

# Clinical, economic, and humanistic burden of needlestick injuries in healthcare workers

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**Introduction:** Needlestick injuries (NSIs) from a contaminated needle put healthcare workers (HCWs) at risk of becoming infected with a blood-borne virus and suffering serious short- and long-term medical consequences. Hypodermic injections using disposable syringes and needles are the most frequent cause of NSIs.

**Objective:** To perform a systematic literature review on NSI and active safety-engineered devices for hypodermic injection.

**Methods:** MEDLINE, EMBASE, and COCHRANE databases were searched for studies that evaluated the clinical, economic, or humanistic outcomes of NSI or active safety-engineered devices.

**Results:** NSIs have been reported by 14.9%–69.4% of HCWs with the wide range due to differences in countries, settings, and methodologies used to determine rates. Exposure to contaminated sharps is responsible for 37%–39% of the worldwide cases of hepatitis B and C infections in HCWs. HCWs may experience serious emotional effects and mental health disorders after a NSI, resulting in work loss and post-traumatic stress disorder. In 2015 International US\$ (IntUS\$), the average cost of a NSI was IntUS\$747 (range IntUS\$199–1,691). Hypodermic injections, the most frequent cause of NSI, are responsible for 32%–36% of NSIs. The use of safety devices that cover the needle-tip after hypodermic injection lowers the risk of NSI per HCW by 43.4%–100% compared to conventional devices. The economic value of converting to safety injective devices shows net savings, favorable budget impact, and overall cost-effectiveness.

**Conclusion:** The clinical, economic, and humanistic burden is substantial for HCWs who experience a NSI. Safety-engineered devices for hypodermic injection demonstrate value by reducing NSI risk, and the associated direct and indirect costs, psychological stress on HCWs, and occupational blood-borne viral infection risk.

**Keywords:** injections, occupational injuries, blood-borne pathogens, healthcare personnel safety, safety-engineered devices

## Introduction

Needlestick injury (NSI) is an accidental percutaneous piercing wound caused by a contaminated sharps instrument, usually a hollow-bore needle from a syringe, and is one of the most frequent routes of transmission in occupationally acquired blood-borne infections.<sup>1</sup> More than 20 blood-borne infections may be transmitted by NSI. In the most severe cases, the transmission of human immunodeficiency virus (HIV), hepatitis B virus (HBV), and hepatitis C virus (HCV) may severely impair quality of life and reduce life expectancy, while incurring substantial costs, especially in the long term.<sup>2–6</sup>

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The World Health Organization (WHO) recommends the use of safety injection devices and instructs governments to transition to their exclusive use by 2020.<sup>7</sup> The USA, Canada, Brazil, Taiwan, United Kingdom (UK) and European Union (EU) countries have enacted legislation requiring the use of safety injection devices. Despite an increased awareness and legislation in some countries, NSIs and their serious consequences still occur. Since NSIs occur most often during hypodermic injections, this review sought to understand the burden of NSI by conducting a systematic literature review on NSI and active safety-engineered devices for hypodermic injection.

## Methods

Literature searches were conducted in PubMed and EMBASE to identify outcomes – evidence of the burden of NSI and impact of safety needles with active mechanisms for hypodermic injection, as there are no currently marketed passive mechanism devices for hypodermic injection (Table S1). Search terms and combinations that were used in PubMed included needlestick injury, accidental needlestick, safety needles, safety-engineered needles, engineered sharps, needleless systems, needles, safety device, viral infections, quality of life, patient satisfaction, worry, distress, resource utilization, resource use, cost, budget impact, indirect cost, work loss, work policy, productivity, policy, public policy, and other related terms. Additional limits applied to each search included: humans, English language only, and publication date within past 10 years.

These searches identified 982 unique references. Inclusion criteria were studies that reported policy or clinical, economic, or humanistic outcomes of NSI or safety injection devices on healthcare workers (HCWs) in healthcare settings. Studies were defined as health economic or budget impact studies, real-world observational studies, comparative effectiveness studies, clinical trials, and case reports with an adequate sample size ( $n=20$ ). Articles were excluded if the full text was not available, or if the article did not include hypodermic injections. Additional searches were conducted using Google and Google Scholar. In total, 155 references were selected after title/abstract screening, with 69 selected after full text review, and discussed in this review article.

## Results

### Legislation

As of 2017, several countries have enacted legislation regarding NSI and safety-engineered devices including the USA, Canada<sup>8</sup>, UK, EU countries,<sup>9</sup> Brazil,<sup>10</sup> and Taiwan.<sup>11</sup>

The legislation has increased the use of safety-engineered devices, even in countries where these devices were available

prior to the legislation. In the USA, voluntary adoption of safety devices without mandated legislation was ineffective in producing a large-scale reduction in NSI rates.<sup>12</sup> A significant 38% drop in hospital NSI rates occurred only after the Needlestick Safety Prevention Act (NSPA) was enacted and safety devices became the predominant technology in healthcare settings.<sup>12,13</sup> Compliance with mandatory safety-engineered device legislation has been high in US hospital settings. However, HCWs in non-hospital settings (i.e., clinics, private offices, long-term care facilities, and free-standing laboratories) account for ~60% of the healthcare workforce, but have 25%–35% lower adoption rates of safety-engineered devices than hospitals.<sup>13</sup> In the UK, since the passage of the EU Council Directive 2010/32/EU and the Health and Safety (Sharps Instruments in Healthcare) Regulations of 2013, the majority of National Health Service (NHS) trusts instruct their staff to use safety devices whenever possible. However, one-third of the NHS trusts have failed to implement safe sharps practices.<sup>14</sup>

Often, legislation without enforcement has less significant impact on the implementation of safety devices in healthcare settings. In Brazil, adoption of safety devices has been slower as there are gaps in the monitoring of the adoption of safe practices, mainly related to preventing and controlling occupational accidents.<sup>10</sup>

### Clinical burden of NSIs

Rates of NSI in the hospital differ by country, use of safety devices, and methodologies (including potential under-reporting) used. Studies report a wide range from 14.9% to 69.4% of HCWs who have experienced a NSI, and 3.2–24.7 NSIs per 100 occupied hospital beds (Table 1).<sup>15–18</sup>

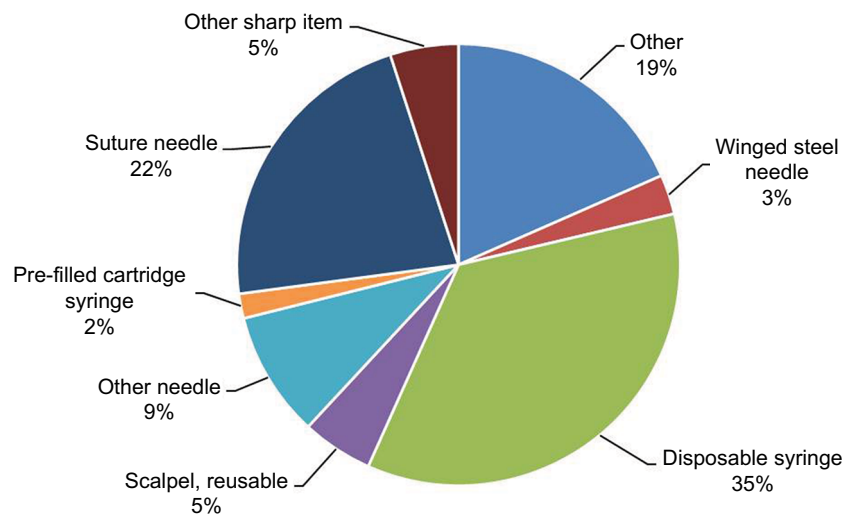
Hypodermic (i.e., intramuscular, subcutaneous, or intradermal) injections using disposable syringes and needles are the most frequent cause of NSIs worldwide.<sup>18–20</sup> In US hospitals, 35.4% of all percutaneous injuries are due to disposable syringes (Figure 1), with similar rates reported in other parts of the world – 32% in 13 European countries and Russia and 34.6% in Saudi Arabia.<sup>18–20</sup>

Literature that relies solely on officially reported NSIs may underestimate NSI rates. The Centers for Disease Control (CDC) estimates that about half of sharps injuries in the US go unreported.<sup>21</sup> In Sweden, 26.9% of HCWs with a NSI in the preceding year did not report any or all of their NSI events, even though 80.1% of respondents knew to contact occupational health services.<sup>22</sup> There are multiple reasons that HCWs do not report NSIs: presumption that the risk of disease transmission is low, lack of knowledge of systems

**Table 1** Representative NSI rates by country

Country	Rate of NSI	Site	Time frame
Australia <sup>57</sup>	2.86 percutaneous exposures per 100 FTE staff	20 Queensland public hospitals	2004–2011
Brazil <sup>58</sup>	386 exposures to biological material recorded among 1,736 nursing staff	Teaching hospital in São Paulo	2003–2009
China <sup>59</sup>	64.9% of nurses experienced NSI within past year	Teaching hospital in Nanjing, Jiangsu Province	April 2012
Egypt <sup>16</sup>	69.4% of HCWs reported at least one NSI in their lifetime and 35.6% reported an injury during the previous 3 months; mean number of injuries during past 3 months was 1.23, equating to the rate of 4.9 NSI per HCW annually	Ninety-eight healthcare facilities in one governorate in the Nile Delta and one governorate in Upper Egypt	Three months prior to date of interview (interview date unknown)
France <sup>60</sup>	6.3 blood and body fluid exposures per 100 beds with most frequent being NSIs	National surveillance of French hospitals	2012
Italy <sup>61</sup>	53% of nurses and nursing students reported having had at least one injury during their career	University hospital of Ferrara	2002–2012
Netherlands <sup>62</sup>	0.5 NSI/day 1,053 total/8 years	Academic Medical Centre in Amsterdam (unknown number of beds or HCWs)	2003–2010
Saudi Arabia <sup>17</sup>	3.2 NSIs per 100 occupied hospital beds	Fifty-two Ministry of Health Hospitals via EPINet	January 2012–December 2012
South Africa <sup>15</sup>	14.9% of HCWs reported having a NSI or blood and body fluid exposure in past 6 months	Small Rural Hospital in Thabo-Mofutsanyana	Survey date unknown, but estimated between 2010 and 2014
South Korea <sup>63</sup>	2.62 cases per 100 HCW-years	Teaching hospital; 94% of cases were NSI	January 1992–December 2001
Taiwan <sup>64</sup>	8,058 percutaneous injuries per 129,548 hospital beds annually (~6 per 100 beds) 8,100 percutaneous injuries per 180,000 HCW FTE annually	National estimates (420 accredited hospitals enrolled in a surveillance program to track blood exposure incidents)	Annually
UK <sup>65</sup>	48% of nurses had NSI in career with 10% sustaining an injury in past year	Randomly selected nurse members of Royal College of Nursing	September 2008
USA <sup>18</sup>	24.7 injuries per 100 average daily census	Geographically diverse hospitals across the USA	January 2014–December 2014

**Abbreviations:** EPINet, exposure prevention information network; FTE, full-time equivalent; HCWs, healthcare workers; NSIs, needlestick injuries.

**Figure 1** Frequency of NSIs by device, n=557.

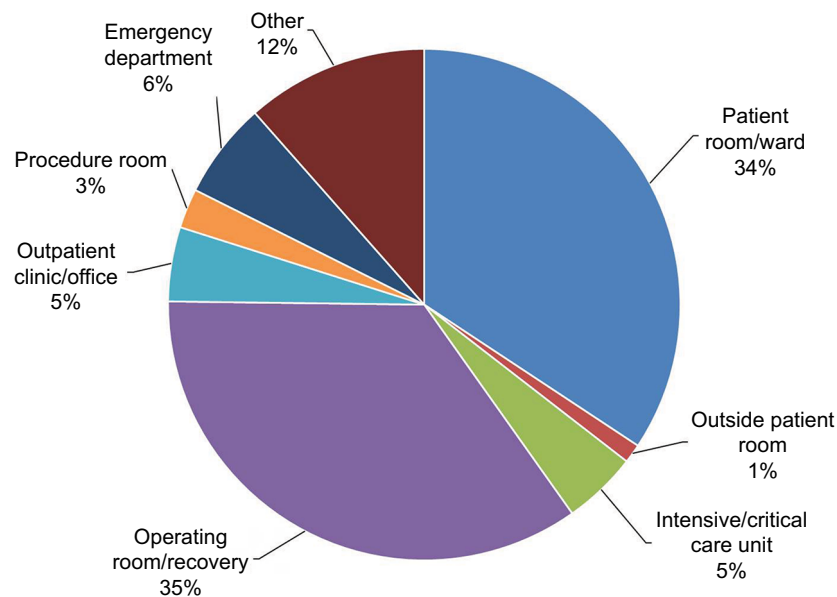
**Notes:** Data from EPINet.<sup>18</sup>

**Abbreviations:** EPINet, exposure prevention information network; NSIs, needlestick injuries.

for reporting, lack of knowledge of the importance of reporting NSIs, complicated and unclear reporting protocols, and HCW belief that an injury may reflect poorly on their practice standards.<sup>2,23</sup>

## NSI risk factors

NSIs appear to be repetitive, with 73% of HCWs who sustained a NSI noting a previous NSI.<sup>24</sup> Risk factors associated with NSIs have been categorized into two groups: modifiable



**Figure 2** Work locations where reported sharps injuries occurred, n=592.

**Notes:** Data from EPINet.<sup>19</sup> The sum is >100% due to rounding.

**Abbreviation:** EPINet, exposure prevention information network.

and non-modifiable.<sup>24,25</sup> Non-modifiable risk factors for NSI are conditions that cannot be deliberately altered. HCWs with the highest rates of NSIs are women, nurses, and those aged 21–30 years.<sup>24,25</sup> The prevalence of these demographic characteristics is associated with higher rates of needle use as the majority of HCWs who handle syringes are female nurses.<sup>24</sup> Modifiable risk factors include hospital care setting, poor working environments such as long work hours, understaffing, and inadequate needle disposal procedures (e.g., 37% of HCWs recapped the needle) and devices (e.g., lack of sharps containers).<sup>24,26</sup> Mental and physical stress associated with excessive working hours are also believed to contribute to a higher NSI rate.<sup>24</sup>

The most common hospital care settings for NSIs are the general medical wards, the operating room, the emergency department (ED), and the intensive and critical care units. In the US, 35% of sharps injuries occurred in the operating room, and 34.3% in patient rooms/wards (Figure 2).<sup>18</sup> In Saudi Arabia, the highest rates of NSI occurred in the patient's room (31.4%), followed by the ED (17.2%), then the intensive and critical care units (14.7%).<sup>19</sup>

HCWs in urban EDs face higher risk for sharps injuries compared to community EDs with rates of 20.3 versus 5.9 per 100,000 patient visits, respectively ( $p < 0.001$ ).<sup>27</sup> The environment in EDs is fast-paced and often unpredictable, in addition to often unknown source status, thus increasing the risk of NSIs and their consequences.

In the intensive care units (ICUs), there is additional concern as patients may be incapacitated and unable to consent

to testing should a NSI occur. This concern is highlighted in a study which found that 62.6% of ICUs in England, Wales, and Northern Ireland had reported one or more NSIs to an HCW from an incapacitated patient.<sup>69</sup> Of the 62 cases of NSIs, at least 25.8% of NSIs were from patients with blood-borne viruses, with 37.5% unaware of their positive status prior to ICU admission.

### Infection risk from NSI

The risk of becoming infected with a blood-borne virus after NSI is highest for hepatitis B, followed by hepatitis C, and then HIV. For every 1,000 NSIs from an infected patient, 300 HCWs will become infected with HBV. For HCV and HIV, seroconversion rates are 30 per 1,000 and three per 1,000, respectively. Since the prevalence of blood-borne pathogens such as HBV, HCV and HIV is higher in hospitalized patients, there is greater risk after NSI in this setting.<sup>29</sup> Despite being unseen by the naked eye, blood remains on the needle after a hypodermic injection.<sup>30</sup> Exposure to even minute quantities of blood from a NSI can result in serious disease, with transmission linked to hypodermic injection noted in developing nations.<sup>31</sup>

### Safety devices reduce NSI rates

About 41% of NSIs from hollow-bore needles occur after the injection has been given: 19% occurring after use, but before disposal, and 22% occurring during, or after, disposal.<sup>32</sup> With disposable syringe/needle use, the process of recapping alone is responsible for 11.1% of injuries.<sup>33</sup> A systematic literature

review on safety devices examined 17 articles, six of which included safety syringe/needle devices for hypodermic injection.<sup>34</sup> Compared to conventional devices, safety syringes/needles for hypodermic injection reduced the risk of NSIs by 43.4%–100%. A more recently published systematic review and meta-analysis found nine studies on safety syringe/needle devices for subcutaneous, intramuscular, and intradermal injections.<sup>35</sup> These hypodermic safety injection devices had a pooled relative risk of NSI of HCW of 0.54 (95% CI 0.41–0.71).

Active safety devices for hypodermic injection include a safety sliding shield needle, a safety toppling shield needle, and a safety pivoting shield needle. An active device (Septodont Safety Plus) reduced avoidable NSIs in a dental school practice from an average of 11.8 to 0 injuries per 1,000,000 hours worked per year as compared with a control unit who reduced their frequency from 26 to 20 injuries per 1,000,000 hours worked.<sup>36</sup> Studies in hospitals that reported the device name describe a one-handed, active manual activation device (BD SafetyGlide), activated by pushing a lever arm forward with a single finger stroke to cover needle tip, and a one-handed, active manual activation device (BD Eclipse) activated by pushing a hinged safety shield over the needle tip with a finger or thumb (Table 2). These studies found a significant reduction in NSIs of 64%–100%.<sup>37–39</sup> In one of the studies, HCWs at a University Hospital in the UK completed questionnaires and noted that the BD SafetyGlide was “safe, usable and compatible with most clinical situations”, and felt that this safety needle device “should be used for any procedure where a risk of exposure to blood and body fluids existed”.<sup>37</sup>

Another study compared NSI rates from different device types, without specifying device names.<sup>70</sup> Data from a French

multicenter study reported the number (95% CI) of NSIs per 100,000 hypodermic injection devices purchased was 5.20 (4.61–5.78) and 2.94 (2.35–3.53) for manually activated protective sliding shield and manually activated protective toppling shield, respectively.<sup>70</sup>

## Economic burden

After a NSI occurs, there is substantial cost, which includes, 1) testing for infection in the injured worker and, if known, the patient on whom the needle/sharp had been used, 2) post-exposure prophylaxis to prevent or manage potential blood-borne virus transmission, 3) short- and long-term treatment of chronic blood-borne viral infections that are transmitted to injured workers, 4) staff absence and replacement, 5) counseling for injured workers, and 6) legal consequences (litigation and compensation claims).<sup>23</sup>

Table 3 summarizes the published economic studies reporting cost of a NSI, national burden, or economic impact of safety needle programs. These studies addressed a mix of direct and indirect costs, national burden, and economic impact of safety needles. Cost of a NSI varies widely and depends on what types of costs are included, as well as the risk/source of the needlestick. For example, the US CDC cites estimates of the direct costs associated with the initial follow-up and treatment of HCWs who sustain a NSI ranging from US\$71 to US\$5,000, depending on the treatment.<sup>40</sup> Some studies report that only some NSIs actually generated costs (e.g., 72.1% of NSIs in Korea), because of underreporting or cases with low-risk known sources.

In studies reporting both direct and indirect costs, the cost breakdown of NSI ranged from 44% to 77% direct costs and 23% to 56% indirect costs.<sup>3,23,41,42</sup> Within direct costs, the top cost driver is prophylaxis medications after the NSI, and ranges from 54% to 96% of the average direct medical costs after NSI. In Korean hospitals the NSI direct costs by department were 54.5% pharmacy, 29.7% laboratory tests, 11.7% medical services, and 4.2% medical treatments.<sup>43</sup>

## Economic benefits of safety injection needles

The current costs of safety needles are ~2–3 times the cost of non-safety needles. To gauge the impact of the use of safety needles on a hospital budget, studies have reported annual cost impact from a perspective important to healthcare administrators.<sup>42</sup> An Australian study found that the annual cost increase due to the use of hypodermic safety needles was the equivalent of \$14 for each at-risk HCW or \$2 per occupied bed per day.<sup>42</sup> Data from Spain show that the direct

**Table 2** Studies reporting rates of NSI after implementation of named active safety devices in hospitals

Study	Device type/name	NSI rate
Adams and Elliott <sup>37</sup>	Safety sliding shield needle (BD SafetyGlide)	70% reduction in NSIs ( $p=0.045$ ) after introduction of BD SafetyGlide
Valls et al <sup>39</sup>	Safety pivoting shield needle (BD Eclipse)	100% reduction in NSIs from hypodermic injections (i.e., 0 NSI after introduction of BD Eclipse)
van der Molen et al, <sup>38</sup> van der Molen et al <sup>66</sup>	Safety pivoting shield needle (BD Eclipse)	64% reduction in NSIs after introduction of BD Eclipse

**Notes:** BD SafetyGlide and BD Eclipse are both manufactured by Becton Dickinson, Franklin Lakes, NJ, USA.

**Abbreviation:** NSIs, needlestick injuries.

**Table 3** Economic analyses of the cost of a NSI and impact of safety devices

Reference	Country/Setting	Cost per NSI <sup>a</sup> (mean) and other economic findings
Mannocci et al <sup>67</sup>	14 studies in eight countries	IntUS\$425 (IntUS\$48–1,516) median direct cost; IntUS\$322 (IntUS\$152–413) median indirect cost, totaling Int\$747 (Int\$199–1,691 [2015]) using a combined calculation by converting costs to international dollars across countries
Oh et al <sup>43</sup>	Republic of Korea	225,758 Won (US\$237) direct costs (54.5% pharmacy, 29.7% laboratory tests, 11.7% medical services, 4.2% medical treatments). Thirty four hospitals reporting 700 NSIs were used to project a national annual economic burden in Korea of 844,587,577 Won (US\$884,385 [2005–2006])
Hanmore et al <sup>23,b</sup>	Belgium	€210–950 direct costs (2012); €63–844 indirect costs. Incidence-based budget impact model projected an 86% reduction in NSIs with safety injection devices. Positive net budget impact for a 420-bed hospital (i.e., savings) of €51,710 over 5 years with switching to safety injection devices
Glenngård and Persson <sup>44,b</sup>	Sweden	€272 (SEK 2,513 [2007]) direct costs. Projected 80% fewer NSIs from hollow-bore needles by conversion to safety needles; resulted in a savings of €0.01 (SEK 0.07) per used needle for tests, investigations, and treatment
Trueman et al <sup>2</sup>	UK	\$550 direct costs (£362 [2005]). £600,000 NHS burden related to NSI with insulin administration
Wittman et al <sup>29</sup>	Germany	€490, with the hospital paying €148 of the cost (Working Party at Bergische University Wuppertal)
Leigh et al <sup>3</sup>	US	\$596 (\$339 direct medical costs and \$257 lost work productivity costs [2004]). Annual national US cost of \$188.5 million (direct medical costs of \$107.3 million and indirect costs from lost-work productivity of \$81.3 million)
O'Malley et al <sup>68</sup>	US	\$376 (\$71–860 [2003]) for exposure to source patient with unknown or negative infection status (n=19). \$650 (\$186–856) for source patient infected with HCV (n=4). \$2,456 (\$907–4,838) for exposure to HIV-infected source patient, including co-infection with HBV or HCV (n=19). Detailed information was collected from four healthcare facilities on time spent on reporting, managing, and following up the exposures; salaries (including benefits) for representative staff who sustained and managed exposures; and costs (not charges) for laboratory testing of exposure sources and exposed healthcare personnel, as well as any post-exposure prophylaxis taken by the exposed personnel
Lee et al <sup>41,b</sup>	Survey USA and OSHA report for State of California	Average cost of NSI per injured nurse was \$259 and average cost per NSI was \$159 (2004). Cost-benefit analysis of safety needles in state hospitals would achieve a net annual statewide savings of \$320 million in medical care costs

**Notes:** <sup>a</sup>Reported in US\$ unless otherwise specified. <sup>b</sup>Assessed cost savings of safety-needle conversion.

**Abbreviations:** HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus; Int, international; NHS, National Health Service; NSI, needlestick injury; OSHA, Occupational Safety and Health Administration; SEK, Swedish Krona.

cost increase for hypodermic safety needles was €0.021 (US\$0.028) per patient in the ED.<sup>39</sup>

Although the acquisition costs of safety needles are greater than conventional needles, safety needles provide economic value based on the reduction in NSIs. In a Swedish study, direct medical costs resulting from 3,906 hollow-bore needle sharps injuries were found to be €0.04 (Swedish Krona [SEK] 0.34) per used needle.<sup>44</sup> Using safety devices instead of conventional needles at all hospitals, primary care facilities, and outpatient clinics outside hospitals was found to save €0.01 (SEK 0.07) per used needle for tests, investigations, and treatment. The assumption was that 80% of hollow-bore needle sharps injuries could be prevented, resulting in 3,125 fewer injuries. A review of the cost-effectiveness of safety devices in a study by Lee et al included data collected by California Occupational Safety and Health Administration (OSHA).<sup>45</sup> Due to the rising rates of NSI, the state of California analyzed the cost-effectiveness of using safety-engineered devices to support pending legislation that would require stricter handling of syringes. The California OSHA reported that the implementation of safety needle devices would cost

the state \$124 million. A cost savings of \$228 million and \$216 million would be realized with the elimination of new HIV and hepatitis cases, respectively. As a result, an annual savings of \$320 million in healthcare costs was projected.<sup>46</sup> California OSHA found that the implementation of safety devices would produce savings much larger than the initial cost of using safety syringes.

In a dental school practice, the authors noted that the “reduction in cost of management of needlestick injuries including the psychological effects are significant” for hypodermic safety syringes.<sup>36</sup>

In Belgium, an economic model found that the decrease in the long-term costs due to NSIs offsets the acquisition costs of safety needles.<sup>23</sup> A 5-year incidence-based budget impact model was developed from a 420-bed Belgian hospital inpatient perspective, comparing costs and outcomes with the use of safety devices and prior-used non-safety devices. The model included device acquisition costs and the costs of NSI management in blood collection, infusion, injection, and diabetes insulin administration. For injections, the average cost per conventional and safety injection device was €0.014 and

€0.046, respectively, with an expected 86% reduction in NSI using safety injection devices. An increase in safety device acquisition costs was offset by savings through avoided NSIs. When switching to safety injection devices (including other safety devices beyond hypodermic injection), the net budget impact over 5 years showed a savings of €51,710. While a variety of sensitivity analyses and changes in model assumptions were performed, the results continued to demonstrate cost savings. The model was most sensitive to variation in the acquisition costs of safety devices, the rates of NSI associated with conventional devices, and the acquisition costs of conventional devices.<sup>23</sup>

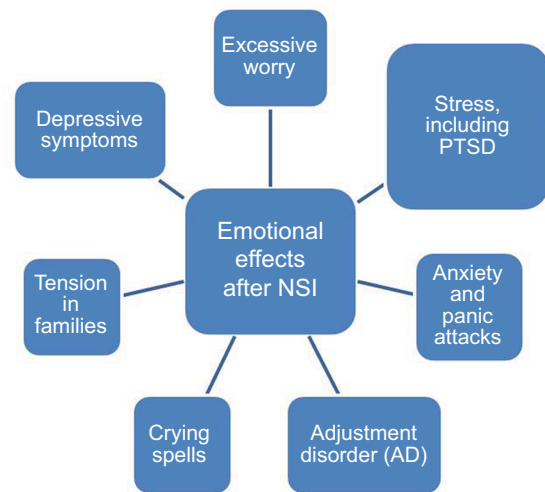
## Avoiding financial penalties due to non-compliance with regulatory requirements

In the USA, OSHA enforces the requirements set forth by the NSPA. One of the requirements is that employers must consider and implement appropriate commercially available and effective safer medical devices designed to eliminate or minimize occupational exposure in healthcare settings where exposure is possible. The use of safety devices can assist with avoiding financial penalties (up to \$12,675 per violation as of January 13, 2017<sup>28</sup>) issued due to violations of the NSPA.

## Humanistic burden

Nurses report that NSIs are the top concern for personal safety, followed by safety in the workplace.<sup>47</sup> In a survey administered through the American Nurses Association to over 700 nurses in the USA regarding NSIs and workplace safety climate, 64% of nurses say NSIs and blood-borne infections remain major concerns. After NSI, most HCWs report experiencing a range of psychological effects, as depicted in Figure 3.<sup>48,49,56</sup> In a study of 313 HCWs post-NSI, 41.8% felt anxious, depressed, or stressed following the NSI.<sup>71</sup> In another study, anxiety was reported by 80.2% of HCWs post-NSI with 66.4% having mild/moderate anxiety, and 13.8% with persistent anxiety.<sup>50</sup> In hospital employees who were recently evaluated for blood/body fluid exposure (n=150), 53% reported feeling some anxiety that could be attributed to their recent exposure.<sup>51</sup>

Experiencing a NSI is significantly correlated with depressive symptoms (odds ratio 2.98), as found in a survey of medical students.<sup>72</sup> The study by Sohn et al provides the most thorough analysis of the effects of NSI on psychological outcomes.<sup>53</sup> In this study, psychological symptoms of 370 HCWs were assessed prior to and after NSI. The analysis showed that NSI was associated with a statistically significant increase in the Beck Depression Index ( $p < 0.01$ ).



**Figure 3** Humanistic impact of NSIs.

**Notes:** Data from Green B and Griffiths EC.<sup>56</sup>

**Abbreviations:** NSIs, needlestick injuries; PTSD, post-traumatic stress disorder.

In addition to depression and anxiety, HCWs exposed to NSI can experience post-traumatic stress disorder (PTSD) and burnout.<sup>52,54,55</sup> After NSI, physicians had a statistically higher likelihood of PTSD (odds ratio of 4.28) based on the Impact of Event Scale questionnaire (IES-6).<sup>54</sup> In a study of 458 nurses, the Maslach Burnout Inventory questionnaire scores from nurses post-NSI indicated a statistically higher probability of burnout compared to unexposed nurses.<sup>52</sup>

Longer-term humanistic impact exists when NSI is from a source with known HIV disease. Even after testing negative for almost 2 years after NSI, US nurses displayed symptoms consistent with PTSD, insomnia, ongoing depression and anxiety, nightmares, and panic attacks upon returning to the work environment where the injuries were received.<sup>55</sup>

The humanistic impact and psychological effects of NSI are linked to lost productivity and work time in the USA and Europe.<sup>41</sup> In 110 US nurses reporting lost time from NSI, 77 days of work were missed, 10 due to seeking and receiving medical attention, six due to side effects from HIV prophylactic medication, and 61 due to emotional distress and anxiety following the NSI.<sup>41</sup> In Europe, nurses report changing their working habits/department 12.3% of time and stop working 2.4% of the time after NSI.<sup>20</sup>

## Gaps in the literature

Many studies describe the impact of safety-engineered devices on overall institutional NSI rates, but do not provide sufficient detail to determine the impact of specific type of safety device used. Safety-engineered devices for hypodermic injection reduce NSI risk, but quantification of reduced disease transmission for HIV, HBV and HCV is

unknown. Calculations of the economic burden of NSI and the economic value of safety-engineered devices have typically lacked the inclusion of indirect cost components such as cost of transportation or the cost of fear/worry, changed behavior at work and at home and pain/suffering costs. These latter costs are difficult to estimate and while it is uncertain whether these costs would significantly change the total cost of NSIs, research needs to define their importance. In addition, most articles that assessed cost of NSI acknowledged that litigation costs due to a NSI may be significant. However, no article included costs of litigation or the incidence of legal action due to NSIs.

## Conclusion

Although highly preventable with proper handling and equipment, NSIs are still a significant issue among HCWs globally despite legislation in many countries. Both direct and indirect costs of NSIs are high; however, healthcare institutions can achieve cost savings and cost offsets with implementation of safety needles and devices. In addition, small studies suggest a broad range of psychological domains that are impacted in HCWs with NSI, yet comprehensive assessments are lacking. Hypodermic injection is the most common cause of NSI. The economic and humanistic burden of NSI could be reduced by implementation of safety needles for hypodermic injection (which have reduced NSIs up to 100%), yet more must be done to enforce legislation. Future research is needed to better quantify the humanistic burden and long-term impacts of NSI for HCWs. In addition, economic studies are needed in country-specific healthcare settings to demonstrate the downstream cost offsets or cost savings of using safety needles and other safety devices for hypodermic injection.

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## Supplementary material

**Table S1** Search terms used in PubMed

Subject area	Search terms
Needlestick injury	(Needlestick injury[Mesh] OR "Accidental needle stick") AND
Safety needles	("Safety needles" OR "Safety-engineered needles" OR "Engineered-sharps" OR "Needleless systems" OR (Needles[majr] AND (Device safety[Mesh] OR "Safety-engineered devices" OR Passive[Title/Abstract] OR Mechanism[Title/Abstract])) OR
Clinical burden	Viral infection[Mesh] OR Hepatitis C[Mesh] OR HIV[Mesh] OR Hepatitis B[Mesh] OR
Quality of life/utilities	"Quality of life" OR QoL OR HRQoL OR "health related quality of life" OR Utility OR Utilities OR Patient satisfaction[Mesh] OR Worry OR Distress OR
Resource utilization/costs	"Resource utilization" OR "Resource use" OR Cost OR Costs OR "Cost analysis" OR "Budget impact" OR
Indirect costs	"Indirect costs" OR Productivity OR "Work loss" OR "Work policy" OR
Policy	Policy[Title/Abstract] OR Public policy[Mesh]

**Abbreviation:** HIV, human immunodeficiency virus.

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