

## ORIGINAL ARTICLE

## Needlestick Injuries: Incidence and Cost in the United States, United Kingdom, Germany, France, Italy, and Spain

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## ABSTRACT

The objective of this study is to evaluate the incidence and cost of needlestick injuries (NIs) in the United States, United Kingdom, Germany, France, Italy, and Spain. Comprehensive search of peer-reviewed literature to gather information on the incidence and costs associated with NIs and a Web-based search to identify pertinent gray literature, trade associations, and key stakeholders for the prevention of NIs. The estimated annual incidence of NIs is 384,000 in the United States, 100,000 in the United Kingdom, 700,000 in Germany, 29,719 in France, 28,200 in Italy, and 21,815 in Spain. The economic burden of NIs varies from country to country; for instance, annual costs are estimated at €7 million in Italy and \$118 million to \$591 million in the United States. An accurate assessment of the incidence and economic burden of NIs is difficult to obtain because of widespread under-reporting. Furthermore, the projected costs do not account for long-term treatment costs resulting from possible infection with a blood-borne pathogen, absenteeism, worker's compensation, or emotional repercussions. A significant proportion of NIs stem from injections and intravenous-related tasks, accounting for roughly one to two thirds of NIs in all countries examined. The US General Accounting Office estimates that 29% of NIs that occur in hospitals could be prevented through the adoption of safety-engineered needles or needle-free devices. In conclusion, findings on the incidence and economic burden of NIs indicate the need for safety-engineered needles or needle-free technology, along with increased education regarding safer practices in the work environment. *Biomed. Int.* 2010; 1: 41-49. ©2010 Biomedicine International, Inc.

**Key Words:** Needlestick injuries epidemiology, needlestick injuries costs, healthcare workers' safety costs.

## INTRODUCTION

Needlestick injuries (NIs) are among the most prevalent and preventable occupational accidents,<sup>1</sup> with disposable syringes and hollow-bore needles as the primary source of injury. In hospitals, health care workers (HCWs), particularly nurses and physicians, are most at risk,<sup>2,5</sup> but cleaning staff and others can also experience NIs due to inappropriate sharps disposal, etc. Needlestick injuries may expose HCWs to more than 20 different blood-borne pathogens,<sup>4</sup> including hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV).<sup>1</sup> Although the importance of monitoring and preventing NIs is recognized in US<sup>5</sup> and European law,<sup>6-8</sup>

significant under-reporting persists.<sup>9,10</sup> Reasons for this may include the time-consuming reporting process,<sup>11</sup> the belief that NIs are minor incidents,<sup>12</sup> and fear of a positive test result for a serious infection (eg, HIV).<sup>13</sup> The goal of this study was to assess the available evidence on the incidence and economic burden of NIs using data compiled from the United States, United Kingdom, Germany, France, Italy, and Spain.

## METHODS AND MATERIALS

The peer-reviewed literature was comprehensively searched to compile information on the incidence and costs of NIs (Table 1). An Internet search along with interviews of experts (n = 13) identified gray literature, information from trade associations, and clinician and industry perspectives, as well as safety guidelines (Table 2). Gray literature refers to documents such as technical reports, working papers, and conference proceedings. Key sources included government and non-government organizations, professional associations, and research groups.

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**Table 1.** Databases for the Identification of Peer-reviewed Literature on the Epidemiology, Incidence, and Economic Burden of NIs

| United States   | United Kingdom        | Germany  | France                      | Italy                    | Spain  |
|---|-----------------------|--|-----------------------------|--------------------------|--------|
| 1990-2004:<br>Medline<br>Cochrane Database of<br>Systematic Reviews | 1985-2004:<br>Medline | 1990-2004:<br>Medline<br>Embase<br>Cochrane<br>SOMED (up to 2001)<br>Springer-Verlagsdatenbank<br>Kluwer-Verlagsdatenbank<br>Deutsche Agentur für Health Technology<br>Assessment (DAHTA)<br>Karger-Verlagsdatenbank<br>Thieme-Verlagsdatenbank<br>MEDIKAT<br>German Medical Science<br>Deutsches Ärzteblatt | MEDLINE<br>Pascal<br>CODECS | MEDLINE<br>www.google.it | PubMed |

NIs, needlestick injuries.

National costs estimates were obtained from the literature or derived from cost per case reported multiplied by the annual numbers of cases reported.

## RESULTS

### *Incidence*

In the United States, various rates of NIs per HCW per year recorded by hospital surveillance systems have been reported: 0.12 for medical students<sup>10</sup> and, more recently, 0.05 based on data from 15 hospitals in 1997/98 from the National Surveillance System for Health Care Workers.<sup>14</sup> A separate study<sup>15</sup> of 65 hospitals in 1990 reported a mean of 45 NIs per hospital. Survey estimates in which staff members were asked about their experience of exposures showed higher incidences, with 0.11 per HCW from 15 National Surveillance System for Health Care Workers hospitals,<sup>14</sup> and an Internet-based survey reported a risk for nurses of 0.24 injuries per nurse per year.<sup>16</sup>

At a national level, analyses from the 1997/98 National Surveillance System for Health Care Workers and the International Healthcare Worker Safety Center's Exposure Prevention Information Network (EPINet; adjusted for 43% under-reporting) estimate that approximately 384,000 NIs occur annually in the United States.<sup>14</sup> Previous national estimates range from approximately 252,000 (based on a 1990 survey of 65 hospitals with no adjustment for under-reporting)<sup>15</sup> to 800,000 based on data from a single hospital published in 1991.<sup>17</sup>

Published estimates of NI incidence within the United Kingdom also vary widely.<sup>18-21</sup> For example, a Scottish study involving 132,000 survey participants reported an annual incidence of just 0.0185 per HCW,<sup>21</sup> while a survey involving 279 doctors and nurses at an acute district general hospital in England indicated an annual incidence of 1.8 per HCW.<sup>18</sup> It

has been suggested that the true United Kingdom incidence of NIs may be as high as 100,000 cases per year (Table 3).<sup>19</sup>

In Germany, as in other countries, the reported annual incidence of NIs can vary widely; for example, one study found rates of 0.053 per HCW per year based on data in hospital surveillance systems compared with 0.41 based on a survey of HCWs.<sup>12</sup> According to a recent survey with the largest HCW sample population to date, the annual incidence of NIs per HCW ranged from 0.08 to 1.28, depending on staff member assignment.<sup>22</sup> Combining these skill mix-specific incidence rates with the total number of HCWs at risk (818,119)<sup>23</sup> leads to an estimate of approximately 700,000 NIs occurring annually in German hospitals<sup>22</sup> (Table 3). The HCWs who contributed most to this number were nurses (47%), physicians (23%), and nurses' aides (12%).

The annual occurrence of NIs in France is estimated at 18,720 for nurses (Table 3), a figure calculated by multiplying the number of nurses at risk (234,000)<sup>24</sup> by the incidences reported per year per nurse (0.08).<sup>25</sup> Alternatively, the national network Réseau d'Alerte d'Investigation et de Surveillance des Infections Nosocomiales estimated that 41,276 blood exposures occurred in France in 2004, 72% (29,719) of which were caused by NIs.<sup>26</sup> That study also estimated that the annual incidence rates of blood and body fluid exposures via NIs were 5.8 per 100 hospital beds, 0.05 per full-time equivalent nurse, 0.02 per full-time equivalent physician, and 0.01 per full-time equivalent nurse's aide.

The Italian Occupational Risk Study on HIV (SIROH) is the main public surveillance program for occupational infections in Italy. The results of a SIROH-EPINet survey that documented 27,000 claims of occupational events in Italian hospitals (January 1994 to December 1999) indicated that

**Table 2.** Key Sources of Information for the Identification of Gray Literature, Trade Associations, and Key Stakeholders for the Prevention of NIs

| United States   | United Kingdom   | Germany   | France   | Italy   | Spain   |
|---|--|---|--|---|---|
| Centers for Disease Control and Prevention (CDC)                        | Department of Health (DoH)                                 | Freiburger Forschungsstelle Arbeits- und Sozialmedizin (FFAS, or Freiburg Research Center for Occupational and Social Medicine)   | Agence Française de Sécurité Sanitaire des Produits de Santé (AFSSAPS, or French Health Products Safety Agency)  | Assobiomedica (National Association for Biomedical and Diagnostic Technologies)   | Instituto Nacional de Gestión Sanitaria, Ministerio de Sanidad y Consumo (Institute of Healthcare Management, Ministry of Health) |
| Food and Drug Administration (FDA)                                      | Medicines and Healthcare Products Regulatory Agency (MHRA) | Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA, or Federal Institute for Occupational Safety and Health)  | Agence Nationale d'Accréditation et d'Évaluation en Santé (ANAES, or the French Office of Technology Assessment)   | Ministero della Salute (Ministry of Health)   | Instituto Nacional de Seguridad e Higiene en el Trabajo (National Institute of Safety and Hygiene at Work)                        |
| United States General Accounting Office (GAO)                           | Health and Safety Executive                                | Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege (BGW, or Institutions for Statutory Accident Insurance and Prevention in the Branches Health Services and Social Welfare) | Groupe d'Etude sur le Risque d'Exposition des Soignants aux agents infectieux (GERES, or Study Group working on the risk of health care workers exposure to contagious agents) | Istituto per la Prevenzione e Sicurezza del Lavoro (ISPESL, or the National Institute for Prevention and Safety at Work)                          | Ministerio de Trabajo y Asuntos Sociales (Ministry of Labour and Social Affairs)  |
| Occupational Safety and Health Organization (OSHA)                      | National Institute for Clinical Excellence (NICE)          | Bundesverband der Unfallkassen (Central Federation of Public Sector Accident Insurers)  | Centre de Coordination de la Lutte contre les Infections Nosocomiales (CCLIN, or Regional Nosocomial Infection Control Coordinating Centre)                                    | Istituto nazionale per l'Assicurazione contro gli Infortuni sul Lavoro (INAIL, or the National Institute for Insurance Against Accidents at Work) | Departament de Sanitat i Seguretat Social (Catalan Department of Health and Social Security)                                      |
| Occupational Safety and Health State Plan Association (OSHSPA)          | Royal College of Nursing (RCN)                             | Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (Academy of Occupational Medicine and Health Protection)   |  | IPASVI (Italian National Association of Nursing Care)   | Butlletí Epidemiològic de Catalunya (Epidemiologic Bulletin of Catalonia)   |
| Joint Commission on Accreditation of Healthcare Organizations (JCAHO)   | British Medical Association (BMA)                          | Hauptverband der gewerblichen Berufsgenossenschaften (HVGB, or German Federation of Institutions for Statutory Accident Insurance and Prevention)   |  | www.regioni.it (the official Web site of Italian Regions)   | Centre Epidemiològic d'Estudis Sobre la SIDA a Catalunya (CEESCAT, or Epidemiologic Centre on AIDS Studies in Catalonia)          |
| Training for Development of Innovative Control Technologies Project     | UNISON Health Group  |   |  |   |   |
| UCLA Department of Emergency Medicine's Needlestick Program             | Emergency Care Research Institute (ECRI)                   |   |  |   |   |
| University of Virginia's International Health Care Worker Safety Center | Sharps Injury Manufacturer Alliance                        |   |  |   |   |
| American Nurses Association   | Safer Needles Network                                      |   |  |   |   |
| American Hospital Association   |  |   |  |   |   |
| Association of Needle-Free Injection Manufacturers                      |  |   |  |   |   |
| Infusion Nurses Society   |  |   |  |   |   |
| International Sharps Injury Prevention Society                          |  |   |  |   |   |
| National Alliance for the Primary Prevention of Sharps Injuries         |  |   |  |   |   |
| Premier Safety Institute  |  |   |  |   |   |
| Service Employees International Union Nurse Alliance                    |  |   |  |   |   |

NIs, needlestick injuries.

**Table 3.** Estimated Occurrence of Total and Injection/IV-related NIs

| Country        | Total annual number of NIs | Annual number of injection/IV-related NIs |
|----------------|----------------------------|---|
| United States  | 384,000                    | 123,000                                   |
| United Kingdom | 100,000                    | 38,000                                    |
| Germany        | 700,000                    | 168,000                                   |
| France         | 18,720 <sup>a</sup>        | 6,552 <sup>a</sup>                        |
| Italy          | 28,200                     | 18,900                                    |
| Spain          | 21,815                     | 14,388                                    |

IV, intravenous; NIs, needlestick injuries.

<sup>a</sup>Nurses only.

nurses accounted for the greatest number of occupational exposures to NIs (57%), followed by auxiliary personnel (18%), training personnel (13%), and physicians (5%).<sup>27</sup> Based on data gathered from the SIROH-EPINet survey, the Assobiomedica estimated that, in Italy, 0.061 NIs occur per HCW each year.<sup>28</sup> Given this incidence and the total number of HCWs at risk (463,000), the Ministry of Health estimated an annual occurrence of 28,200 NIs in Italy (Table 3).<sup>27</sup> The annual incidence rates reported by SIROH-EPINet<sup>28</sup> for NIs appear broadly consistent with results from a separate report that found an annual incidence of 0.084 for nurses and 0.028 for physicians.<sup>29</sup> The EPINet in Spain reported a mean annual incidence of 11.8 NIs per 100 occupied beds using data collected from 64 hospitals between 1996 and 2000.<sup>30</sup> Given an estimated 158,068 hospital beds in 2004, this suggests that there were 18,652 cases of NI.<sup>31</sup> Another study<sup>32</sup> reported an annual incidence of 0.078 NIs per HCW, and an estimated 279,680 HCWs were at risk for NIs in 2004<sup>31,31</sup>; thus, an alternative estimate suggests that 21,815 NIs occur in Spain annually (Table 3).

Overall when incidence rates for NIs are obtained from hospital reporting systems, it would appear that only a small proportion of HCWs (range 0.05 to 0.10 for nurses with a lower rate recorded for physicians) experience an NI. By contrast, data obtained from surveys of staff typically suggest that a significant proportion or even a majority of HCWs (0.2-1.8) experience an NI. Under-reporting to hospital recording systems appears to be widespread.

#### Extent of Non-reporting

The rate of non-reporting is extremely high in all the countries examined. In the United States, under-reporting has been estimated from surveys to be 43% for HCWs in general<sup>14</sup> and 45% to 65% among medical students.<sup>10</sup> In Germany, studies indicate that only

6.3% to 14.7% of NIs are reported.<sup>9,12,22</sup> The major reasons HCWs gave for non-reporting included consideration of the NI as a minor injury (38%), belief of having sufficient protection against HBV (19%), lack of time (12%), and unknown reporting system (10%).<sup>12</sup> In interviews conducted with surgeons in France,<sup>33</sup> 45% said they had experienced an NI, but two thirds of them never reported it, primarily because the reporting process was too difficult and complex. Estimated rates of non-reporting in the United Kingdom range from 13% to 85%.<sup>34,35</sup> There, the reasons given by HCWs for non-reporting included the view that the reporting process was not only time-consuming but also futile,<sup>11</sup> along with the fear of confirming a blood-borne illness infection.<sup>13</sup> Other estimated rates of non-reporting ranged from 40% to 65% in Italy<sup>27,36</sup> and 40% to 60% in Spain.<sup>37,38</sup>

#### Potential Causes of NIs

Needlestick injuries occur most often while using disposable syringes with hollow-bore needles.<sup>39</sup> The Centers for Disease Control estimates that 236,000 NIs involving hollow-bore needles occur each year in the United States.<sup>39</sup> Research (N = 1,910) by the International Health Care Worker Safety Center<sup>40</sup> found that injections (intramuscular and subcutaneous) and intravenous (IV)-related tasks accounted for 21% and 11% of the reported cases of NIs, respectively. Given the Centers for Disease Control's estimate of 384,000 NIs per year, 123,000 cases of injection- and IV-related NIs are estimated to occur each year in the United States (Table 3).

According to the Health Protection Agency in the United Kingdom,<sup>41</sup> the EPINet in Germany,<sup>42</sup> and Réseau d'Alerte d'Investigation et de Surveillance des Infections Nosocomiales in France,<sup>26</sup> injections (intramuscular and subcutaneous) and IV-related procedures account for 25%, 24%, and 35% of reported cases of NIs, respectively. Given annual total estimates of 100,000, 700,000, and 18,720 (nurses only) NIs in the United Kingdom, Germany, and France, 38,000, 168,000, and 6,552 (nurses only) NIs may result from injections and IV-related tasks, respectively (Table 3).

Most of the 28,157 NIs reported to the SIROH-EPINet database (January 1994 to September 2002) in Italy were caused by disposable syringes, winged steel needles, and IV catheters.<sup>27</sup> A detailed analysis of data from 18 hospitals (1994 to 1998) indicated that NIs occurred while inserting a catheter (32.5%),

**Table 4.** Estimated Annual Number of Infections Caused by NIs in German Hospitals<sup>23,45-49</sup>

| Virus | Total annual number of NIs | Risk of transmission | Prevalence in population (per 100,000 people) | Annual number of infections (calculated) | Annual number of infections (observed) |
|-------|----------------------------|----------------------|---|--|--|
| HBV   | 700,000                    | 30%                  | 610 <sup>a</sup>                              | 256                                      | 293                                    |
| HCV   | 700,000                    | 3%                   | 610   | 181                                      | 408                                    |
| HIV   | 700,000                    | 0.5%                 | 0.73  | 2  | 2                                      |

NIs, needlestick injuries; HBV, hepatitis B virus; HCV, hepatitis C virus; HIV, human immunodeficiency virus.

<sup>a</sup>Estimated vaccination rate of health care workers = 80%.

administering parenteral therapy (25.8%), and taking blood samples (21.9%).<sup>27</sup> In a separate survey in Le Marche Region (1995 to 2001), 67% of the 704 reported accidents happened during injection procedures.<sup>43</sup> Assuming that 28,200 NIs occur each year in Italy, an estimated 18,900 NIs may be attributed to injection-related tasks (Table 3). Similarly, a study in Spain estimated that 66% of NIs are caused by disposable or pre-loaded syringes and IV-catheter needles used for intramuscular and IV injections and/or drawing blood,<sup>32</sup> which translates into 14,398 NIs annually (Table 3).

### Consequences of NIs

One of the greatest concerns regarding NIs is the potential to cause serious, chronic, life-threatening infections. Needlestick injuries that occur during the insertion of an IV line pose especially high risks of infection.<sup>44</sup> The rate of infection (seroconversion) per 100 HCWs after percutaneous exposure to HBV, HCV, or HIV is 6 to 30, 1.8, and 0.3, respectively.<sup>1</sup> A review of the literature published in 2003 estimated that NIs result in more than 1,000 new cases of HBV, HCV, or HIV in the United States each year.<sup>1</sup>

In the United Kingdom, a Health Protection Agency survey (July 1997 to 2005)<sup>20</sup> noted that 1 HCW had a documented HIV seroconversion, 8 HCWs had "probable" occupational HIV acquisition, and 9 HCWs were infected with HCV between 1997 and 2005.

In Germany, a bottom-up estimate of the likely number of infections resulting from HBV, HCV, and HIV exposure via NI was obtained by multiplying the 700,000 projected number of NIs per year by the risk of viral transmission and its prevalence in the population (Table 4).<sup>22,45-49</sup> Based on this bottom-up estimate, the total annual number of infections resulting from HBV, HCV, and HIV exposure via NI was calculated to be 256, 427, and 2, respectively. These estimates compare closely with the number of infections observed nationally in 2007 resulting from exposure to these viruses (293, 408, and 2, respectively).<sup>45,49</sup> These values were calculated using information from the private health care sector (public sector data are typically recorded only under a general category of "infectious diseases" and may include such infections as salmonellosis, tuberculosis, and shigellosis in addition to HBV, HCV, and HIV). According to a 2004 French RAISIN study,<sup>26</sup> 72% of all blood and body fluid exposures were caused by NIs, 6.2% of all exposures involved HCV-positive blood or body fluid, and 3.1% of all exposures involved HIV-positive blood or body fluid. The EPINet in Spain reported that 12.9% of documented occupational exposures resulted from NIs associated with HCV-infected patients.<sup>30</sup> Results of a study<sup>50</sup> in Catalonia found 3 cases of HCV out of a total of 433 exposures, with a 0.7% risk of seroconversion; another study<sup>51</sup> conducted in Italy reported a similar risk of 0.6%.

### Economic Burden of NIs

The economic burden of NIs, especially those that result in infection, is substantial. In the United States,<sup>39</sup> estimated costs for NI treatment range from \$500 to \$3,000, but these figures do not account for long-term costs associated with illness contracted from the NI or litigation and compensation costs.<sup>52</sup> In their analysis of treatment costs associated with NIs, the Centers for Disease Control examined 3 cost scenarios in which each NI would result in postexposure costs of \$500, \$1,500, or \$2,500, figures that are within the range of published costs per event.<sup>39</sup> Using these numbers, the Centers for Disease Control calculated the annual economic burden of NIs in the United States to be between \$118 million and \$591 million (Table 5) based on an expected national annual occurrence of 236,000 cases.<sup>39</sup>

In England and Wales, the cost burden for NIs has been reported to be as much as £300 million per year, and although the methods for calculating cost were not explicitly reported, this figure may include potential litigation and compensation costs (Table 5).<sup>53</sup> A more conservative estimate from the Safer Needles Network (2003) reported that if 3% of HCWs experienced NIs at a cost of £2,037 per claim, the economic burden for the National Health Service would amount to £4 million annually.<sup>53</sup> In Scotland, an estimated £260,000 per year is spent on legal costs, compensation, and lost staff time as the result of NIs.<sup>21</sup>

Projected annual costs of NIs in Germany (according to unpublished estimates) range from €12 million to €30 million per year; Hofmann<sup>54</sup> estimated that €6.1 million is spent on the treatment of HBV and HCV. The Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege (ie, occupational health insurance for private hospitals and practices) calculated that initial diagnostic tests and post-exposure prophylaxis associated with a single NI costing €400.<sup>55</sup> In 2003, the Berufsgenossenschaft für Gesundheitsdienst und Wohlfahrtspflege reported that €3.1 million was spent on the treatment of blood-borne occupational infections, while pensions for the inability to work because of blood-borne occupational infections amounted to €1 million.<sup>55</sup> Because these figures account for only two thirds of the cost (public insurers share the remaining one-third), the

**Table 5.** Estimated Costs as the Result of Total and Injection/IV-related NIs

| Country        | Total annual cost of NIs (million) | Annual cost of injection/IV-related NIs (million) |
|----------------|------------------------------------|---|
| United States  | \$118-\$591                        | \$38-\$189  |
| United Kingdom | £300                               | £114  |
| Germany        | €4.6                               | €1.1  |
| France         | \$6.1 <sup>a</sup>                 | \$2.1 <sup>a</sup>                                |
| Italy          | €7.0                               | €4.7  |
| Spain          | €6-€7                              | €4-€5   |

IV, intravenous; NIs, needlestick injuries.

<sup>a</sup>Nurses only.

total costs are estimated at €4.6 million (Table 5) and €16.5 million for diagnostic tests or treatment and pensions, respectively.<sup>55</sup> If all HCWs experiencing an NI actually came forward for diagnostic testing, the cost for the initial diagnostic process alone could potentially be €133 million in Germany (based on an assumption of a mean cost of €190 for diagnostic testing [according to unpublished estimates] and an annual occurrence of 700,000 NIs).

A study in France estimated that a single NI costs approximately \$325; this figure, in 1998 US dollars, was calculated according to French national guidelines on the management and follow-up of blood exposure in hospital staff.<sup>56</sup> Given that each NI costs \$325, and that 18,720 (nurses only) NIs occur annually in France, the total economic burden is estimated at \$6.1 million per year (Table 5).

In Italy, evaluation of direct costs per occupational exposure (HBV, HCV, and HIV) based on data collected by SIROH-EPINet showed the mean costs to be €248 per event (sum of source patient diagnostic test [€22], HCW diagnostic test [€172], and HCW prophylactic treatment [€54]; 1999 prices).<sup>27</sup> Combining these cost estimates with the incidence of NIs suggests annual costs for NIs in Italy are just under €7 million (not including longer term treatment, lost productivity, legal, or compensation costs; Table 5).

In Spain, a study<sup>57</sup> assessed the mean cost of treatment following potential occupational exposure to HBV, HCV, or HIV; cost variables included staff costs (time utilized by the Preventative Medicine Service workers), laboratory tests, pharmaceuticals, energy costs (for the Preventative Medicine Department), medical equipment, and loss of productivity for HCWs during testing and prophylactic treatment. Costs for prophylactic HIV treatment, longer term treatment costs, longer term productivity losses, and compensation for infected HCWs were not included. Results indicated an average cost per exposure of €73.78, ranging from €138.68 (source negative for all 3 viruses) to €522 (source positive for a virus and injured HCW not immunized; 1994 prices).<sup>57</sup> Results of an unpublished study conducted in 1998 put the average cost at €34.25 per NI (1998 prices).<sup>58</sup> Given these cost estimates per NI, the total economic costs resulting from NIs may be €6 million to €7 million per year in Spain (Table 5).

As previously described, a significant proportion of reported NIs resulted from injections and IV-related procedures. The same country-specific proportions were applied to obtain the estimated cost impact of this subset of NIs (Table 5).

#### *Potential Benefit of Safety-engineered Needle Devices*

Implementation of improved devices along with HCW education may substantially alleviate the economic burden of NIs. The US General Accounting Office estimates that 29% of NIs that occur in US hospitals may be prevented through introduction of

safer devices, which translates into a potential cost savings of \$34 million to \$173 million per year (Table 6).<sup>39</sup> Furthermore, the implementation of safety-engineered equipment may prevent more than 25 HBV infections and more than 16 HCV infections each year.<sup>39</sup> One 3-year study<sup>59</sup> in the United States noted that the use of an IV catheter stylet with a retractable protection shield significantly reduced the incidence of IV catheter-related injuries in at-risk HCWs. A recent review<sup>60</sup> of studies in the United Kingdom indicated that, compared with other safety-engineered needle devices, blunt suture needles and safety cannulas were associated with the most notable reductions in NIs.

In France, the costs and benefits of measures designed to prevent NIs in a university hospital were evaluated from 1990 to 1997.<sup>56</sup> Evaluation of the added costs of using safety-engineered needle devices and the averted costs from reductions in NIs through the use of educational measures showed a cost-effectiveness of \$4,000 per injury prevented.<sup>56</sup> Another study<sup>25</sup> of 32 French hospitals indicated that using safety-engineered devices during phlebotomy procedures reduced the risk of NIs by 74%.

Data from a cost-benefit analysis of engineered sharp injury (SI) prevention devices in a tertiary Spanish hospital indicated that safety needles for implanted ports had the most favorable cost-effectiveness ratio (€2.65/sharp injury avoided), followed by syringes with a protective shield (€69.79/sharp injury avoided).<sup>61</sup>

## DISCUSSION

Working conditions and the rate of NIs reported by HCWs to hospital systems appear broadly similar in the countries evaluated in this analysis. Substantial under-reporting of NIs to hospital systems also appears to be a significant issue in all countries. The differences in the incidence rates reported between the countries in this review relate to the availability of estimates of the extent of unreported NIs, with the lower rates in France,<sup>26</sup> Italy,<sup>62</sup> and Spain,<sup>32</sup> reflecting only those cases recorded by hospital surveillance systems. In contrast, those for Germany,<sup>22</sup> the United Kingdom,<sup>19</sup> and the United States<sup>14,15,17</sup> include some estimates for cases not captured by hospital systems. The estimates for economic burden are conservative because long-term costs in cases of infection, possi-

**Table 6.** Estimated Cost-savings From Use of Safety-engineered Devices in the United States

| Assumed cost/injury | Current estimated costs of NIs (million) | Estimated costs of NIs with safety-engineered needles (million) | Cost savings with safety-engineered needles (million) |
|---------------------|--|---|---|
| \$500               | \$118                                    | \$84  | \$34  |
| \$1,500             | \$354                                    | \$251   | \$103   |
| \$2,500             | \$591                                    | \$418   | \$173   |

NIs, needlestick injuries.

ble litigation costs, or indirect costs associated with absenteeism from work and loss of productivity were not included. An apparent exception was the high cost reported for England and Wales, which may include litigation and compensation costs. The reported costs themselves are also conservative because many reported cases do not include the costs incurred for viral testing and prophylaxis. If more HCWs experiencing NIs were to come forward, then the national costs would increase by many orders of magnitude as evidenced by our projected costs of €133 million in Germany.

Although they are difficult to quantify, NIs can significantly impact psychological well-being.<sup>63</sup> For example, 60% of nurses reported enhanced fear of needles following an NI, and 42% reported feeling anxious, depressed, or stressed.<sup>64</sup> Health care workers have reported both acute severe distress and persistent moderate distress after exposure to HIV, leading some to leave their jobs.<sup>65</sup> Posttraumatic stress disorder has also been documented in such cases.<sup>66</sup>

A significant proportion of NIs result from injections and IV-related tasks. Analyses of the costs of using safer devices showed that additional acquisition costs could in part be offset.<sup>39,56</sup>

Guidelines put forth by the US Department of Labor and Occupational Safety and Health Organization<sup>5</sup> and directives by the Council of European Communities<sup>6-8</sup> recommend proper training, monitoring regarding NIs, and the use of needle-free devices.<sup>39</sup> While eliminating the unnecessary use of needles and adopting safer work practices can reduce the incidence of NIs, further efforts are needed to address the under-reporting of NIs found in this review.

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