
Increase in Sharps Injuries in Surgical Settings Versus Nonsurgical Settings after Passage of National Needlestick Legislation

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- BACKGROUND:** The operating room is a high-risk setting for occupational sharps injuries and bloodborne pathogen exposure. The requirement to provide safety-engineered devices, mandated by the Needlestick Safety and Prevention Act of 2000, has received scant attention in surgical settings.
- STUDY DESIGN:** We analyzed percutaneous injury surveillance data from 87 hospitals in the United States from 1993 through 2006, comparing injury rates in surgical and nonsurgical settings before and after passage of the law. We identified devices and circumstances associated with injuries among surgical team members.
- RESULTS:** Of 31,324 total sharps injuries, 7,186 were to surgical personnel. After the legislation, injury rates in nonsurgical settings dropped 31.6%, but increased 6.5% in surgical settings. Most injuries were caused by suture needles (43.4%), scalpel blades (17%), and syringes (12%). Three-quarters of injuries occurred during use or passing of devices. Surgeons and residents were most often original users of the injury-causing devices; nurses and surgical technicians were typically injured by devices originally used by others.
- CONCLUSIONS:** Despite legislation and advances in sharps safety technology, surgical injuries continued to increase during the period that nonsurgical injuries decreased significantly. Hospitals should comply with requirements for the adoption of safer surgical technologies, and promote policies and practices shown to substantially reduce blood exposures to surgeons, their coworkers, and patients. Although decisions affecting the safety of the surgical team lie primarily in the surgeon's hands, there are also roles for administrators, educators, and policy makers. (*J Am Coll Surg* 2010;210:496–502. Published by Elsevier Inc. on behalf of the American College of Surgeons)
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An estimated 384,000 percutaneous injuries are reported by health care workers in hospitals in the United States each year, placing them at risk of exposure to human immunodeficiency virus (HIV), hepatitis B virus (HBV), or hepatitis C virus (HCV).¹ In addition to the risk of illness and death after an exposure, psychological trauma and long-term disability are of

great concern. Historically, operating room has been second only to patient rooms in the frequency of reported injuries.² The surgical environment is unique among health care settings in that it is blood-intensive, requires extensive manipulation of sharp instruments, often with compromised visual cues, and involves highly orchestrated interactions among members of the surgical team. These special circumstances place surgical personnel at higher risk of percutaneous injury and blood exposure than most other health care professionals.^{3–7} Also, the prevalence of bloodborne pathogen infection among surgical patients in some settings is disturbingly high. In a recent study in an urban hospital, as many as 38% of surgical procedures involved a patient infected with at least 1 bloodborne pathogen.⁸

The number of occupationally infected surgical personnel in the United States is not known, but Centers for Disease Control and Prevention reported 10 possible or documented cases of occupationally transmitted HIV among surgical personnel before 1997.⁹ Although both HBV and HCV have higher exposure and transmission

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rates than HIV, surveillance of occupational exposures to HBV and HCV is not systematically carried out or reported in the United States.

Despite their high injury risk, surgical personnel are among the least likely to report their injuries. A recent survey among surgical residents found that 51% of their needlesticks were unreported.¹⁰ Earlier studies estimated under-reporting rates as high as 90% among surgical personnel.¹¹

Percutaneous injuries to surgical staff carry a reciprocal risk for patients, with potential for infection transmission from provider to patient. The operating room is the highest-risk setting for this mode of transmission because open wounds are susceptible to contamination, and injury to the hands of surgical staff resulting in bleeding is not uncommon. Since 1991 there have been 132 documented cases of health care worker-to-patient transmission of HIV, HBV, and HCV worldwide; 131 cases were transmitted during deeply invasive surgery.¹² The potential for reciprocal exposures is not rare; as many as 25% of injuries in surgery occur while the operator's hands are in contact with the surgical site.⁷ Reducing percutaneous injuries in surgery would also reduce patients' risk of exposure to surgeons' blood.

The close working conditions and interaction among surgical team members lead to a "shared risk" of sharps injuries. Decisions regarding the selection of surgical tools and injury-mitigating techniques by 1 member (often the attending surgeon) have direct bearing on injury risk to nurses, technicians, and residents.

Prevention of percutaneous injuries among health care workers has been the subject of national regulation in the United States dating to the Occupational Safety and Health Administration Bloodborne Pathogens Standard of 1991.¹³ More recently, the Needlestick Safety and Prevention Act of 2000 explicitly required health care employers to provide safety-engineered needles and sharp instruments "with a built-in safety feature or mechanism that effectively reduces the risk of an exposure incident."¹⁴

Safety-engineered needles and sharp instruments are widely available in the United States and typically involve substitution of a blunt device for a sharp one when feasible, or incorporation of features that shield or retract needles or blades after use or between uses. The law has been associated with a marked increase in the hospital adoption of safety-engineered sharp devices.¹⁵ The impact of the law specifically on the adoption of safety-engineered surgical devices and on injury rates among surgical personnel requires a focused analysis because of the unique devices and procedures associated with that setting. The potential for

reducing surgical sharps injury risk by effectively implementing the law remains to be determined.

METHODS

We analyzed percutaneous injury data reported in a cumulative total of 87 US hospitals voluntarily participating in a research group from January 1993 through December 2006, in collaboration with the International Healthcare Worker Safety Center at the University of Virginia. These hospitals, from 11 states, were diverse in characteristics including teaching and nonteaching, small and large, and public and private facilities. (A complete list of institutions is available at <http://www.healthsystem.virginia.edu/internet/epinet/EPINetHospitalList.cfm>.) Data from individual hospitals were included for each year. The protocol mandated by the Occupational Safety and Health Administration for reporting at-risk percutaneous injuries, instructing workers to report their at-risk blood exposures, was in effect for all participating institutions. Incident descriptions were recorded in the standard format of the Exposure Prevention Information Network (EPINet) sharps injury and blood and body fluid exposure surveillance system. The Exposure Prevention Information Network solicits information on the mechanism of injury, the type of device causing injury, and whether or not the device was "safety-engineered" (with a shielded, recessed, retractable, or blunted needle or blade).¹⁶ Participating hospitals forwarded anonymous incident reports to the University of Virginia annually, where they were merged into a network database.

Injuries occurring in the operating room or postoperative recovery area were analyzed separately from those occurring in all other hospital settings. Excluded were injuries that occurred before use of the sharp device, when there was no associated risk of blood exposure. Injuries to non-surgical personnel, such as anesthesia personnel, and to those of undetermined role were excluded.

Average daily census is the most commonly used denominator for calculating hospital-wide rates. For this study, the average daily census for each hospital for each year of participation in the network was combined as the denominator for calculating injury rates. To assess the differential impact of the Needlestick Safety and Prevention Act of 2000, we calculated injury rates in surgical and nonsurgical settings before and after enactment of the law (1993 to 2000 versus 2001 to 2006) using a likelihood ratio test. We further compared the mechanism of device-specific injuries among different members of the surgical team to assess potential causal factors and project the potential impact of interventions.

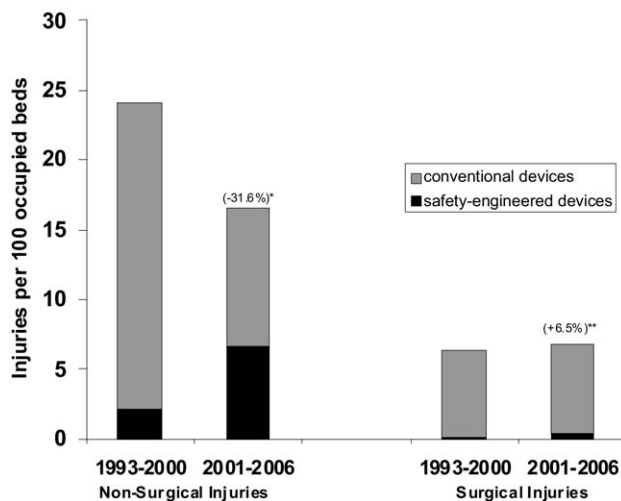


Figure 1. Injury rates in surgical versus nonsurgical hospital settings in the United States before and after the Needlestick Safety and Prevention Act of 2000. Data are from the Exposure Prevention Information Network (EPINet), International Healthcare Worker Safety Center, University of Virginia Health System. *Ratio of injury rates: 0.68 (95% CI 0.66 to 0.71); $p < 0.0001$. **Ratio of injury rates: 1.065 (95% CI 1.013 to 1.119); $p < 0.05$.

RESULTS

From 1993 to 2006, there were 24,138 percutaneous injuries reported in nonsurgical settings and 7,186 injuries in surgical settings. Of surgical injuries, 15.6% were to surgeons, 17.0% to surgical residents and fellows, 30.3% to operating room nurses, and 37.1% to surgical technicians (including surgery technicians, attendants, and ward assistants). The average daily census for each year for 87 hospitals combined was 111,030.

The comparative impact of the Needlestick Safety and Prevention Act of 2000 on injury rates in surgical versus all other settings is shown in Figure 1. In nonsurgical settings, during the prelegislation period, the injury rate was 24.1 per 100 occupied hospitals beds; this rate declined to 16.5 per 100 beds for the postlegislation period—a drop of 31.6% ($p < 0.0001$). Corresponding with this was an increase in the proportion of injuries associated with safety-engineered devices, indirectly reflecting the widespread adoption of safety devices. The highly significant overall decrease translates to a relative risk reduction effect from safety-engineered devices.

These findings contrasted with those from the surgical setting, where the proportion of injuries attributed to safety-engineered surgical devices was less than 1.0% before and after passage of the law, reflecting very low adoption of safety-engineered devices. In addition, the injury rate increased significantly, although to a smaller degree, from 6.3 to 6.8 injuries per 100 occupied beds ($p < 0.05$). (Not all hospitals contributed data for both periods; anal-

ysis of the subset of hospitals contributing during both periods [$n = 56$] reinforced the overall findings, with non-surgical decrease $p < 0.0001$ and surgical increase $p < 0.0001$.)

A large majority of injuries (72.7%) was associated with only 3 devices (Table 1). Suture needles were by far the most common cause of injury, accounting for 43.4% of all injuries; scalpel blades ranked second, accounting for 17.1%; disposable syringes accounted for 12.1%. The rank order of the top 3 devices was the same for all job categories. The remaining 27.3% of injuries were caused by a wide array of devices, mostly solid sharps used for cutting, clamping, retraction, and fixation.

Surgeons and surgical residents were most often the original users of devices causing their injuries (81.9% and 67.3% of injuries, respectively); conversely, nurses and surgical technicians were most often injured by devices originally used by others (77.2% and 85.1% of injuries, respectively). Most injuries to surgeons (71%) and surgical residents (66%) occurred during use of the device (Fig. 2). By contrast, injuries to nurses (75.3%) and surgical technicians (73.4%), occurred when passing or disassembling devices or during or after their disposal.

The mechanism of injury for suture needles, scalpels, and disposable syringes provides a basis for assessing the potential impact of device-specific interventions. Of these top 3 devices, suture needles are unique in that most injuries (54.0%) occur during their use (ie, during the act of suturing) (Fig. 3). However, for all 3 devices, the majority of injuries occur near the beginning of the use-disposal cycle—that is, during use, while passing the device, or between steps of a multistep procedure. Injuries during these early phases accounted for 83.5% of suture needle injuries, 69.8% of scalpel blade injuries, and 51.9% of injuries from disposable syringes. Only a small fraction of injuries, fewer than 4%, occurred during disassembly of suture needles and syringes. Attaching and removing blades from reusable handles caused a somewhat larger fraction of scalpel-related injuries (12.0%). A similar fraction of suture needle and scalpel blade injuries occurred after use, during or after disposal (11.3% and 14.4%, respectively); for disposable syringes, a larger proportion of injuries occurred during this latter phase of the cycle (29.3%). Recapping-related injuries occurred uniquely with syringes, accounting for 11.1% of syringe injuries.

DISCUSSION

Throughout the 1990s, devices with sharps injury protection were gradually and voluntarily adopted in US hospitals, until the Needlestick Safety and Prevention Act of 2000 was passed. Surveillance of percutaneous injuries in a

Table 1. Devices Most Frequently Causing Injuries to Surgical Personnel by Job Category

Device	Surgeons		Surgical residents		Nurses		Surgical technicians		All	
	n	%	n	%	n	%	n	%	n	%
Suture needle	566	51.5	670	55.1	746	35.2	1,082	41.4	3,064	43.4
Scalpel (reusable/disposable)	134	12.2	153	12.5	364	17.2	551	21.1	1,202	17.1
Disposable syringe	119	10.8	104	8.5	351	16.5	279	10.7	853	12.1
Wire	37	3.4	45	3.7	37	1.7	46	1.8	165	2.3
Retractors, skin/bone hooks	20	1.8	16	1.3	41	1.9	66	2.5	143	2.0
Electrocautery device	25	2.3	28	2.3	38	1.8	44	1.7	135	1.9
Intravenous catheter	19	1.7	19	1.6	69	3.3	11	0.4	118	1.7
Pin	14	1.3	16	1.3	41	1.9	30	1.1	101	1.4
Unattached hypodermic needle	10	0.9	9	0.7	33	1.6	26	1.0	78	1.1
Trocar	12	1.1	11	0.9	19	0.9	27	1.0	69	1.0
Pickup/forceps/hemostats/clamps	9	0.8	13	1.1	21	1.0	22	0.8	65	0.9
Bone cutter	15	1.4	7	0.6	9	0.4	26	1.0	57	0.8
Drill bit	9	0.8	8	0.7	8	0.4	26	1.0	51	0.7
Staples, steel sutures	8	0.7	4	0.3	14	0.7	22	0.8	48	0.7
Scissors	8	0.7	6	0.5	13	0.6	21	0.8	48	0.7
Other	94	8.5	110	9.0	317	14.9	337	12.9	858	12.2
Total	1,099*	99.9	1,219*	100	2,121*	100	2,616*	100	7,055	100

Data are from the Exposure Prevention Information Network (EPINet), International Healthcare Worker Safety Center, University of Virginia Health System. *Devices could not be identified in 23 injuries to surgeons, 6 to surgical residents, 54 to nurses, and 48 to surgical technicians.

network of US hospitals from 1993 to 2006 highlights the differential impact of that policy in surgical settings compared with nonsurgical settings.

Percutaneous injury rates decreased significantly outside the surgical setting following this Act, concomitant with widespread adoption of safety devices. No such decrease in rates occurred in the surgical setting (in fact rates increased), consistent with low rates of safety-device adoption. These findings suggest that the surgical setting, compared with the rest of the hospital, has been relatively unresponsive to the adoption of mandated occupational safety measures.

The majority of injuries occurred as the device was being used or passed. This underscores the importance of measures that either eliminate sharp instruments (such that there is no sharp as the task is being performed) or reduce risk during passing of sharp instruments through mechanical protection or use of the hands-free passing technique.

In the hierarchy of prevention strategies, elimination of sharp instruments, when possible, is the preferred approach. Makary and colleagues¹⁷ demonstrated the feasibility of reducing sharps use in surgical procedures. They re-

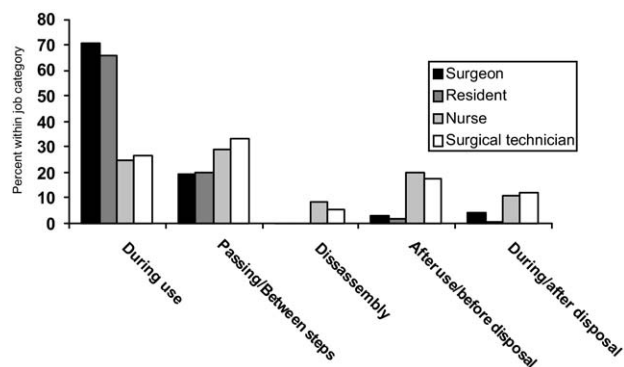


Figure 2. Mechanism of injury by job category of surgical personnel. Data are from the Exposure Prevention Information Network (EPINet), International Healthcare Worker Safety Center, University of Virginia Health System.

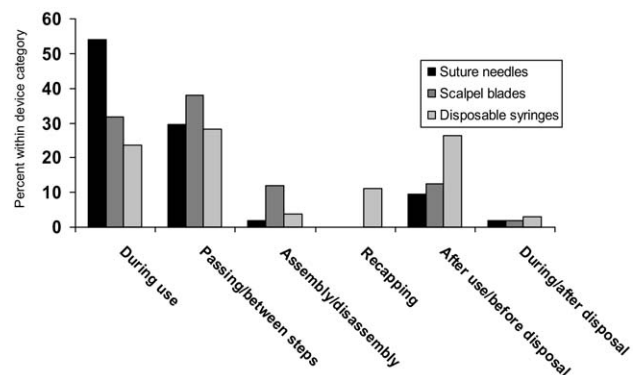


Figure 3. Mechanism of injuries caused by suture needles, scalpel blades, and disposable syringes. Data are from the Exposure Prevention Information Network (EPINet), International Healthcare Worker Safety Center, University of Virginia Health System.

ported that for 21% of procedures performed in a general surgery practice, sharps use was completely eliminated.

Focusing on suture needles as the predominant cause of injury in surgical settings presents the greatest opportunity for injury reduction in the operating room. Proven strategies for reducing suture needle injuries include substituting blunt suture needles for sharp ones when suturing less-dense tissues. Blunt suture needles have shown a high degree of efficacy in preventing injuries;¹⁸ one study estimated a potential 59% reduction in suture needle injuries by replacing sharp sutures with blunt ones for suturing muscle and fascia.⁷ That level of reduction in suture needle injuries, applied to this study, would have reduced the overall injury rate by 29.2%.

In 2005, the American College of Surgeons (ACS) issued a statement supporting “the universal adoption of blunt suture needles as the first choice for fascial suturing.”¹⁹ This was followed by a more comprehensive statement reaffirming the need for universal adoption of blunt suture needles.²⁰ This position is supported by the Occupational Safety and Health Administration and the National Institute for Occupational Safety and Health,²¹ the Association of periOperative Registered Nurses, and the Council on Surgical and Perioperative Safety.²² According to industry sources, adoption rates of blunt suture needles remain low, less than 5%, in the United States. By contrast, approximately one-third of general surgeons in Japan have adopted blunt suture needles for fascial closure (personal communication, Brett Sarnoff, Ethicon, Inc.). And in some sub-Saharan countries where risk of bloodborne pathogen exposure is extremely high, blunt suture needles have been adopted at much higher rates than in the United States.²³

Blunt suture needles are available in sizes and materials suitable for closure of muscle, fascia, and subcutaneous tissue. Their use involves a habituation period because there is mild to moderately increased pressure needed to drive the needle through tissue. A characteristic “pop” is felt as the blunt tip pierces the tissue. Surgeons can become comfortable with their use and learn to associate the feel of the needles with the use of a safer device—much like the secure feeling of wearing a seatbelt. For skin closure, other methods of minimizing exposure to sharp suture needles are available, including the use of tissue adhesives, adhesive strips, staples, and shielded suturing devices.^{7,24}

Across the spectrum of safety practices, the hands-free technique for passing sharp instruments—using a neutral zone rather than hand-to-hand passing—has shown effectiveness ranging from 35% to 59% in reducing sharps injuries in operations where blood loss is greater than 100 mL (lower for operations in which blood loss is less).^{24,25} The

American College of Surgeons, Association of periOperative Nurses and the Occupational Safety and Health Administration all explicitly support the use of hands-free passing in their statements on sharp safety. Yet the technique is rarely practiced in the United States.^{26,27}

However, this may be changing. Increasing use of local anesthesia in all operations makes disposable syringes nearly ubiquitous in the surgical field. The frequency of injuries to surgical team members from these devices may provide impetus to adopt the hands-free technique. So the majority of injuries from sharp suture needles can potentially be prevented by a combination of blunt suture needles, “sharpless” skin closure methods, and hands-free passing.

The safety scalpel device category is not so clear. Even fewer surgeons report using safety scalpels than blunt suture needles. Furthermore, most safety scalpels on the market are packaged in kits and used outside the operating room in locations like interventional radiology and the emergency department. There are still usability problems that deter surgeons from accepting the sheathed or retractable scalpel designs—issues that have been addressed by some, but not all manufacturers in current second generation scalpels. We did not feel that this device category was advanced enough to address because there are no data supporting or refuting the effectiveness of safety scalpels in reducing sharps injuries during surgery.

The need for teamwork in implementing surgical safety measures is emphasized by the finding that most injured members of the surgical team were not the original users of the devices causing their injuries. The attending surgeon has the leadership role for decisions that affect patient safety and outcomes, as well as the safety of all members of the surgical team. Ironically, in this study only 15.6% of reported injuries were to surgeons; the remaining 84.4% were to other members of the surgical team, all of whom have a tangible stake in decisions regarding devices and protocol. Protection of the surgical team, through the application of safety-engineered devices and techniques, has a potential for improved safety for health care workers and patients, and should be an integral component of any safety initiative.²⁸

The Needlestick Safety and Prevention Act of 2000 applies equally to surgical and nonsurgical settings. Yet, this study strongly suggests that compliance with its provisions is low in surgical settings and that preventable injuries continue unabated. There is a role for surgical educators and the Council for Graduate Medical Education in informing students about the use of surgical safety-engineered devices, alternative closure options, and safe passing techniques, with special attention to endorsement from sur-

geons currently using these with success. Educators must also instill the importance of a safety culture for patients and staff within the operating room setting. Hospitals must make safety for employees a priority. Hospital administrators and purchasing departments must also understand that compliance is mandatory, and that new devices are continually coming to the market and must be evaluated for adoption. Increased enforcement by the Occupational Safety and Health Administration or Joint Commission is one potential route to increased compliance. However, a primary commitment on the part of surgeons, along with cooperation and encouragement from operating room personnel and hospital administrators, to apply the considerable knowledge and available technology to substantially reduce this potentially life-threatening risk will be critical to progress.

Author Contributions

Study conception and design: Jagger, Berguer, Goma

Acquisition of data: Jagger, Parker

Analysis and interpretation of data: Jagger, Phillips, Berguer, Goma, Parker

Drafting of manuscript: Jagger, Berguer, Goma, Phillips

Critical revision: Phillips, Jagger

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