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Sharps Injuries in Medical Training: Higher Risk for Residents Than for Medical Students

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Sharps Injuries in Medical Training:

Higher Risk for Residents Than for Medical Students

by

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ABSTRACT

Because of their relative inexperience in performing procedures and handling sharps devices, medical students and resident physicians are considered to be at high risk for sharps injuries. A higher rate of sharps injuries for medical trainees implies a higher risk for occupationally-acquired infection with bloodborne pathogens and may have financial and legal implications for training institutions. This study examines the prevalence of sharps injuries among US medical students and resident physicians. A systematic review of the literature yielded 10 studies that gave data on sharps injuries for US medical students or residents, and those data were combined with data from our institution to produce pooled prevalences. Results from our institution showed that residents had a significantly higher risk of sharps injuries than medical students. While sharps injuries increased with students' years of training, residents' rates decreased with increasing level of training. Resident rates were highest in the department of Surgery and lowest for Pediatrics. Comparing pooled prevalences of US trainees revealed that residents were 6 times more likely than medical students to have a sharps injury. This information can be used by training programs to inform changes in residency training curricula and infection control policies, as well as to forecast Worker's Compensation and long-term disability insurance coverage requirements. Medical training institutions must continue to provide opportunities for students and residents to perfect their procedural skills, but at the same time, trainees must be protected from the risk of sharps injuries and exposure to bloodborne pathogens.

CHAPTER 1: INTRODUCTION

During the course of their training, medical students and resident physicians are commonly exposed to blood and body fluids. Exposures are generally classified as either mucocutaneous exposures (*e.g.*, splashes into the eyes or onto skin) or percutaneous exposures, which are skin-penetrating injuries with sharps such as needles or scalpels. Percutaneous exposures involving bloodborne pathogens, specifically hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) are a serious concern for physicians in training, as for all healthcare workers .[1] The World Health Organization's (WHO) risk assessment model predicts that each year 73,000 healthcare workers will become infected with a bloodborne pathogen after a sharps injury.[2] Recent studies from China,[3] Germany,[4] Canada,[5] Brazil,[6] and the United States (US)[7] concur that medical students have a high risk of exposure and as many as half of their sharps injuries go unreported to employee health services. Not as widely studied, but much more alarming, is the evidence that the sharps injury rate among resident physicians may be much higher than the rate for medical students, and as much as five times the rate for all healthcare workers.[8]

The possible consequences of elevated sharps injury rates for medical trainees can be far-reaching for training institutions. The institutions may face increased employee health expenditures and/or Worker's Compensation insurance premiums, increased scrutiny by federal agencies such as the Occupational Safety & Health Administration

(OSHA), and an increased number of occupationally-acquired infections with bloodborne pathogens. The cost of evaluating one healthcare worker's injury depends on the infectious status of the source patient: from $376 for a negative source up to $2,456 when the source patient is infected with HIV.[9] Unlike medical students, resident physicians are employees of the training institutions, whether universities or hospitals, and their injuries are generally covered by the institutions' Worker's Compensation insurance carriers. Also unlike medical students, residents are protected by OSHA regulations, including its Bloodborne Pathogens Standard, which outlines the control measures that employers must implement in order to "eliminate or minimize" the "significant health risk as the result of occupational exposure to blood and other potentially infectious materials."[1]

Based on a 2002 review of eight studies from US, United Kingdom, Scotland, Italy, India, and Australia, the mean rate of sharps injuries for all healthcare workers is 4.0 injuries per 100 workers.[10] The sharps injuries rate for medical trainees is not as well-defined because resident physicians' injuries are often included in the category of "physicians," which also includes attending physicians and surgeons, and, because medical students are not employees, their injuries may not be recorded on employee injury logs. Following the recommendations of the Centers for Disease Control and Prevention (CDC) for designing a sharps injury prevention program, establishing a baseline sharps injury rate is a critical step for training institutions in order to determine intervention priorities, develop action plans, and monitor program performance.[11]

The primary objective of this study was to test the hypothesis that resident physicians have a higher risk of sharps injury than medical students in the US. The study followed a three-step process for comparing the prevalences of sharps injures among US medical students and residents: 1) calculate the prevalence of sharps injuries at one institution (the University of South Florida); 2) conduct a systematic review of the literature to find the prevalence of sharps injuries among medical trainees at other institutions; and, 3) calculate pooled prevalences from our institutional data and the data from other institutions in order to compare sharps injury rates among US medical students and resident physicians. The secondary objectives are to define the relationships between sharps injuries in medical training and trainees' level of training and specialty, to reveal targets for interventions that will reduce the sharps injury rates among trainees, and to prompt further research toward improving the occupational health and safety at all medical training institutions.

CHAPTER 2: METHODS

Sharps Injuries Among Medical Students and Residents at USF

In December 2010, a retrospective cohort study to determine the prevalence of percutaneous exposures to bloodborne pathogens among medical students and residents began at the University of South Florida (USF) College of Medicine. A starting year of 2002 was selected because it was the first full calendar year that a sharps injury log was required to be kept under OSHA's Bloodborne Pathogens Standard, which was amended by the passage of the Needlestick Safety and Prevention Act in 2000.[12] An ending year of 2009 was selected because it was the last calendar year of completed logs at the time the study began. Inclusion criteria for the cohort were medical students and residents at USF for the academic years 2002-2008, corresponding to the dates of July 1, 2002 to June 30, 2009. All medical students and residents were considered to be equally at-risk for sharps injuries; none were excluded.

At USF, initial and annual training for medical students and resident physicians on bloodborne pathogens included details on the procedure for reporting exposures. Laminated badge cards with contact information for reporting exposures at each of the clinical training sites were distributed at initial training. All exposures to bloodborne pathogens by medical students or residents at USF-affiliated hospitals and outpatient clinics were reported to the USF Medical Health Administration Office for inclusion with other employee exposures in annual exposure logs. The logs' columns were labeled for date of exposure, code name for the employee, department, location, type of exposure, occupation, device involved (with safety features and manufacturer, if known), activity or brief description of the event, personal protective equipment, source patient's infectious status, and post-exposure prophylaxis. All columns were free-text entries; post-exposure prophylaxis was noted as yes or no, and if yes, whether or not the first dose was taken within 2 hours of the exposure.

The source for USF sharps injury data was the annual exposure logs. Copies of the logs were provided by the USF Medical Health Administration Office that only showed the columns for department, type of exposure, occupation, device, and activity. A line separated each year's exposures into Fall (July 1 – December 31) and Spring (January 1 – June 30) semesters; academic years spanned from Fall of one year to Spring of the following year. The study was approved by the University of South Florida's Institutional Review Board.

Cases were defined as medical students or residents who reported a percutaneous exposure described as a needlestick, puncture, cut, laceration, or scrape that occurred during the study period. The cases were entered onto an Excel spreadsheet by year and semester, "MS" or "PGY" for medical student or resident, respectively, plus year of training if given, department and device. Residents in the Medicine department included those in Internal Medicine, Family Medicine, Emergency Medicine, Dermatology, Neurology, and Physical Medicine, as well as fellows in all medical subspecialties. In addition to General Surgery residents, the Surgery department included residents and fellows in Otolaryngology, Urology, Orthopedic Surgery, Plastic Surgery, and Neurosurgery.

Prevalences of sharps injuries for medical students and residents were computed by dividing the total number of injuries by the number of trainees in each category over the study period. The annual prevalence of sharps injuries for medical trainees was computed by dividing the number of resident and student injuries by the total number of trainees in each academic year from 2002 to 2008. The number of injuries was divided by the number of trainees in each category to determine prevalence by level of training. Prevalence of resident sharps injuries by department were computed by dividing the number of injuries by the number of residents in each department over the study period. The frequencies of injuries by device were calculated by dividing the number of injuries for each category of device by the total number of exposures for which a device was recorded. Frequency tables were produced with Epi Info™ for Windows[13]; descriptive statistics were calculated in Excel. Mid-P exact 95% confidence intervals (95% CI) for proportions were calculated with OpenEpi version 2.3.1.[14]

To compare the prevalences of sharps injuries between groups of trainees and between departments, Mantel-Haentzel chi-square tests were used; odds ratios were calculated for significant differences. A chi square test for linear trend was used to evaluate for trends in sharps injuries by academic year and by resident level of training. Statistical tests were conducted with OpenEpi version 2.3.1.[11] For all tests, a p-value of <0.05 was regarded as significant.

Sharps Injuries Among Medical Students and Residents at Other US Institutions

A systematic review of the literature was used to identify studies that gave a prevalence of sharps injuries for medical students or residents at US training institutions and were published after the passage of the Needlestick Safety and Prevention Act of 2000. A PubMed search was conducted in March 2011 with the search strategy ("percutaneous exposure" OR needlestick OR sharps) AND (students OR interns OR residents OR house staff), limited by publication date since 1/1/2001. The search yielded 136 publications; all abstracts were reviewed. Publications involving settings outside of the US were excluded (99). Twenty-seven additional studies were excluded because they were: off-subject (8), reports that did not give a prevalence of sharps injuries for students or residents (8), studies of populations that did not include medical students or residents (6), letters to the editor or comments that did not qualify as research (4), or duplicate studies from the same population using the same instrument (1). Review of the full text of the 10 selected publications confirmed that each contained numerator and denominator data from which either point prevalence or period prevalence could be calculated. The following data was extracted from each study: author(s) and publication year, data source, study population, number of trainees assessed during the study period, and the number of sharps injuries reported. Also, the numbers and/or percentage of unreported injuries were noted from the survey studies that gave that data.

The prevalence of sharps injuries among medical students and residents from survey-based studies was calculated by dividing the total number of injuries by the total number of trainees in each category; the crude prevalence from exposure logs before adjustment for under-reporting was calculated in the same way. The mean under-reporting rate for each group of trainees was determined by dividing the total number of unreported injuries by the total number of sharps injuries given in survey studies. The under-reporting rates for students and residents were used to adjust the number of injuries from each study that gave data from exposure logs by dividing the number of injuries by the proportion of reporting (1- the under-reporting rate) for the corresponding category of trainee.

Pooled Prevalences of Sharps Injuries Among US Students and Residents

The pooled prevalence for each category of trainees was calculated by adding the number of injuries from survey studies and the adjusted number of injuries from exposure logs and dividing by the number of trainees in all studies. To compare the prevalences for medical students and residents, a Mantel-Haentzel chi-square test was used and an odds ratio was calculated with OpenEpi version 2.3.1.[11] A p-value of <0.05 was regarded as significant.

CHAPTER 3: RESULTS

Sharps Injuries Among Medical Students and Residents at USF

During the study period, 3142 students were enrolled at USF College of Medicine as first-year to fourth-year medical students. A total of 3982 resident physicians were employed in the departments of Medicine, Surgery, Obstetrics and Gynecology, Ophthalmology, Radiology, Pathology, Pediatrics, Psychiatry, and Anesthesiology. There were 839 employee exposures to infectious diseases reported during the study period: 662 (79%) percutaneous, 136 (16%) mucocutaneous, and 41 (5%) were other types of exposures to infectious disease. Of the percutaneous exposures, 86 (13%) occurred in medical students, 455 (69%) in residents, and 120 (18%) in other occupations. There were no reported infections with bloodborne pathogens over the study period.

Residents at USF were greater than 4.5 times more likely than medical students to have a sharps injury (OR=4.58, 95% CI 3.52-5.64). The period prevalence of sharps injuries for trainees at USF from 2002-2008 was 2.7% (95% CI 2.21 – 3.35%) for students and 11.4% (95% CI 10.47 – 12.44%) for residents. Student injuries by academic year demonstrated a significant decreasing trend from 2002 to 2004 (p=0.0082), then remained stable through the end of the study period (Figure 1). Resident injuries mirrored the students' decreasing trend from 2002 to 2004, then began a significant increasing trend through the end of the study period (p=0.0376).

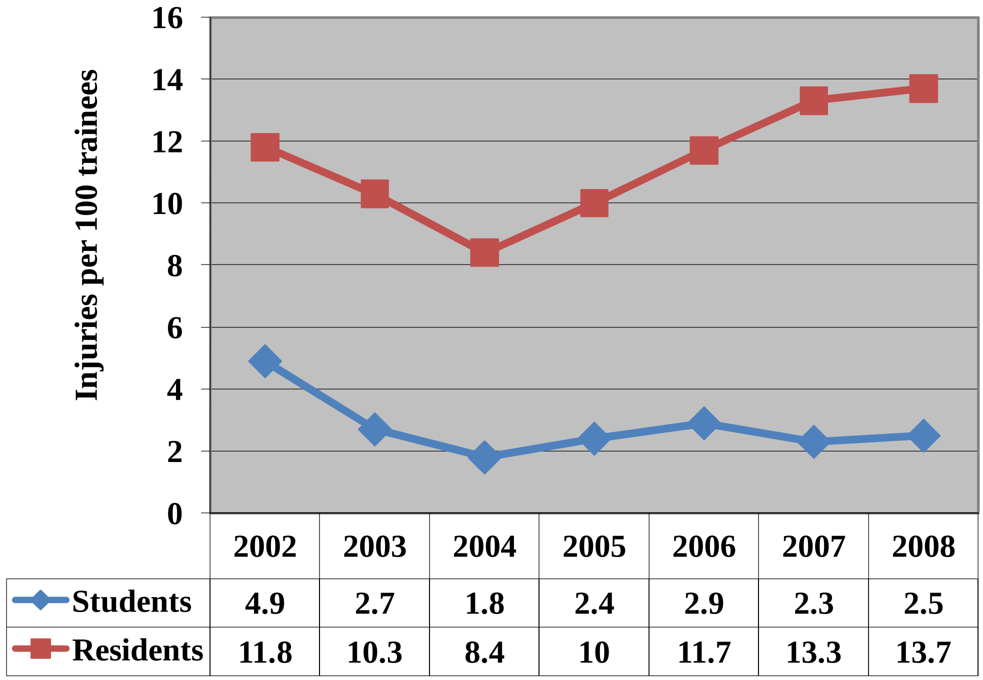

Figure 1: Annual rates of sharps injuries among USF medical students and residents for academic years 2002-2008.

For 75 (86%) of the injuries reported by medical students, the student's year of training was given. Injuries among first and second year students accounted for 8 (11%) and third and fourth year students had 67 (89%) injuries. Third and fourth year students were about 9.5 more likely to have a sharps injury than first and second year students (OR=9.47, 95% CI 4.54-19.82). For 421 (93%) of the resident injuries, the resident's post-graduate year of training was available. Sharps injuries by residents' level of training showed a statistically significant inverse dose-response relationship between post-graduate year and prevalence of sharps injuries (Figure 2; p=0.0002).

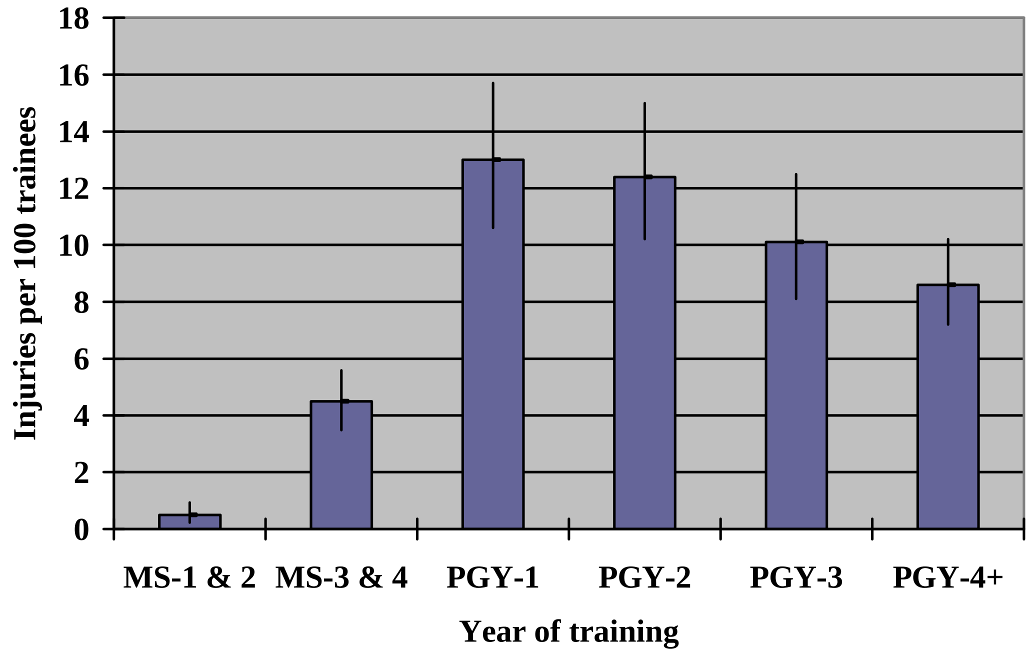

Figure 2: Sharps injuries by year of training for USF medical students (MS) and residents (PGY), shown with 95% CI.

For 450 (99%) of the injuries reported by residents, the resident's department was given. Residents in the Surgery department had the highest proportion of sharps injuries per number of residents, followed in decreasing rank by Obstetrics & Gynecology, Ophthalmology, Pathology, Anesthesiology, Medicine, Psychiatry, and Pediatrics. For all departments in which residents had at least one injury per year, the risk of sharps injury for residents was significantly higher than for medical students (Table 1). Residents in Pediatrics had only 3 sharps injuries over the 7-year study period, which gave them a significantly lower risk than medical students (p=0.0055).

Table 1: Prevalence of sharps injuries among USF trainees by department.

Department	Trainees (%) n=7124	Sharps injuries (%) n=536	Injuries per 100 trainees (95% CI)	Odds Ratio	95% Confidence Interval
COM (medical students)	3142 (44%)	86 (16%)	2.8 (2.2 – 3.4)	1.0 (baseline)	
Surgery	695 (10%)	198 (37%)	28.5 (25.3 – 32.0)	14.16	10.8, 18.6
OB/GYN	174 (2%)	44 (8%)	25.3 (19.4 – 32.3)	12.03	8.0, 18
Ophthalmology	83 (1%)	16 (3%)	19.3 (12.1 – 29.2)	8.5	4.7, 15.3
Pathology	135 (2%)	24 (4.5%)	17.8 (12.2 – 25.2)	7.7	4.7, 12.6
Anesthesiology	292 (4%)	51 (10%)	17.5 (13.5 – 22.3)	7.5	5.2, 10.9
Medicine	1691 (24%)	99 (18.5%)	5.9 (4.8 – 7.1)	2.21	1.7, 3.0
Radiology	246 (4%)	13 (2%)	5.3 (3.0 – 8.9)	1.98	1.1, 3.6
Psychiatry	236 (3%)	2 (<1%)	0.8 (0.0 – 3.2)	0.30	0.1, 1.2
Pediatrics	430 (6%)	3 (1%)	0.7 (0.1 – 2.1)	0.25	0.1, 0.8

There were 494 (91%) injuries for which a device was recorded: 214 (43%) involved suture needles, 125 (25%) hollow-bore needles, 79 (16%) scalpels, and 41 (8%) surgical instruments or hardware. The remaining 35 (7%) devices implicated were staples, lancets, bone, glass, and solid-bore needles. The majority of injuries among residents in Surgery and Obstetrics & Gynecology involved suture needles, while the majority of Pathology residents' injuries involved scalpels. Hollow-bore needles were the most commonly reported device for the departments of Ophthalmology, Anesthesiology, Medicine, and Radiology (Figure 3). Residents in the departments of Pediatrics and Psychiatry had too few injuries to be classified by device.

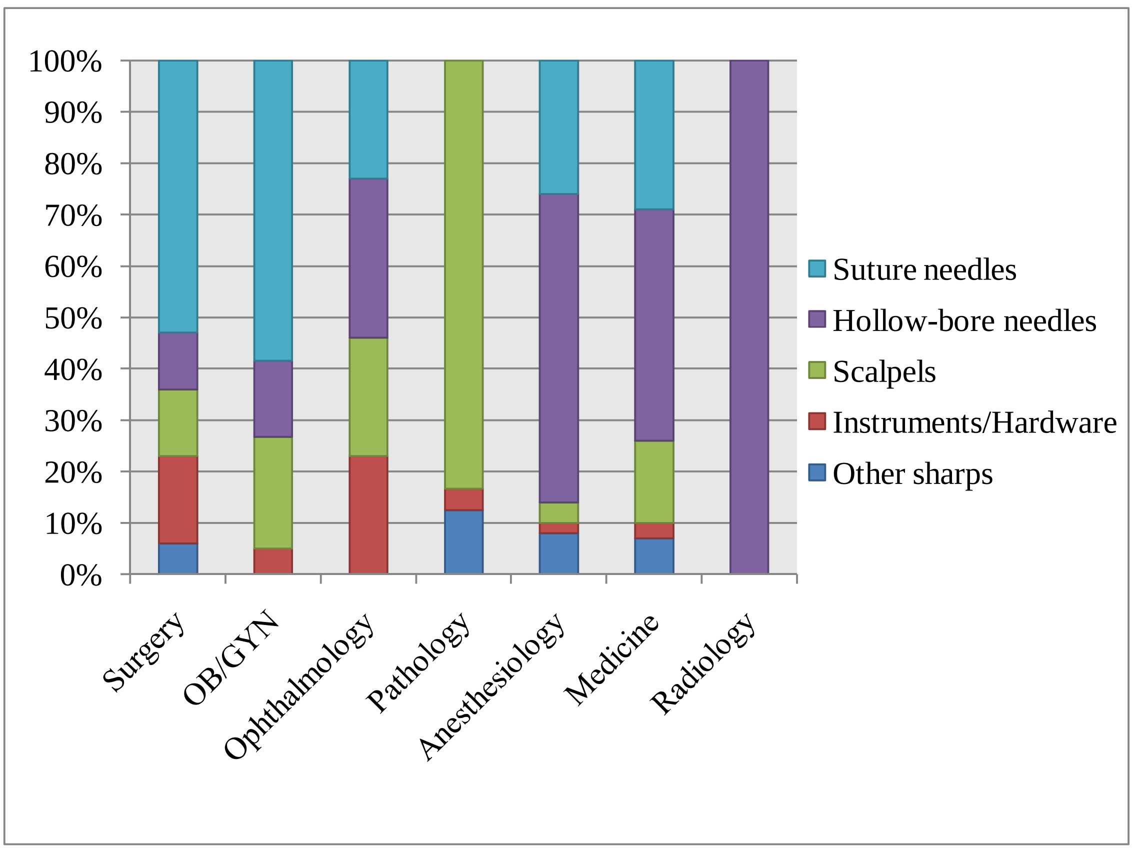

Figure 3: Distribution of sharps injuries by device for USF residents in the departments of Surgery, Obstetrics & Gynecology, Ophthalmology, Pathology, Anesthesiology, Medicine, and Radiology.

Sharps Injuries Among Medical Students and Residents at Other US institutions

Of the 10 studies selected for data acquisition, 6 were survey-based studies: 3 of medical students, 2 of residents, and 1 included medical students and residents in additional to other healthcare workers (Table 2). Mean prevalences of sharps injuries from the survey-based studies was 20.6% (95% CI 17.15 – 24.37%) for students and 31.8% (95% CI 30.3 – 33.37) for residents. Five of six survey-based studies gave a number and/or percentage of injuries that were not reported to employee health services. The overall proportion of unreported student injuries was 44.4% (95% CI 34.89 – 54.32%), and residents failed to report 46.3% (95% CI 43.42 – 49.24%) of their injuries. The difference in proportion of unreported injuries for students compared to residents was not statistically significant (p=0.4333).

The data source for the other 4 selected studies was institutional exposure logs: 2 included numerator and denominator data for medical students, and 2 for residents. The crude sharps injury rate calculated from studies based on exposure log data was 3.3% (95% CI 3.01 – 3.63%) for students and 18.5% (95% CI 17.28 – 19.67%) for residents.

Pooled Prevalences of Sharps Injuries Among US Students and Residents

Including USF data and adjusting the number of injuries from exposure logs for under-reporting, the pooled prevalence of sharps injuries among US medical trainees is 6.6% (95% CI 5.82 – 6.57%) for medical students, and 29.1% (95% CI 28.25 – 29.91%) for resident physicians. Residents are over 6 times more likely to have a sharps injury than medical students (OR=6.22, 95% CI 5.77 – 6.71).

Table 2: Studies assessing sharps injuries among US medical students and resident physicians published since 2001.

Author(s), Year of Publication	Study population	Data source	# of Trainees	# of Injuries	# (%) of Unreported Injuries
Birenbaum et al,[15] 2002	3rd-year medical students from University of Florida	Survey	119	24	14 (58%)
Patterson et al,[16] 2003	3rd & 4th-year medical students at Washington University School of Medicine	Survey	143	59	24 (41%)
Chen et al,[17] 2008	3rd-year medical students at New York-Presbyterian Hospital/Weill Cornell Medical Center	Survey	75	7	Not given
Kessler et al,[18] 2011	Healthcare workers at the University of Illinois Medical Center (Medical students' data shown)	Survey	144	9	6 (67%)
Ayas et al, [19] 2006	Interns in US residency programs	Survey	2737	498	209 (42%)
Makary et al,[20] 2007	Surgery residents at 17 residency training programs	Survey	699	582	297 (51%)
Kessler et al,[18] 2011	Healthcare workers at the University of Illinois Medical Center (Residents' data shown)	Survey	106	47	16 (34%)
					Best estimate for # of injuries, adjusted for under-reporting
Trape-Cardoso & Schenck,[21] 2004	Healthcare workers at University of Connecticut (Medical & dental students' data shown)	Exposure logs	2445	142	255
Askew[22] 2004	Students at medical schools in Virginia (Data shown for Eastern Virginia Medical School & the University of Virginia School of Medicine)	Exposure logs	10131	274	493
Current study	Medical students at University of South Florida	Exposure logs	3142	86	155
Dement et al,[23] 2004	Healthcare workers at Duke University Health System (Residents' data shown, number of injuries calculated from rate and FTE's)	Exposure logs	3792	626	1166
Brasel et al,[24] 2007	Surgical residents at Medical College of Wisconsin	Exposure logs	240	118	220
Current study	Residents at University of South Florida	Exposure logs	3982	455	847

CHAPTER 4: DISCUSSION

Despite the estimated 1,000 sharps injuries that occur every day among US healthcare workers,[25] infection with a bloodborne pathogen is sufficiently rare to be considered an occupational sentinel health event.[26] As of 2006, only 57 cases of occupationally-acquired infection with HIV in the US had been confirmed by the CDC, with another 140 deemed “possible” cases,[27] About 400 US healthcare workers contract HBV on the job each year;[28] the number who become infected with HCV is predicted to be 390 per year.[2] The WHO risk assessment model uses four variables to predict the number of occupationally-acquired infections with HBV, HCV, and HIV: the prevalence of infection in the general population, the susceptible proportion of healthcare workers, the risk of transmission after exposure, and the rate of sharps injuries.[2] The latter 3 variables are directly amenable to prevention strategies: the susceptible proportion of healthcare workers is decreased by vaccination against HBV, the risk of transmission after exposure to HBV and HIV is reduced by post-exposure prophylaxis, and the sharps injury rate can be reduced by training and safety-engineered sharps.

Variations in the sharps injury rate can greatly affect the predicted incidence of occupationally-acquired infections. For example, holding all other variables constant in the WHO equation, a 4 times higher sharps injury rate (as demonstrated for residents in this study) yields a 3-fold increase in the incidence of infection. This is a risk assessment tool; there is no data to confirm that the rate of infection is higher for residents than for other healthcare workers. However, this information should be used by training institutions to inform changes in residency training curricula and infection control policies, as well as to forecast Worker's Compensation and long-term disability insurance coverage requirements.

A limitation of our study is that data from survey-based studies was combined with exposure logs and the two data sources present two distinct types of error. Survey-based studies are subject to recall bias, while exposure logs reflect only the injuries that were reported and therefore are subject to "under-reporting." To account for under-reporting, the number of injuries from exposure logs was adjusted by the average proportion of unreported injuries indicated in the survey studies of US medical trainees. The survey studies revealed that both medical students and residents fail to report about half of their injuries. Birenbaum et al[15] found that third year medical students did not report the exposures that they deemed "too trivial." Kessler et al[18] also found that the most common reason for not reporting an exposure was the healthcare worker's perception that the exposure was "low risk."

Understanding and addressing the reasons that trainees give for not reporting injuries is an important component in reducing the risk of infection after a sharps injury. While bloodborne pathogens training must include information on the risk of transmission of bloodborne pathogens from sharps injuries, it should also address any misconceptions about the risk of infection. For example, training should stress that reporting the exposure allows for testing of the source patient's blood, which is the only way to define the risk of infection; trainees should never assume that the patient is "low risk." Another benefit of reporting a sharps injury is that it allows the injured trainee to receive counseling and evaluation for effective post-exposure prophylaxis. Even though 96% of MD-granting schools in the US require trainees to be vaccinated against HBV, only 56% check titers on all students.[29] Therefore, reporting a sharps injury is an opportunity to test the trainee for protective antibodies against HBV in order to detect the 5-10% who does not develop detectable antibodies.[30] If the trainee has inadequate protective antibodies, he/she should be given hepatitis B immune globulin and a second vaccine series, which are 75% effective in preventing transmission.[31] Post-exposure prophylaxis against HIV with anti-retroviral agents reduces the risk of transmission by 81%.[32]

Under-reporting is the most likely explanation for the difference in prevalences between exposure logs and survey data; however, differences in study populations may also have had an effect. Specifically, the survey-based studies of medical students included primarily third and fourth year medical students, while exposure log studies included medical students in all years of training. Our data showed that third and fourth year “clinical” students had a significantly higher prevalence of sharps injuries than their first and second year “pre-clinical” counterparts. This is most likely explained by the fact that third and fourth year students have many more opportunities to handle and contact sharps devices while on their clinical clerkships compared to first and second year students who are primarily involved in classroom learning. However, because trainees remained anonymous, we were not able to correlate sharps injuries with the number of opportunities for sharps contact or to assess for “time at risk” among trainees.

Another consequence of healthcare workers not reporting sharps injuries is the lost opportunity to gather information about potentially risky work settings. The development of safety interventions can be guided by an understanding of the details of incidents, such as the procedure being performed, the amount of assistance or supervision provided, and the location of the sharps at the time of injury. Fixing “problem” procedures may require introducing safety-engineered devices, which has been shown to be effective in reducing the rate of sharps injuries during phlebotomy.[33] Inadequate supervision during procedures has been implicated as a factor in sharps injuries among medical trainees, specifically the practice of “see one, do one, teach one,” and was improved upon at one institution by using a faculty-supervised procedures rotation.[34] Finally, information about the location of the sharp device at the time of injury has prompted simple and effective interventions such as relocating sharps disposal bins closer to the bedside,[35] and promoting “hands-free” hand-off techniques in the operating room[36]. A limitation of the data from USF used in this study is that information about the injured trainees’ activity during the incident was not obtained.

A higher risk for sharps injuries among medical trainees has been attributed to several intrinsic and extrinsic factors. Factors intrinsic to healthcare workers that have been associated with an increased risk for sharps injuries include age younger than 45,[23] having less than 4 years on the job,[23] and feeling fatigued while handling sharps.[37] Extrinsic risk factors include long work hours,[19,38] working during night shift,[19,39] and working in operating rooms.[23,40] Most of these factors apply to medical trainees in that they are typically young and inexperienced and work as many as 80 hours a week with overnight call. In addition to having increased opportunities for contact with sharps while working in operating rooms, surgical residents may also encounter a relative lack of available safety-engineered sharps.[41]

Our analysis of resident injuries by device and department revealed specialty-specific risks: medical residents were more likely to injure themselves with hollow-bore needles, but surgical residents were more likely to injure themselves with suture needles. A wide variety of hollow-bore needles on syringes with engineered safety features were available at the clinical training sites in this study; however, blunt suture needles were not used in any of the sites. Since the passage of the Needlestick Safety and Prevention Act of 2000, which required the evaluation and implementation of safety-engineered devices by employers, the significant decrease in sharps injury rates among non-surgical settings has been credited to the widespread implementation of safety-engineered devices.[41] In contrast, the sharps injury rates have increased in surgical settings, corresponding to the very low adoption of blunt suture needles.[41] Training institutions should focus on "closing the loop" by bringing this information to their Surgery departments and assisting in the development of effective safety interventions, such as launching pilot programs for the use of blunt suture needles, encouraging double gloving, and establishing a policy for using hands-free techniques for passing sharps in the operating room.[42]

Using the argument that trainees who spend more time handling sharp devices would have more sharps injuries, it would follow that residents at higher levels of training would be expected to have the most sharps injuries. For example, surgery chief residents typically perform 250 surgeries during their PGY-5 year,[43] and interventional cardiology fellows must perform at least 250 interventional cardiac procedures in their PGY-7 year. [44] The hypothesis that higher level residents have higher rates of sharps injuries was supported by the study by Makary et al[20] in which the mean total number of sharps injuries among surgery residents increased according to post-graduate year.

However, Brasel et al[24] found the opposite - the rate of sharps injuries decreased with residents' level of training, even though the number of operative cases increased. There are at least two possible explanations for this disagreement: 1) Because the study by Makary et al[20] asked residents if they were "ever" exposed, the rates in that study reflected lifetime prevalence rather than an annual rate as in the Brasel et al[24] study; and, 2) The Makary et al[20] study included surgery residents from 17 programs, while Brasel et al[24] involved residents from one program, and senior residents at that program may have performed more operative cases than at other programs.

Our study agrees with the finding by Brasel et al[24] that the risk of sharps injuries decreases with increasing level of training. In the Brasel et al[24] study, not only did senior residents report fewer sharps injuries than junior residents, but attending surgeons reported an "extremely low number" of sharps injuries. This finding was used to suggest a "protective effect of experience" and prompts the hypothesis that there is a point at which procedural competency overcomes the potential increased risk of sharps injury that is due to having more opportunities for contact with sharps. Research is ongoing to determine how that point of competency can be measured, promoted, and reached earlier in training. A promising field of study is the use of simulation-based training for procedural skills, which eliminates the risks to both patients and trainees of learning procedures on patients, and has been shown to improve standardized learning outcomes.[45] After using simulator training for central line insertion, residents showed improved procedural performance and reported an increased level of comfort with the tasks involved.[46,47]

A surprising finding in our study was the low number of sharps injuries among USF pediatrics residents, which suggests that there may be features of the USF Pediatrics residency program that are effective in reducing the risk of sharps injuries. Pediatrics residents at USF had the lowest prevalence of sharps injury by department and were the only group of residents to show a lower risk of sharps injuries compared to medical students. In comparison, pediatrics residents in the studies by Ayas et al[19] and Dement et al[23] had rates comparable with medicine residents; pediatrics was below the average resident rate, but not the lowest rate by department. Unlike other residents at USF, residents in Pediatrics spend a large part of their training at a specialty children's hospital, which may have a different program for sharps safety prevention than the other clinical training sites. Also of interest, the department of Pediatrics is the home of the Team Education and Multi-disciplinary Simulation (TEAMS) Center, where residents train in simulated medical scenarios and practice procedures such as umbilical catheter insertion and ultrasound-guided central line placement on high-fidelity patient simulators.[48] Whether or not program differences are to credit for the low occurrence of sharps injuries among USF pediatrics residents requires further study.

While training institutions carry an ethical duty to keep medical students safe during their training, as employers of resident physicians, they are legally bound to protect residents against occupationally-acquired infection with bloodborne pathogens. The duty of training institutions to provide evaluation and treatment for medical students' sharps injuries is advocated by the American Association of Medical Colleges, a non-profit group of medical schools, training hospitals, and academic societies.[49] In contrast, the requirement to protect residents rests with OSHA, whose regulations are enforceable as law, and who has issued specific directives for employers to take action to prevent sharps injuries.[50] Training institutions must continue to provide ample opportunity for medical students and residents to perfect their procedural skills, but at the same time, the trainees must be protected from the risk of sharps injuries and exposure to bloodborne pathogens.

The interventions required by specific institutions should be guided by their own program assessment. An indispensible resource is the CDC's Workbook for Designing, Implementing and Evaluating a Sharps Injury Prevention Program, which outlines a 6-step process for healthcare facilities to follow toward the goal of preventing sharps injuries among healthcare workers.[11] The methods of this study best correspond with Step 3 (Prepare a Baseline Profile of Sharps Injuries), which is necessary for the next step of determining intervention priorities. Our analysis revealed priorities based on frequency of injuries as residents over medical students, surgical residents over medical residents, and junior residents over senior residents.

At USF, residents in the department of Surgery most often injured themselves with suture needles. A proposed intervention for the next step in the process (Develop and Implement Action Plans), centers on creating pilot programs for implementing blunt suture needles in the department of Surgery, along with an educational program on the indications and use of the needles. Specific targets should be defined, and may be focused on reducing the number of injuries, such as "Within one year of implementing the use of blunt suture needles, the Health Administration Office will detect a 25% reduction in the number of suture needle injuries among surgery residents." Alternatively, the goals may focus on performance measures, such as "Within one year, the Surgery department will use blunt suture needles in 80% of the cases that meet criteria for their use."

The final step involves monitoring program performance, so that at the end of the specified time period, there is an assessment of whether or not an intervention has met its objectives. Multiple interventions may be ongoing in a single institution with overlapping timelines, and multiple training institutions may implement similar interventions. Equipped with the knowledge that residents have a significantly elevated rate of sharps injuries compared to medical students, training institutions should now prioritize interventions aimed at reducing the number of sharps injuries among residents. Finally, individual institutions should be encouraged to publish their outcomes so that the knowledge can be shared by all healthcare facilities for the benefit of all healthcare workers at risk of sharps injuries.

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