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# DIFFERENCES IN PERCUTANEOUS INJURY PATTERNS IN A MULTI-HOSPITAL SYSTEM

Hilary M. Babcock, MD; Victoria Fraser, MD

## ABSTRACT

**OBJECTIVE:** Determine differences in patterns of percutaneous injuries (PIs) in different types of hospitals.

**DESIGN:** Case series of injuries occurring from 1997 to 2001.

**SETTING:** Large midwestern healthcare system with a consolidated occupational health database from 9 hospitals, including rural and urban, community and teaching (1 pediatric, 1 adult) facilities, ranging from 113 to 1,400 beds.

**PARTICIPANTS:** Healthcare workers injured between 1997 and 2001.

**RESULTS:** Annual injury rates for all hospitals decreased during the study period from 21 to 16.5/100 beds (chi-square for trend = 22.7;  $P = .0001$ ). Average annual injury rates were higher at larger hospitals (22.5 vs 9.5 PIs/100 beds;  $P = .0001$ ). Among small hospitals, rural hospitals had higher rates than did urban hospitals (14.87 vs 8.02 PIs/100 beds;  $P = .0143$ ). At small hospi-

tals, an increased proportion of injuries occurred in the emergency department (13.7% vs 8.6%;  $P = .0004$ ), operating room (32.3% vs 25.4%;  $P = .0002$ ), and ICU (12.3% vs 9.4%;  $P = .0225$ ), compared with large hospitals. Rural hospitals had higher injury rates in the radiology department (7.7% vs 2%;  $P = .0015$ ) versus urban hospitals. Injuries at the teaching hospitals occurred more commonly on the wards (28.8% vs 24%;  $P = .0021$ ) and in ICUs (11.4% vs 7.8%;  $P = .0006$ ) than at community hospitals. Injuries involving butterfly needles were more common at pediatric versus adult hospitals (15.8% vs 6.5%;  $P = .0001$ ). The prevalence of source patients infected with HIV and hepatitis C was higher at large hospitals.

**CONCLUSIONS:** Significant differences exist in injury rates and patterns among different types of hospitals. These data can be used to target intervention strategies (*Infect Control Hosp Epidemiol* 2003;24:731-736).

Healthcare workers have a long history of exposure to blood-borne pathogens through traumatic sharps injuries and other body substance exposures. The Centers for Disease Control and Prevention estimated in 1995 that 600,000 to 800,000 percutaneous injuries occur per year, an average rate of 30 injuries per 100 hospital beds each year,<sup>1</sup> although a more recent estimate suggested more than 385,000 injuries per year.<sup>2</sup> Methods to reduce exposures initially focused on barrier strategies and educational interventions, but have more recently focused on the use of safer devices.

Recently, legislation was passed, first in California and then nationally with a federal bill signed in November 2000, mandating the use of safer devices, but it is not yet clear how this legislation will affect injury rates.<sup>3-6</sup> Virtually all of the new "safety devices" cost substantially more per device than do traditional devices. These devices vary considerably by the manufacturer: some are "active," some are "passive," and some require different techniques for use as compared with traditional devices. Choosing which prevention strategies are

most appropriate for a specific hospital can be challenging.

Most published reports on the epidemiology of needlestick injuries are from single institutions, predominantly large, urban, academic medical centers; however, more than 50% of patient discharges in the United States are from nonteaching facilities.<sup>7</sup> The reporting hospitals of the National Surveillance System for Hospital Healthcare Workers (NaSH) and EpiNET networks are mostly large, adult hospitals. Few data exist on the rates and distribution of percutaneous injuries in small, rural, community, and pediatric hospitals. These hospitals are under the same mandate from the government to implement safer devices, but have less available information about the risks to their healthcare workers.

We reviewed all percutaneous injuries occurring from 1997 to 2001 at nine midwestern hospitals, large and small, adult and pediatric, teaching and community, and urban and rural, to define the differences in occurrences of percutaneous injuries among various types of hospitals.

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**TABLE 1**  
DESCRIPTION OF THE NINE HOSPITALS FROM WHICH  
PERCUTANEOUS INJURY INFORMATION WAS REVIEWED

Hospital	Setting	Type	Average No. of Percu- taneous Injuries per Year (1997–2001)	No. of Beds*	Average No. of Percu- taneous Injuries per 100 Beds*
1	Urban	Teaching (adult)	354.6	1,400	25.3
2	Urban	Community	12.8	222	5.8
3	Urban	Community	14.6	111	13.1
4	Urban	Community	27.2	113	24.1
5	Urban	Teaching (pediatric)	56.8	235	24.2
6	Urban	Community	101.2	698	14.5
7	Rural	Community	9.2	58	15.9
8	Urban	Community	80.6	494	16.3
9	Rural	Community	19.2	133	14.4

\*For analysis, hospitals were considered "large" if they had more than 250 beds.

## METHODS

Barnes–Jewish Christian HealthCare system includes 13 acute care hospitals, 6 long-term-care facilities, and multiple affiliated outpatient care settings. We reviewed all percutaneous injuries occurring between January 1, 1997, and December 31, 2001, at 9 of the acute care hospitals (Table 1), which all report body substance exposures into a common occupational health database. The occupational health nurses of these 9 hospitals all participate in the Barnes–Jewish Christian occupational health nurse council, which coordinates occupational health and safety surveillance and interventions throughout this healthcare system.

The Occupational Health Service has a computerized network and database for tracking employee injuries and exposures. Each hospital's individual occupational health specialists use common data collection tools and definitions for body substance exposures. The database includes demographic and job information on each employee sustaining an exposure, as well as information on the exposure itself, including the location, activity, device, and serologic results of tests performed on the source patient. Choices for each field are offered from a drop-down menu, including codes for location of the injury, job description of injured personnel, and activity being performed at the time of injury. Text fields are available if the injury does not fall into any of the offered categories. Attending physicians are employees of the medical school, which has a separate occupational health office, and are therefore not included in this database.

De-identified data were downloaded from this data-

base for analysis. Data review and cleaning was performed in SPSS software (version 10 for Windows; SPSS, Inc., Chicago, IL). Rates of injury were calculated per 100 beds annually for each hospital, for all hospitals, and for each group of hospitals by category. The denominator of 100 beds was chosen as a crude adjustment for patient volume. It was also selected because it is easily obtained by all institutions, making comparisons with reported rates easier. We also compared rates over time for each hospital using injuries per 1,000 patient-days, 100 employees, and 100,000 productive hours worked. Although each denominator choice obviously changed the actual calculated rates, the trend over time was the same. The denominator was used only for annual rate reports; subsequent analysis was performed by comparing the proportion of injuries in specific categories at each facility (ie, the proportion of injuries sustained by nurses at each facility).

During the study period, several safety devices were introduced. Standard sharps disposal boxes were introduced in 1997. Needleless intravenous tubing and safety intravenous insertion catheters were introduced in 1998 and 1999. Safety butterfly needles were introduced in 2000 and 2001. With the introduction of the safer disposal boxes and the needleless intravenous tubing, the old equipment was completely removed from each facility. With the introduction of the safety intravenous insertion catheters and butterfly needles, some old equipment was retained in each facility for uses such as arterial line insertion, for which no satisfactory safer device had yet been identified. These devices were selected for initial replacement based on the high risk of the injuries with which they were usually associated. In our system, syringes, although associated with a larger number of injuries, were primarily used for intramuscular injections and not for phlebotomy; the injuries they caused were usually lower risk for blood-borne pathogen transmission.

Hospitals were grouped into several categories for comparison: large versus small, urban versus rural, teaching versus community, and pediatric versus adult. Large hospitals were defined as having more than 250 beds. As there are no large rural hospitals in the system, urban and rural comparisons were made among the small hospitals only. The two teaching hospitals each support at least one residency program. The pediatric hospital has a large housestaff training program (69 residents), and surgical and emergency medicine residents also rotate there. The adult teaching hospital has internal medicine, surgery, obstetrics and gynecology, neurology, psychiatry, pathology, and emergency medicine residencies.

Variables used for comparison include the location where the injury occurred, the job of the injured employee, the equipment implicated in the injury, the activity being performed at the time of injury, and source-patient serologies for blood-borne pathogens. Comparisons between groups were made with the chi-square or Fisher's exact test, using a *P* value of less than .05 to indicate statistical significance on two-tailed testing. The Bonferroni correction for multiple comparisons was performed for each

group of comparisons. Trends over time were analyzed with a chi-square test for linear trend calculation, with a *P* value of less than .05 considered as significant. Approval was obtained from the Washington University School of Medicine Human Subjects Committee for a waiver of informed consent from subjects as all data were de-identified and analysis was performed on preexisting data.

## RESULTS

During the study period, annual injury rates for all 9 hospitals combined declined from 21 percutaneous injuries per 100 beds to 16.5 injuries per 100 beds (chi-square test for linear trend = 22.7; *P* = .0001). Average annual injury rates at large hospitals were significantly higher than those at small hospitals (22.5 vs 9.5 injuries per 100 beds; *P* = .0001). Among the small hospitals, rural hospitals had higher average annual injury rates than did urban hospitals (14.87 vs 8.02 injuries per 100 beds; *P* = .0143), and teaching hospitals had higher rates than did community hospitals (24.5 vs 14.5 injuries per 100 beds; *P* = .0001). Average annual rates at the pediatric hospital were higher than those at the adult hospitals, but the difference did not reach statistical significance (24.2 vs 18.9 injuries per 100 beds; *P* = .1063). Rates at the two teaching facilities, one pediatric and one adult, were similar (24.2 vs 24.6; *P* = .9256).

At the 9 study hospitals, there were 3,381 percutaneous injuries during the 5-year study period (Table 2). More than half of the injuries (1,773; 52.4%) occurred at the largest hospital, a tertiary-care teaching facility with 1,442 beds (41.1% of the 3,506 beds in all 9 hospitals). The most commonly injured personnel were nurses (1,498 injuries; 44.3%). Housestaff were the second most commonly injured group overall (551 injuries; 16.3%), although they primarily work only at the two teaching hospitals. Overall, injuries occurred most frequently in the operating room or on the wards.

With the use of information from all 9 hospitals, of the 2,492 source patients tested for hepatitis C, 213 (8.5%) were positive. Of the 2,522 source patients tested for human immunodeficiency virus (HIV), 55 (2.2%) were positive. Of the 2,482 source patients tested for hepatitis B surface antigen, 29 (1.2%) were positive. Six source patients had both HIV and hepatitis C. Four source patients were positive for HIV and hepatitis B surface antigen. Four source patients had hepatitis B and hepatitis C. One source patient had HIV, hepatitis B, and hepatitis C.

Comparisons were made between the large and small hospitals (Table 3). During the 5-year study period, 2,682 percutaneous injuries occurred at the large hospitals (2,634 beds combined), and 699 occurred at the small hospitals (872 beds combined). The locations where injuries were likely to occur differed between the two groups of hospitals. The proportion of injuries that occurred on the wards was higher at large hospitals (29.9% vs 15.7%; *P* = .0001). Small hospitals had a higher proportion of injuries occurring in their emergency departments (13.7% vs 8.6%; *P* = .0001) and operating

**TABLE 2**  
DEMOGRAPHICS OF ALL PERCUTANEOUS INJURIES AT THE NINE HOSPITALS, 1997–2001 (N = 3,381)

Characteristic	No. of Injuries (%)
Type of hospital	
Teaching hospitals (1,677 beds)	2,057 (60.8)
Community hospitals (1,829 beds)	1,324 (39.2)
Large hospitals (> 250 beds)	2,682 (79.3)
Small hospitals	699 (20.7)
Small rural hospitals	142 (20.3)
Small urban hospitals	557 (79.7)
Pediatric hospital (235 beds)	284 (8.4)
Location in hospital	
Medical and surgical floors	911 (26.9)
Operating rooms	908 (26.9)
Intensive care units	338 (10.0)
Emergency departments	326 (9.6)
Job status of injured HCW	
Nurse	1,498 (44.3)
Housestaff physician	551 (16.3)
Operating room personnel	225 (6.7)
Unit/nursing assistant	189 (5.6)
Housekeeping	163 (4.8)
Activity being performed when injured	
Phlebotomy	460 (13.6)
Sharps disposal	451 (13.3)
Operating (other than suturing)	384 (11.4)
Suturing	281 (8.3)
Equipment involved in injury	
IM/SQ needle	514 (15.2)
Suture needle	495 (14.6)
Butterfly needle	246 (7.3)

HCW = healthcare worker; IM/SQ = intramuscular or subcutaneous.

rooms (32.3% vs 25.4%; *P* = .0002). In the smaller hospitals, operating room personnel (12.2% vs 5.2%; *P* = .0001) and phlebotomists (5.3% vs 2.7%; *P* = .0005) were injured at a higher rate than at large hospitals. Unit nursing assistants were injured at higher rates at larger hospitals.

Five hundred fifty-seven injuries occurred at the small urban hospitals (681 beds) and 142 occurred at the small rural hospitals (191 beds) (Table 3). Urban hospitals had a higher proportion of percutaneous injuries occurring in the intensive care units (14.2% vs 4.9%; *P* = .0027) than did rural hospitals. Rural hospitals had significantly higher rates of injury in the radiology department (7.7% vs 2%; *P* = .0015) than did urban hospitals. A greater proportion of injuries also occurred among radiology technicians in the rural hospitals (7% vs 2%; *P* = .0016). Other locations, activities, and equipment had similar frequencies.

The two teaching hospitals were compared with the community hospitals. During the study period, 1,324 percutaneous injuries occurred at the community hospitals

**TABLE 3**  
LOCATION OF INJURY, ACTIVITY PERFORMED, AND EQUIPMENT IN USE AT THE TIME OF INJURY BY HOSPITAL SIZE AND SETTING

Characteristic	Size of Hospital			Small Hospital Setting		
	Large (%)	Small (%)	P	Urban (%)	Rural (%)	P
<b>Location</b>						
Ward	801 (29.9)	110 (15.7)	.0001*	86 (15.4)	24 (16.9)	.6694
Operating room	682 (25.4)	226 (32.3)	.0002*	192 (34.5)	34 (23.9)	.0167
Intensive care unit	252 (9.4)	86 (12.3)	.0225	79 (14.2)	7 (4.9)	.0027*
Emergency department	230 (8.6)	96 (13.7)	.0001*	73 (13.1)	23 (16.2)	.3398
<b>Activity</b>						
Phlebotomy	364 (13.6)	96 (13.7)	.9114	76 (13.6)	20 (14.1)	.8919
Sharps disposal	342 (12.8)	109 (15.6)	.0491	85 (15.3)	24 (16.9)	.6306
Operating (not suturing)	287 (10.7)	97 (13.9)	.0184	86 (15.4)	11 (7.7)	.0180
Suturing	222 (8.3)	59 (8.4)	.8893	52 (9.3)	7 (4.9)	.0920
<b>Equipment</b>						
Suture needle	398 (14.8)	97 (13.9)	.5214	78 (14)	19 (13.4)	.8480
IM/SQ needle	373 (13.9)	141 (20.2)	.0004*	107 (19.2)	34 (23.9)	.2099
Blood collection needle	354 (13.2)	30 (4.3)	.0001*	28 (5)	2 (1.4)	.0577
Butterfly needle	178 (6.6)	68 (9.7)	.0051	61 (11)	7 (4.9)	.0308

IM/SQ = intramuscular or subcutaneous.

\*Statistically significant after correction for multiple comparisons

(1,829 beds) and 2,057 occurred at the teaching hospitals (1,677 beds). Injuries at the teaching hospitals occurred more commonly on the wards (28.8% vs 24%;  $P = .0021$ ) and in the intensive care units (11.4% vs 7.8%;  $P = .0006$ ), compared with the community hospitals. Rates of injury in the emergency departments and operating rooms were similar. Nursing personnel were the most frequently injured group at both hospitals, although they made up a larger proportion of the injured personnel at the teaching hospitals (46.3% vs 41.2%;  $P = .0040$ ). At the community hospitals, injuries occurred more frequently among phlebotomists (6.3% vs 1.2%;  $P = .0001$ ) and operating room personnel (13% vs 2.6%;  $P = .0001$ ) than at the teaching hospitals. The injury rate related to sharps disposal was lower at the teaching hospitals (11.9% vs 15.6%;  $P = .0023$ ), although it was higher with suturing (9.6% vs 6.3%;  $P = .0006$ ).

Comparisons were made among the pediatric hospital (a 235-bed urban teaching facility) and the adult hospitals (3,271 beds). Two hundred eighty-four percutaneous injuries occurred at the pediatric hospital and 3,097 occurred at the adult hospitals. Compared with adult hospitals, injuries at the pediatric hospital were more common in the emergency department (17.6% vs 8.9%;  $P = .0001$ ) and intensive care unit (23.2% vs 8.8%;  $P = .0001$ ). Injuries occurring on the wards were more common in the adult hospitals (27.8% vs 17.3%;  $P = .0001$ ). Nursing personnel were the most frequently injured group at both hospitals, although they made up a larger proportion of the injured personnel at the pediatric hospital (59.5% vs

42.9%;  $P = .0001$ ). Injuries were less likely in the operating room of the pediatric hospital compared with the adult hospitals (1.8% vs 7.1%;  $P = .0005$ ), although the rates were similar when comparing operating room personnel at the adult teaching hospital with those at the pediatric hospital (2.7% vs 1.8%;  $P = .3499$ ). Injuries were more likely to occur during the use of butterfly needles at the pediatric hospital than at the adult hospitals (15.8% vs 6.5%;  $P = .0001$ ).

Source-patient serologies among patients who were tested for blood-borne pathogens were also reviewed (Table 4). Source patients with HIV and hepatitis C were more likely at teaching hospitals than community hospitals and at large rather than small hospitals. Among the small hospitals, there was no difference between the urban and rural facilities. HIV and hepatitis C rates were lowest at the pediatric hospital. Rates of positive hepatitis B surface antigen were low, but similar among all categories.

## DISCUSSION

The Barnes-Jewish Christian HealthCare system is a large, integrated healthcare delivery system with multiple hospitals of varying size with different patient populations and settings. All of these hospitals use a common mechanism with consistent definitions for reporting percutaneous injuries, which are entered and tracked in a single occupational health database. The diversity of hospitals combined with a unified reporting system makes this system ideal for studying percutaneous injuries in varied settings. During the past 5 years, percutaneous injury

rates have decreased at all of the study hospitals. Multiple educational interventions and the introduction of several safer devices have contributed to this substantial decrease.<sup>8-11</sup>

Significant differences were found in the patterns of occurrence of percutaneous injury among the hospitals studied. Most published data are from large, adult, urban hospitals, and may not accurately reflect which personnel, locations, equipment, and activities are at the highest risk at other types of facilities. Some of these differences are simply reflections of diverse practices. Butterfly needles are used more commonly on pediatric patients than on adult patients; therefore, it is not surprising that they should be involved in more injuries at pediatric hospitals. More procedures may be performed in radiology suites in rural settings. More procedures may be performed on the wards in teaching hospitals. In all hospital groups, nurses were the most frequently injured healthcare workers.

Occupational health specialists at hospitals without their own data may have to rely on published reports to decide where to focus efforts to decrease injury rates. Introducing safer needleless intravenous tubing might not have a large impact on percutaneous injury rates at a pediatric facility, whereas the introduction of safer butterfly needles might.

Although most percutaneous injuries occurred on inpatient wards at large hospitals, at small hospitals, percutaneous injuries were more common in operating rooms. This pattern is particularly noticeable at small urban hospitals. At smaller hospitals, targeting operating rooms as high-risk areas for intervention might have a greater effect than would interventions on inpatient wards.

In assessment of the risk to healthcare workers of acquiring a blood-borne pathogen infection after an exposure, the type and location of the hospital may also be factors. HIV and hepatitis C are more common among source patients at large hospitals. However, among small hospitals, the prevalence of source patients with blood-borne pathogens was similar in rural and urban settings. Hepatitis B surface antigen positivity was uncommon, but equally distributed among all types of hospitals, including the pediatric hospital. Promoting universal hepatitis B vaccination for all healthcare workers, regardless of the type of hospital or setting in which they work, remains crucial.

There are several limitations of this study. As in all retrospective studies of percutaneous injuries, data are available for reported injuries only, and multiple studies have shown low rates of reporting.<sup>12,13</sup> These particular data are also limited because they do not include information about percutaneous injuries sustained by attending physicians as they report to a separate occupational health system. There are only two small rural hospitals in this cohort of nine facilities, so the numbers involving the rural settings are smaller. There is only one (small, urban, teaching) pediatric facility, so attributing the differences between the pediatric facility and multiple adult facilities

**TABLE 4**  
SOURCE-PATIENT SEROLOGY FOR HEPATITIS B, HEPATITIS C, AND HUMAN IMMUNODEFICIENCY VIRUS BY HOSPITAL SIZE AND SETTING, AND TEACHING STATUS AND PATIENT POPULATION

SeroLOGY	Size of Hospital		P	Small Hospital Setting		P	Teaching Status		Patient Population		
	Large (%)*	Small (%)*		Urban (%)*	Rural (%)*		Teaching (%)*	Community (%)*	Pediatric (%)*	Adult (%)*	P
Hepatitis C	198 (10.3)	15 (2.6)	.0001 <sup>†</sup>	12 (2.6)	3 (3.1)	.7315	167 (11.3)	46 (4.5)	0	213 (9.5)	.0001 <sup>†</sup>
Hepatitis B	24 (1.3)	5 (0.8)	.3983	4 (0.8)	1 (0.9)	1.0	19 (1.3)	10 (1)	2 (0.8)	27 (1.2)	.4401
HIV	54 (2.8)	1 (0.2)	.0025 <sup>†</sup>	0	1 (.9)	.1883	45 (3)	10 (0.9)	0	55 (2.4)	.0131

HIV = human immunodeficiency virus.  
<sup>†</sup>Percent of source patients who tested positive.  
<sup>‡</sup>Statistically significant after correction for multiple comparisons.

to any one factor is problematic. However, many of the differences between the one pediatric hospital and the combined adult hospitals are also seen in a comparison of the pediatric hospital with the adult teaching facility, which is also urban, although large, so that some of the variability is probably due to the pediatric patient population. The acceptance and adoption of the safer devices in cases where old equipment was still available may have varied among the hospitals and among different departments within the hospitals. These differences may also have had some effect on injury patterns at each facility. Although we did perform multiple comparisons between each category, we used the Bonferroni correction for multiple comparisons to minimize the likelihood of a difference being found to be statistically significant by chance alone.

Despite these limitations, this study demonstrates significant differences regarding which healthcare workers sustain percutaneous injuries, where the injuries occur, what activity is being performed at the time of the injury, and what equipment is being used, depending on the type of hospital evaluated. Awareness of these differences may encourage individual facilities to evaluate their own data prior to initiating programs to prevent percutaneous injury. Knowledge and understanding of these differences can help to target intervention and prevention strategies to the personnel at the highest risk.

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