not activate an SED is made by the individual, staff themselves need take ownership of their own safety [27,28]. Non-activated SED (and tampered SED) carry the same SI risk as non-SED [16]. For SI to decrease, SED must be activated correctly every time as a further 32% of SI can be prevented if all SED are activated after use [23]. It is poor use of resources to pay the extra cost of SED and the cost of staff training in their correct use, then use them as conventional devices. When this occurs, it may indicate staff dissatisfaction with the SED (perhaps through non-involvement in the selection process) [2,20] or inadequate SED education and training [10,17].

Early descriptions referred to SED as "active" or "passive" (depending on whether user activation is needed) [16] but with development of SED with minimal user intervention, the terms "manual" (e.g. slide mechanism), "semi-auto" (e.g. push-button), and "auto" (e.g. retractable syringes) have emerged [26]. There is much evidence that healthcare facilities should seek to adopt semi-auto and auto SED [16,23,29] given their activation rates are close to 100% [16,24]. That 1% of SED were tampered with in both study years is of concern. Tampered SED have been found in one previous PDA [20], sought but not found in another, [20] and mentioned in UK guidelines [28]. It is hoped it is a rare occurrence as it renders the SED a conventional device, wastes financial resources, likely places the user at risk, and indicates user-frustration and belief the SED is safer without the safety mechanism [20].

In reviewing UK SI literature since 2013, the author became aware of the scarcity of publications from UK hospitals on their overall SI rates, causes, and successful prevention strategies. Also, apart from BBP exposure incidence [14], there is no annual national SI database of SI incidence in UK. Such studies and databases are eminently possible as all hospitals are required to collect exposure data under the legislation [6]. These publications would be of value in assessing HCW exposure risk, SED efficacy and involvement, and SI-prevention strategies [27,29]. Notwithstanding their value, most SI databases are dependent on voluntary reporting, only show activation data on devices causing an SI, and do not give an indication of SED use and activation in near-misses or when no injury occurred [23]. As an adjunct to such databases, post-disposal audits offer unique insights into staff behaviour in sharps handling. Although not achieved by hospitals in this study, activation rates of 100% and SED usage rates of 98% are achievable [30] and setting these goals would assist UK institutions greatly in their strategies to reduce staff exposure risk, but they need be coupled with thorough and widespread staff education and training.

KEY FINDINGS

What is already known about this subject

- Without a national UK sharps injury (SI) incidence database, little is known as to the reasons behind the recent Eye of the Needle increase in reported exposures to bloodborne viruses.
- Safety engineered devices (SED) can markedly reduce SI and, following the UK 2013 sharps legislation, several UK

studies have examined SED policies, purchasing trends and staff perceptions, but studies on SED use and activation are absent.

- A study on the frequency and correctness of SED use, by examining the contents of sharps containers, was needed to assist in understanding: the reasons behind the exposure increase; the impact of the UK 2013 legislation; and the level of sharps-safety implemented by staff during sharp procedures.

What this study adds

- This study, of seven hospitals in three regions in 2013 and 2016, shows uptake and correct use of SED was low in 2013, and, although 2016 revealed significant improvement, the proportion and non-activation of SED, and proportion of needles discarded naked or capped, indicate an unacceptable risk of SI remains.
- The study's key message is that the following are needed: increased competency-based training in SED handling; assiduous adherence to safe sharps work practices; a higher level of individual safety-ownership; and SED products should be reviewed regularly with a view to finding and evaluating newer, safer SED.

What impact this may have on practice, policy or procedure

- Hospital sharps-safety policies and procedures must be present in all hospitals and accurately mirror the 2013 Sharps law requirements, including regular examination of SED safety-efficacy.
- Regular, competency-based sharps-safety training and education be required of all staff.
- A national, publicly-available SI incidence database be established.

Acknowledgements

The author wishes to thank Sharpsmart UK for their financial grant and use of their factories, and the staff of Waikato DHB Medical Library New Zealand for their untiring help in the literature review for this study.

Conflict of Interest statement

None declared

Funding:

This study was supported by a grant of £3 500 from Sharpsmart UK, Spennymoor UK [UK SED17]. No other funding was received.

References

[1] Jagger J, Perry J, Gomaa A and Phillips EK. The impact of U.S. policies to protect healthcare workers from bloodborne pathogens: The critical role of safety engineered devices. J Infect Public Health 2008; 1:62-72. doi:10.1016/j.jiph.2008.10.002.

[2] Adams D and Elliott TSJ. Impact of safety needle devices on occupationally acquired needlestick injuries: a four-year prospective study. J Hosp Infect 2006;64:50-55.

[3] Tuma S, Sepkowitz K. Efficacy of Safety-Engineered Device Implementation in the Prevention of Percutaneous Injuries: A Review of Published Studies. Clin Infect Dis 2006;42(8):1159-1170.

[4] Safer Sharps? A barometer of take-up in the UK. A MindMetre research note on the implementation of EU Directive 2010/32/EU in UK Acute Hospitals. 2014. http://www.mindmetreresearch.com/wp-content/uploads/2014/02/Safer-sharps_A-barometer-of-take-up-in-the-UK_report.pdf [last accessed Sept 30, 2019].

[5] Pellowe CM, Pratt RJ, Harper R, et al. National Institute for Clinical Excellence. Infection control: prevention of healthcare associated infection in primary and community care. NICE Clinical guideline 2. J Hosp Infect 2003;55:S2-S127. DOI:10.1016/S0195-6701(03)00292-5.

[6] The Health and Safety (Sharp Instruments in Healthcare) Regulations 2013. Statutory Instruments, 2013 No 645, Health and Safety. http://www.legislation.gov.uk/uksi/2013/645/made [last accessed Sept 30, 2019].

[7] Health and Safety (Sharp Instruments in Healthcare) Regulations 2013. Guidance for employers and employees. HSE Information Sheet HSIS7, Mar 2013. Health and Safety Executive UK.

http://www.hse.gov.uk/pubns/hsis7.pdf [last accessed Sept 30, 2019].

[8] Healthcare-associated infections: prevention and control of healthcare-associated infections in primary and community care. Clinical Guideline (CG139) published Mar 2012, updated Feb 2017. 2018. National Institute for Health and Clinical Excellence. https://www.nice.org.uk/guidance/cg139/resources/healthcareassociated-infections-prevention-and-control-in-primary-and-community-care-pdf-35109518767045 [last accessed July 2019].

[9] Health staff still at risk of needle injuries. Unison News, Oct 9, 2014. https://www.unison.org.uk/news/article/2014/10/health-staff-still-at-risk-of-needle-injuries/ [last accessed Sept 30, 2019].

[10] Sohn S, Eagan J, Sepkowitz K, Zuccotti G. Effect of implementing safety-engineered devices on percutaneous injury epidemiology. Inf Contr Hosp Epid 2004;25:536-542.

[11] Alvarado-Ramy F, Beltrami E, Short L, Srivastava P, Henry K, Mendelson M, et al. A comprehensive approach to percutaneous injury prevention during phlebotomy: results of a comprehensive study, 1993–1995. *Infect Control Hosp Epidemiol* 2003;24:97-104.

[12] Needlestick Injuries. The point of prevention. RCN 003-313, 2009. Royal College of Nursing, London. https://www.primarycaretraining.co.uk/wp-content/uploads/2013/07/47.pdf [last accessed Sept 30, 2019].

[13] Prevention and management of sharps injuries: Inspection of NHS Organisations. Report of an inspection initiative 2015/16. 2016. Health and Safety Executive, United Kingdom. http://www.hse.gov.uk/healthservices/needlesticks/prevention-management-sharps-injuries.pdf [last accessed Sept 30, 2019].

[14] Woode Owusu M, Wellington E, Rice B, Gill ON, Ncube F & contributors. Eye of the Needle United Kingdom Surveillance of Significant Occupational Exposures to Bloodborne Viruses in Healthcare Workers: data to end 2013. December 2014. Public Health England, London. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/385300/EoN_2014_-_FINAL_CT_3_sig_occ.pdf [last accessed Sept 30, 2019].

[15] Mendelson M, Solomon R, Shekletski E, Henry K, Campbell S, Collins A, et al. Evaluation of Safety Devices for Preventing Percutaneous Injuries Among Health-Care Workers During Phlebotomy Procedures -- Minneapolis-St. Paul, New York City, and San Francisco, 1993-1995. Morbidity and mortality Weekly Reports 1997;46(02):21-25. https://www.cdc.gov/mmwr/preview/mmwrhtml/00045648.htm [last accessed Sept 30, 2019].

[16] Stringer B, Astrakianakis G, Haines T, Kamsteeg K, Danyluk Q, Tang T, et al. Conventional and sharp safety devices in 6 hospitals in British Columbia, Canada. Am J Infect Control 2011;39:738-45. doi:10.1016/j.ajic.2010.12.004.

[17] Stringer B, Haines T. Ongoing Use of Conventional Devices and Safety Device Activation Rates in Hospitals in Ontario, Canada. J Occup Environ Hyg 2011; 8:154–160. doi:10.1080/15459624.2011.555258.

[18] Grimmond T. Frequency of use and activation of safety-engineered sharps devices: a sharps container audit in five Australian capital cities. Healthcare infection 2014;19(3):95-100. http://dx.doi.org/10.1071/HI14009.

[19] Occupational Health and Safety Regulation Guidelines, Part 6, substance-specific requirements: biological agents. Workers Compensation Act, British Columbia. WorkSafeBC. https://www.worksafebc.com/en/law-policy/occupational-health-safety/searchable-ohs-regulation/ohs-guidelines/guidelines-part-06#SectionNumber:G6.34-1 [last accessed Sept 30, 2019].

[20] Stringer B, Astrakianakis G, Haines, T. Increasing sharp safety device use in healthcare: A semi-structured interview study. Contemp Nurse 2013;44(2):144-155

[21] Cardo DM, Culver DH, Ciesielski CA, et al. A case-control study of HIV seroconversion in health care workers after percutaneous exposure. N Engl J Med 1997; 337: 1485-1490.

[22] Abramson JH. WinPepi v11.65, 2016. Computer Programs for Epidemiologic Analysis. http://www.brixtonhealth.com/pepi4windows.html [last accessed Sept 30, 2019].

[23] Black L, Parker G, and Jagger J. Chinks in the Armor: Activation Patterns of Hollow-Bore Safety-Engineered Sharp Devices. *Infect Control Hosp Epidemiol* 2012;33(8):842-844. DOI: 10.1086/666630.

[24] Whitby M, McLaws M-L, Slater K. Needlestick injuries in a major teaching hospital: The worthwhile effect of hospital-wide replacement of conventional hollow-bore needles. Am J Infect Control 2008;36:180-6. doi:10.1016/j.ajic.2007.07.009.

[25] Phillips E, Conaway M, Parker G, Perry J, Jagger J. Issues in Understanding the Impact of the Needlestick Safety and Prevention Act on Hospital Sharps Injuries. Infect Control Hosp Epidemiol 2013;34(9):935-939.

[26] Tosini W, Ciotti C, Goyer F, Lolom I, L'Heriteau F, Abiteboul D, et al. Needlestick Injury Rates According

to Different Types of Safety-Engineered Devices: Results of a French Multicenter Study. *Infect Cont Hosp Ep*. 2010;31(4):402-407.

[27] Good L & Grimmond T. Proven Strategies to Prevent Bloodborne Pathogen Exposure in EXPO-S.T.O.P. Hospitals. J Assoc Occ Hlth Prof 2017:36(1);1-5. https://aohp.org/aohp/Portals/0/MembersOnlyDocuments/Education/WEB027-1.pdf [last accessed Sept 30, 2019].

[28] Managing the risks of sharps injuries. NHS Employers. The NHS Staff Council. Dec 2015. https://www.nhsemployers.org/-/media/Employers/Documents/Retain-and-improve/Health-and-wellbeing/Managing-the-risks-of-sharps-injuries-v7.pdf [last accessed Sept 30, 2019].

[29] Good L, Grimmond T. Burnson J, et al. Exposure Injury Reduction Strategies: Results that Protect Lives. J Assoc Occ Hlth Prof. Fall,2018;38(4):10-13. https://aohp.org/aohp/Portals/0/Documents/MemberServices/journal/18%20Fall%20Journal%20-web.pdf [last accessed Sept 30, 2019].

[30] Grimmond T. Safety Engineered Device Usage and Activation in Six Western U.S. Hospitals. J Assoc Occ Hlth Prof. Fall, 2018;38(4);14-18. https://aohp.org/aohp/Portals/0/Documents/MemberServices/journal/18%20Fall%20Journal%20-web.pdf [last accessed Sept 30, 2019].